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Development of A Table Tennis Learning Model For Children With Intellectual Disabilities

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ABSTRACT

This study was conducted based on the condition of table tennis learning at SLB Bhakti Putra Palu, which showed that students with intellectual disabilities (tunagrahita) still experience various difficulties in participating in table tennis lessons. These difficulties are caused by limitations in intellectual capacity, motor coordination, concentration, and the ability to understand instructions given by the teacher. These conditions result in students lacking selfconfidence, being less active, and showing little interest in table tennis learning. This study employed the Research and Development (R&D) method referring to the Borg and Gall development model, which includes the stages of identifying potentials and problems, information gathering, product design, expert validation, product revision, smallgroup trials, product revision, largegroup trials, final revision, and final product. Research data were obtained through observation, questionnaires, documentation, and expert validation, then analyzed using descriptive percentage analysis. The results showed that the developed learning model obtained a validation score of 75% from learning experts and 83.33% from table tennis experts, both falling into the "Feasible to Use" category. In the smallgroup trial, a percentage of 89.28% was obtained, while in the largegroup trial, it increased to 94.40%, indicating that the learning model is highly feasible for use in table tennis learning for children with intellectual disabilities. Based on these research results, it can be concluded that the table tennis learning model utilizing equipment modifications such as lighter paddles, lighter balls, adjusted table sizes, and progressive exercises like shadow strokes—is effective in helping students with intellectual disabilities learn basic table tennis techniques, improving motor coordination, selfconfidence, and participation in the learning process. Thus, the resulting product is expected to serve as a reference for physical education teachers in developing table tennis learning that is more effective, adaptive, and tailored to the needs of students with special needs, particularly those with intellectual disabilities

Keywords: Development, Learning Model, Intellectual Disability, Table Tennis.

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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 (DSMV), 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 multistep 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 eyehand coordination (Siedentop, 2021). Precise ballstriking 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 indepth 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 150200 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 pingpong balls, which is too fast without any additional sound stimuli, and the singlebounce rule that demands splitsecond 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 (70100 grams) with safe materials, using a table whose size is reduced to resemble a study desk, and using larger, colorful balls equipped with soundproducing 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.

METHOD

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 10step 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) Broadscale 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, shortterm 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 smallgroup 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 mixedmethods 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 (150200 grams) was replaced with a lightweight wooden paddle coated with sponge material, totaling 70100 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 pingpong balls were replaced with slightly larger plastic balls, colored in bright neon hues, and equipped with soundproducing 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

Before the product was tested on the research subjects, the model prototype and its guidebook had to undergo validation by experts to test content validity and pedagogical suitability. The first validator was an expert in adaptive physical education and learning.

The quantitative results from the learning expert's assessment showed that out of the 15 evaluated aspects, the model design obtained a total score of 45 out of a maximum score of 60. Converted through the percentage formula, this model achieved a feasibility rate of 75.00%, categorically placing it under "Feasible / Usable." The learning expert assessed that the material structure, use of concise instructional sentences, suitability of stages to the cognitive capacities of children with intellectual disabilities, and safety aspects of the modified equipment use were very well accommodated in the design.

Nevertheless, the learning expert provided qualitative and highly crucial evaluative feedback regarding the student assessment instrument. In the initial draft, the student evaluation format focused too heavily on the affective domain (courage) and general coordination. The validator suggested improvements: "Focus remains on courage and coordination, but do not neglect the assessment of correct and incorrect movements.

Add an assessment of the fundamental technique correctness value, as well as the quantity or number of successful strokes as a success indicator." Based on this input, the researcher promptly revised the teacher evaluation guideline sheet in the guidebook by incorporating criteria for assessing biomechanical accuracy (such as foot positioning and bounce angle) and calculating the number of rallies successfully completed by the student.

Table Tennis Expert Validation Results

The second validator was an academic and practical expert in the sport of table tennis. Assessment from this sports expert was vital to ensure that despite massive modifications, the essence and fundamentals of table tennis techniques were not lost and remained taught through correct procedures (for instance, the shakehand grip and ready position).

The evaluation results from the table tennis expert yielded a higher quantitative score than the learning expert. The model received a score of 50 out of 60, resulting in a feasibility percentage of 83.33%. This figure placed the product in the "Highly Feasible / Usable" category. The expert confirmed that the stages of introducing basic techniques (how to hold the paddle, bouncing the ball statically, basic service, and striking (drive/block)) were very precise and structurally safe for the motor limitations of children with intellectual disabilities.

As constructive input to perfect the product, the table tennis expert provided an important note regarding the neuromotor readiness of the students: "Provide initial stimulus before children directly strike or make contact with a moving ball, such as shadow stroke exercises." This recommendation was immediately implemented by the researcher. In the preliminary/warmup stages of the guidebook, a specific session was added where children held the paddle and imitated swinging motions from the instructor repeatedly without using a ball. The goal was to build muscle memory first before facing the pressure of an approaching bouncing ball.

Small Group Field Trial (Limited Scale)

Once all expert revisions (addition of accuracy indicators and integration of shadow stroke exercises) were accommodated into the product draft, the next operational stage was the smallgroup trial. This stage was implemented at SLB Bhakti Putra Palu involving 7 (seven) students with mild intellectual disabilities as the subject sample. During this trial, students were guided to practice 10 aspects of basic skills progressively (stepbystep).

Table 1. Percentage of Motor Aspect Achievement in Small Group Trial (n=7)

No	Assessed Motor Skill Indicators	Total Score (∑X)	Ideal Max Score (∑Xi)	P (%)
1.	Holding the paddle with the correct position (grip)	26	28	92%
2.	Bouncing the ball upward (vertically) repeatedly	25	28	89%
3.	Bouncing the ball onto the table surface with control	26	28	92%
4.	Focusing attention (visual attention) on the ball's movement	25	28	89%
5.	Eyehand coordination when striking	27	28	96%
6.	Executing service movements according to instructional stages	25	28	89%
7.	Striking the service ball past the net/boundary line	25	28	89%

8.	Blocking/returning an incoming ball from the opponent	23	28	82%
9.	Directing the ball's bounce to the target table area	25	28	89%
10.	Performing a continuous series of basic table tennis movements	23	28	82%
Overall Score Accumulation (10 Indicators)		**250**	**280**	**89.28%**

Based on the data analysis in Table 1, the smallgroup trial results reached a total percentage of 89.28%, placing it within the "Highly Feasible / Usable" criterion. Qualitatively, field observations recorded that the vast majority of students showed extraordinary enthusiasm and freedom from the fear of failure. Their attention was successfully locked by the bright ball color and the jingling sound produced when the ball bounced on the table.

Although the aggregate feasibility percentage was exceptionally high, detailed observations noted specific weaknesses. Aspect number 8 (blocking incoming balls) and number 10 (chaining continuous movements) obtained the lowest scores of 82%. Some students still experienced a cognitive processing lag when the ball slid towards them, causing delayed paddle swings. Furthermore, a few children still required full physical prompting from the teacher to adjust their arm posture. Responding to these weaknesses, the researcher implemented microrevisions: the duration of shadow stroke exercises was extended, and teachers were instructed to use rhythmic verbal cues (e.g., "ready... strike!") to help synchronize the children's rhythm

Large Group Field Trial (Broad Scale)

The learning model product, refined through postsmallgroup trial revisions, was subsequently implemented on a scale more representative of the actual classroom population. The broadscale field trial involved 13 students with intellectual disabilities. In this extensive trial phase, one critical point was added to the observation instrument as a direct implementation of the learning expert's advice: quantitatively measuring the level of "basic technique accuracy and the number of successful strokes executed."

Table 2. Percentage of Motor Aspect Achievement in Large Group Trial (n=13)

No	Assessed Motor Skill Indicators	Total Score (∑X)	Ideal Max Score (∑Xi)	P (%)
1.	Holding the paddle with the correct position (grip)	50	52	96%
2.	Bouncing the ball upward (vertically) repeatedly	48	52	92%
3.	Bouncing the ball onto the table surface with control	51	52	98%

4.	Focusing attention (visual attention) on the ball's movement	50	52	96%
5.	Eyehand coordination when striking	50	52	96%
6.	Executing service movements according to instructional stages	48	52	92%
7.	Striking the service ball past the net/boundary line	48	52	92%
8.	Blocking/returning an incoming ball from the opponent	46	52	88%
9.	Directing the ball's bounce to the target table area	48	52	92%
10.	Performing a continuous series of basic table tennis movements	50	52	96%
11.	Basic technique accuracy and the number of successful strokes (quantity)	51	52	98%
Overall Score Accumulation (11 Indicators)		**540**	**572**	**94.40%**

Field test data on the large group (Table 2) showcased highly impressive surges in effectiveness. The cumulative total feasibility reached 94.40%, a figure representing the overall stability and success of the model. Prior corrective interventions—especially the repetition of rhythmic verbal cues and the expansion of shadow stroke exercise sessions—significantly helped students internalize movement patterns. Consequently, when the real ball was introduced, their anticipatory reflexes and striking accuracy broke through the 98% success rate

Students appeared much more independent in holding the paddle with a correct grip. They were more confident, not easily distracted, and able to focus their attention on the noisy, colorful ball movements during the activity without needing constant individual supervision. These results serve as the ultimate validation that the developed adaptive table tennis learning model product possesses immensely high efficacy and is ready for implementation as a standard physical education instrument for students with intellectual impairments.

DISCUISSION

The success of the adaptive table tennis learning model, evidenced by the significant jump from the smallgroup trial (89.28%) to the largegroup trial (94.40%), opens an important academic discourse on the urgency of sports ergonomics and pedagogical modification in special education settings. The 94.40% achievement rate is not merely a statistical representation but strong empirical evidence that if the learning environment structure and teaching aids are precisely adapted to the inherent deficits of

the learners, children with intellectual disabilities can achieve motor mastery often considered impossible with standard equipment

Significance of Biomechanical Modification of Equipment (Paddle and Ball)

Drastically reducing the mass of the table tennis paddle from 150-200 grams (ITTF standard) to a range of 70-100 grams serves a fundamental function in addressing the primary physical weakness of children with intellectual disabilities, namely hypotonic upper extremities (lack of strength). Excessively heavy paddles in initial trials often caused muscle fatigue within minutes, triggering loss of grip technique and decreasing motivation to play. Modifications using balsa/lightweight wood layered with sponge materials not only reduced the mechanical load on wrist joints but also provided biomechanical flexibility and maneuverability for the children. This finding aligns with the concept of equipment adaptation in inclusive physical education, which states that aligning the tool's mass proportion with the subject's muscle mass optimizes fine motor coordination.

Beyond the mechanical aspects of the arm, ball modifications produced extraordinary neurocognitive implications. A central issue for children with intellectual disabilities is a very short attention span and weakness in processing singular stimuli. The use of table tennis balls colored in bright neon palettes and equipped with internal soundproducing elements (small bells) proved tactically effective in stimulating multisensory attention mechanisms (visual and auditory simultaneously). The ringing sound acts as an auditory cue signaling the child's brain regarding the ball's presence, proximity, and speed in realtime. Observation results noted that this modified ball successfully "locked on" the concentration of children typically easily distracted by their surroundings, keeping them fixated on the game table. This supports the sensory integration theory that learning for individuals with learning difficulties must combine various sensory modalities to create robust memory pathways.

Effectiveness of Rule Modification: Reaction Time Extension

Regarding game rule adaptation, the radical regulation allowing the ball to double bounce on the student's table area before being hit drastically reduced cognitive overload. In regular table tennis, the speed of a singlebounce ball demands splitsecond reaction times and decisionmaking. This demand frequently triggered cognitive anxiety and intense frustration in children with intellectual disabilities, as their neural pathways require more time to process visual stimuli into motor (kinesthetic) commands

With an extra second bounce, children gain a latency delay of a few vital seconds. This pause is utilized by the child's brain to perform spatial calculations: reading the bounce direction, adjusting footwork, and executing the arm swing. This regulatory leniency proved to democratize the game, creating a non threatening learning environment. Students no longer felt rushed, gradually diminishing the fear of failure, replacing it with the enthusiasm to strike the ball back.

Shadow Stroke Intervention and Muscle Memory Formation

One of the most vital academic contributions of this R&D research was adopting expert input to integrate shadow stroke exercises during the warmup phase. Since children with intellectual disabilities struggle to process simultaneous dual instructions

(e.g., looking at the ball, while thinking about how to hold the paddle, and stepping concurrently), breaking down complex movements into isolated actions (chunking) is a crucial solution.

By practicing bodily swing movements repeatedly without the distraction of a moving ball (shadow stroke), students slowly built muscle memory and movement automation in their motor cortex. This biomechanical repetition ensured the correct stroke form was strongly internalized. When the actual ball was eventually fed in the subsequent stage, the addition of an object was no longer confusing. The child's brain only needed to recall the already stored movement record, enabling the surge in the "basic technique accuracy and successful stroke quantity" percentage in the largegroup trial to reach a spectacular 98%.

Psychosocial Impact and Increased Participation

Finally, psychosocially, the effectiveness of this adaptive learning model has restored the essence of play in educational sports. The combination of soundproducing balls, lightweight paddles, and doublebounce rule tolerances collectively generated numerous "small wins" for students with intellectual disabilities. The sensation of successfully hitting the ball and bouncing it back over the net produced internal positive reinforcement. This success cycle triggers dopamine production, enhancing intrinsic motivation and selfefficacy (selfconfidence) among the children at SLB Bhakti Putra Palu. They became more actively participative without coercion, sparking smiles, laughter, and better interstudent communicative interactions proving that this model trains not only the physical body but also builds character and inclusive social spaces.

CONSLUSION

The development of an adaptive table tennis learning model focusing on an overhaul of visual approaches, physical equipment modification (reducing paddle weight to 70-100 grams, incorporating soundproducing multisensory balls), and the simplification of technical regulations (allowing double ball bounces) has proven conclusively to be highly feasible, practical, and effective in accelerating the motor skills of children with mild intellectual disabilities. The feasibility and validity levels of this model were confirmed through cumulative expert scores, where the learning expert assigned 75.00% and the table tennis sports expert assigned 83.33%. Empirically, the product's efficacy was strongly proven through a drastic increase in the students' motor performance percentage, moving from 89.28% (highly feasible category) in the smallscale field trial, skyrocketing to 94.40% in the largescale usage trial. The implementation of repetitive pedagogical approaches, especially the pretraining introduction through the shadow stroke method, successfully facilitated muscle memory recording, which had a parallel impact on sharp improvements in body mechanics accuracy and eyehand coordination, without excessively burdening the children's cognitive processing.

The practical implications born from the success of this R&D research send an academic message that equipment ergonomic modification and pedagogical regulatory adaptation are absolute prerequisites (*conditio sine qua non*) in an inclusive and disabilityfriendly physical education ecosystem. The output product, in the form of a guidebook and learning model framework, is highly recommended to be adopted and

utilized as an instructional Standard Operating Procedure (SOP) by physical education teachers, not only at SLB Bhakti Putra Palu but also in other special education institutions. To broaden academic horizons, it is recommended that future researchers test the retention level (longterm memory) of motor skills derived from this model through longitudinal studies, as well as expand similar modification designs to serve subjects with more severe intellectual disability classifications, autism spectrum, or diversification to other racketbased sports

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