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Educational Motor Skills Game for Preschoolers: A Freestyle Swimming Learning Model

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Abstract

Study purpose. Freestyle swimming instruction for early childhood students in Palopo City still employs conventional approaches that do not align with children's developmental characteristics, leading to psychological barriers such as fear of water (aquaphobia) and low learning motivation. This study aims to: (1) develop a play-based motor skills educational game model for teaching freestyle swimming to young children in Palopo City; (2) test the model's feasibility through expert validation; and (3) evaluate the model's effectiveness in improving children's aquatic motor skills.

Materials and methods. This study employed the Research and Development (R&D) method using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The research subjects were 30 children aged 4–6 years from three Early Childhood Education (ECE) institutions in Palopo City. The instruments used were an expert validation form, an aquatic motor skills observation sheet, and an interview guide.

Results. The expert validation results showed an average score of 4.31 (86.1%) in the "Highly Acceptable" category. Field test results indicated an increase in aquatic motor skills scores from 48.9% (pretest) to 71.6% (posttest), representing a 22.7 percentage point increase.

Conclusions. The six educational games developed proved effective in improving children's water adaptation, movement coordination, and self-confidence. This model makes a tangible contribution to the development of play-based physical education for early childhood.

Keywords: Educational Games, Early Childhood Motor Skills, Freestyle Swimming, Learning Model

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Introduction

Early childhood motor development is one of the most critical dimensions in the holistic process of child growth and development, inseparable from cognitive, social, and emotional dimensions (Zulnadila et al., 2025). The 0–6-year-old age phase, known as the golden age, is a period when the child's brain undergoes the most rapid development and is most responsive to various environmental stimuli (Kemendikbudristek, 2022). Lipkin and Macias (2020) emphasize that appropriate and structured stimulation during this period is an absolute prerequisite for achieving optimal child development across all domains of life. Therefore, every motor stimulation program designed for young children must be grounded in a deep understanding of children's developmental characteristics, rather than merely adapting approaches intended for older age groups (Mariati et al., 2024; Yusroni, 2024).

Aquatic activities, particularly freestyle swimming, offer highly comprehensive benefits in supporting the multidimensional gross motor development of young children (Kwok et al., 2025; Mashud, Warni, et al., 2023; Sin, Tjung & Hudayani, 2020). Swimming simultaneously engages nearly all major muscle groups, trains coordination between upper and lower extremities, develops balance in a medium distinct from the of daily life on land, and builds children's cardiorespiratory capacity from a very early age (Saifu et al., 2021). Leo et al. (2022), in their study at the University of Padua, found that aquatic activities from an early age provide unique sensory stimulation that cannot be replaced by any land-based activity, as the water medium slows down movement, thereby enhancing children's proprioceptive perception of their own movements. Gu and Wen (2024) further emphasize that early childhood is a critical period for the development of basic motor skills, and swimming offers development opportunities unmatched by any other type of physical activity.

From a public safety perspective, the urgency of teaching swimming to young children is increasingly undeniable. The World Health Organization (WHO) notes that drowning is one of the leading causes of unintentional death among children globally, and WHO projections (2022) indicate that basic swimming instruction starting in preschool could potentially prevent hundreds of thousands of drowning deaths over the next three decades. Contextually, Indonesia, as an archipelagic nation with thousands of rivers, lakes, seas, and irrigation canals spread across its territory, positions swimming proficiency as a fundamental life skill for every citizen, including young children (Iverson, 2021; Moura, et al., 2022; Dese et al., 2025).

On-the-ground realities in Palopo City reveal a significant gap between the potential and the actual implementation of swimming instruction for young children. Initial observations from research conducted at several swimming pools and children's sports centers in Palopo City found that the swimming instruction models currently in use are still heavily dominated by conventional, instructor-centered approaches. Children are taught swimming techniques through demonstrations and repetition without adequate modifications for their age, disregarding the fundamental principles of early childhood education that emphasize learning through play. As a result, the majority of young children participating in swimming programs in Palopo City report a fear of water (aquaphobia), low motivation to learn, and technical proficiency far below their actual potential.

Roche et al. (2022) in their study on aquaphobia in children state that fear of the aquatic environment is the most fundamental psychological barrier in the swimming learning process, and that conventional approaches that force technical instruction without psychologically preparing children tend to exacerbate this fear rather than address it. Mekkaoui et al. (2022), in their systematic review of pedagogical practices in aquatic learning for children aged 4–6 years, also found that there is no consensus on the most effective teaching approach and emphasized the urgent need for the development of more innovative and evidence-based pedagogical tools for this age group.

In this context, educational games emerge as a robust conceptual solution that is theoretically most aligned with the fundamental principles of early childhood education. Alotaibi (2024), in a comprehensive meta-analysis involving 136 studies, found that the game-based learning approach has moderate to large effects on children's cognitive, social, emotional, motivational, and engagement outcomes in early childhood education. Simón-Piqueras et al. (2022) specifically demonstrated that aquatic learning programs based on motor games (motor stories, learning environments, and motor circuits) are significantly more effective in improving aquatic motor skills in 4- to 5-year-old children compared to conventional repetition-based programs, particularly regarding aspects related to mastering advanced aquatic skills.

Pratt and Duncan (2024) also demonstrate that swimming-based interventions not only improve aquatic motor skills but also have a positive impact on general gross motor development in children. These findings have very important implications: that investing in quality swimming instruction for young children is not merely about producing children who can swim, but about producing children who have a stronger motor foundation for all their future physical activities. Furthermore, Abidin et al. (2023), in their study on swimming instruction in Early Childhood Education (ECE) institutions in Indonesia, found that fun, play-based learning methods have a significant positive impact on children's gross motor skills and make the learning process more participatory and meaningful.

A review of existing research literature identifies a very significant research gap: there is no educational game model specifically developed for teaching freestyle swimming to young children in the local Indonesian context, particularly in the city of Palopo. Research on motor-based educational games is generally conducted in land-based contexts (Taverna et al., 2020; Vukićević, 2019), whereas research on children's swimming instruction rarely systematically integrates a game-based learning approach. The exploration of learning models and play-based approaches in swimming instruction conducted by Ruslan et al. (2024) has indeed identified the great potential of play-based approaches in the context of swimming; however, the development of concrete, validated, and contextually relevant models for young children in Indonesia remains very limited.

Accordingly, the novelty of the present study lies in the development and empirical validation of an educational motor skills game model specifically designed to teach freestyle swimming to preschool children. Unlike previous studies that mainly examined the outcomes of swimming participation or the benefits of play-based instruction, this research develops a comprehensive learning model that integrates (1) fundamental motor skill development, (2) age-appropriate educational games, and (3) progressive freestyle swimming instruction within a single instructional framework. The model is systematically validated by experts in swimming education, early childhood education, and educational media before being tested for its effectiveness in improving children's aquatic motor competence. Furthermore, this study represents one of the first context-specific model development studies conducted in Indonesia, particularly in Palopo City, thereby addressing the shortage of locally validated instructional resources for preschool swimming education.

Based on these considerations, this study aims to: (1) develop a play-based educational motor skills model that systematically introduces the fundamental techniques of freestyle swimming to preschool children in Palopo City; (2) evaluate the content validity and feasibility of the model through expert review involving specialists in swimming instruction, early childhood education, and educational media; and (3) examine the effectiveness of the developed model in improving children's aquatic motor skills.

Materials and methods

Study participants

The research was conducted in Palopo City, South Sulawesi Province, from March to August 2025. The research subjects consisted of three groups: (1) expert validation subjects, comprising 4 experts (a swimming content expert, an early childhood learning expert, a learning media expert, and an experienced ECE teacher practitioner); (2) small-scale pilot test subjects, consisting of 10 children aged 4–6 years from one ECE institution; and (3) the main field trial subjects, consisting of 30 children aged 4–6 years (15 boys, 15 girls) from three early childhood education institutions in Palopo City, selected via purposive sampling based on the criteria of having access to swimming pool facilities and having never participated in a swimming instruction program before.

Study organization

This study employs the Research and Development (R&D) method using the ADDIE development model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected due to its cyclical, structured nature and its focus on validated products, making it the most suitable approach for developing a learning model to be implemented in real-world settings. Herdianto et al. (2020) demonstrated that the ADDIE model has proven effective in developing swimming learning models within the Indonesian context because it ensures each development stage is validated before proceeding to the next. The ADDIE diagram can be seen in Figure 1.

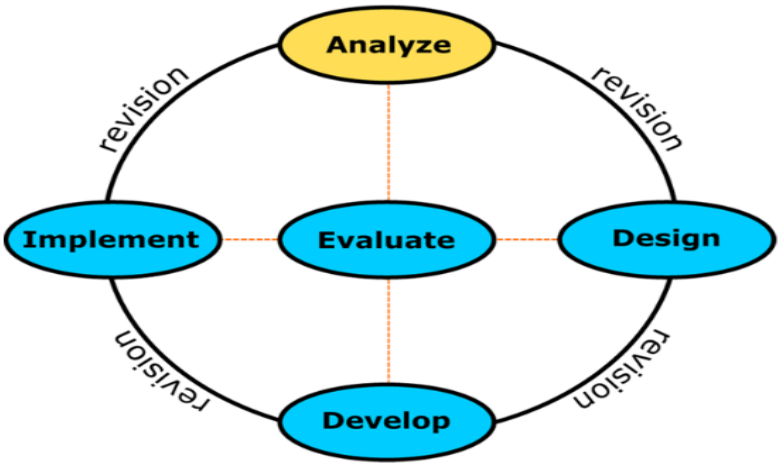

Figure 1. Stages of the ADDIE Model

Development Phases

The Analysis phase included needs analysis through direct observation at 5 swimming pools and 8 ECE institutions in Palopo City, in-depth interviews with 12 ECE teachers and 8 children's swimming instructors, as well as a review of the current ECE curriculum documents. In the Design phase, the researcher designed a conceptual framework for an educational game model that integrates Gallahue and Ozmun's theory of fundamental motor development with Vygotsky's principle of the zone of proximal development. The Development phase included drafting the model guidelines, designing 6 educational games along with their implementation procedures, and validating the initial product with experts. The Implementation phase was carried out through a small-scale pilot study (n=10) followed by a main field trial (n=30) using a one-group pretest-posttest design. The Evaluation phase involved data analysis and model revision based on empirical findings.

Research Instruments

The research instruments used include: (1) an Expert Validation Form, designed using a 1–5 Likert scale covering aspects of content, pedagogy, appropriateness for children's developmental levels, and practicality of implementation; (2) Aquatic Motor Skills Observation Sheet, developed based on the validated Escala de Competencia Motriz Acuatica (ECMA) and adapted to the local context, with five assessment aspects: water adaptation/familiarization, leg movement coordination, arm movement coordination, basic breathing control, and confidence in the water; and (3) Structured Interview Guidelines for teachers and coaches. Prior to use, the aquatic motor skills observation instruments underwent content validity testing by two experts and inter-rater reliability testing, yielding a Cohen's Kappa coefficient of 0.84 (Very Good category).

Statistical analysis

Expert validation results were analyzed using a percentage of acceptability formula with the following criteria: highly acceptable (81–100%), acceptable (61–80%), somewhat acceptable (41–60%), less acceptable (21–40%), and unacceptable (<21%). Field test data were analyzed using the Wilcoxon Signed-Rank Test (due to non-normal data distribution based on the Shapiro-Wilk test with $p < 0.05$) to compare children's pre-test and post-test aquatic motor skills scores. The effect size of the intervention was calculated using Cohen's d to determine the effectiveness level of the developed model. All statistical analyses were performed using SPSS software version 26.0 with a significance level of $\alpha = 0.05$.

Results

Description of the Developed Educational Game Model

The aquatic motor skills educational game model developed in this study is named the Aquatic Eduplay Model (AEM). This model consists of six educational games arranged hierarchically and progressively, following the stages of aquatic motor skill development in young children from the most basic (water familiarization) to the most complex (integration of freestyle techniques). Each game is designed to last 15–20 minutes, can be played in small groups (4–6 children), and uses simple, readily available aids such as colorful floats, small plastic balls, and waterproof toys. The six educational games are presented in Table 1.

Table 1. Description of Educational Games in the Aquatic Eduplay Model (AEM)

No.	Game Name	Activity Description	Motor Skills Objectives
1	Brave Submarine	Getting used to having your face in the water, holding your breath	Overcoming aquaphobia, water adaptation
2	Little Frog Race	Flutter kick at the pool edge	Coordination and rhythm of freestyle leg movements
3	Magic Sailboat	Gliding with a floatboard	Horizontal body balance in the water
4	Swimming Starfish	Alternating arm coordination (crawl stroke)	Basic freestyle arm movement pattern
5	Shark Breathing	Head rotation and breathing	Breathing rhythm while swimming freestyle
6	Dolphin Swim Race	Integration of leg, arm, and breathing movements	Mastery of integrated freestyle technique

Each game in the AEM model is designed based on four pedagogical principles that form the conceptual foundation of the model: (1) The Progressive Principle, where each game is designed with gradually increasing levels of difficulty in accordance with the stages of children's aquatic motor development; (2) The Authentic Play Principle, in which game elements such as stories, imaginative characters, challenges, and rewards are organically integrated into aquatic motor activities; (3) The Psychological Safety Principle, where each game is designed to build the child's sense of safety and comfort before introducing new challenges; and (4) The Differentiation Principle, where each game offers varying levels of difficulty to accommodate individual ability differences among children within the same group.

Expert Validation Results

Expert validation was conducted by four validators: a swimming instructor with over 10 years of coaching experience, a PhD-holding expert in early childhood education, an educational media specialist, and an experienced ECE teacher. The validation process consisted of two rounds: the first round yielded several revision suggestions that were subsequently implemented, and the second round resulted in validation approval with the final scores shown in Table 2.

Table 2. Expert Validation Results for the Aquatic Eduplay Model (AEM)

Validator	Average Score	Percentage	Category
Swimming Expert	4.35	87%	Highly Recommended
EC Learning Expert	4.28	85.6%	Highly Recommended
Learning Media Specialist	4.41	88.2%	Highly Recommended
ECE Practitioner / Teacher	4.19	83.8	Highly Recommended
Overall Average	4.31	86.1%	Highly Recommended

Based on Table 2, all validators rated the games as "Highly Suitable," with an overall average of 4.31 (86.1%). Suggestions for improvement provided during the first round of validation for the " " included: (1) adding more detailed safety procedures for each game; (2) simplifying the language of instructions to make them easier for 4-year-olds to understand; and (3) adding more economically accessible variations of assistive tools. All of these recommendations were implemented before the model was field-tested, resulting in the final version of the Aquatic Eduplay Model, which is ready for empirical implementation.

Field Trial Results

The main field trial was conducted over eight weeks with a frequency of two sessions per week, each session lasting 60 minutes. Each session consisted of three parts: a warm-up on land (10 minutes), implementation of educational games in the pool (40 minutes), and a cool-down and group reflection (10 minutes). The pretest assessment was conducted in the first week before the intervention began, and the posttest was conducted in the eighth week after the entire intervention cycle was completed. The comparison of pretest and posttest results is presented in Table 3.

Table 3. Comparison of Pretest and Posttest Scores for Aquatic Motor Skills

Aspects Assessed	Pretest (%)	Posttest (%)	Description
Water Adaptation (Familiarization)	52.4	73.8	Improved
Leg Coordination	48.6	71.2	Increased
Arm Movement Coordination	46.8	68.9	Increased
Basic Breathing Control	41.3	65.4	Improved
Confidence in the Water	55.2	78.6	Increased
Overall Motor Skills Score	48.9	71.6	Increased (+22.7)

Based on Table 3, there was a consistent improvement across all assessed aspects of aquatic motor skills. The greatest improvement occurred in the water adaptation/familiarization aspect (from 52.4% to 73.8%, an increase of 21.4 points), reflecting the model's success in addressing aquaphobia through a safe and enjoyable play-based approach. Improvements in the aspects of leg movement coordination (from 48.6% to 71.2%) and arm movement coordination (from 46.8% to 68.9%) also demonstrate the effectiveness of games specifically designed to build basic freestyle movement patterns. The overall increase in aquatic motor skills scores from 48.9% to 71.6% (delta = 22.7 points) indicates a practically significant effectiveness of the intervention.

Results from the Wilcoxon Signed-Rank Test revealed a statistically significant difference between pretest and posttest scores ($Z = -4.782$, $p < 0.001$). The effect size of the intervention, calculated using Cohen's d, yielded a value of $d = 1.23$, which falls into the "large effect" category according to Cohen's (1988) convention. These findings indicate that the Aquatic Eduplay Model not only produces statistically significant differences but also has a substantial practical impact on improving the aquatic motor skills of young children in Palopo City.

Discussion

The findings of this study confirm and expand upon the empirical evidence generated by various previous studies on the effectiveness of game-based approaches in early childhood aquatic learning. Simón-Piqueras et al. (2022) found that motor-based water play programs are significantly more effective than conventional repetition-based programs, particularly in improving advanced water skills. The results of this study reinforce these findings while adding a new dimension: that the effectiveness of game-based approaches is also very evident in the Indonesian context, and that the benefits extend not only to technical motor skills but also to psychological dimensions, such as increased children's self-confidence in aquatic environments.

The highly significant improvement in water confidence (from 55.2% to 78.6%) is a highly meaningful finding, as water confidence is a psychological prerequisite for mastering all technical swimming skills. Roche et al. (2022) emphasize that fear of water (aquaphobia) is the most fundamental barrier in the swimming learning process, and that a learning approach that creates a psychologically safe environment is key to overcoming this barrier. The AEM model successfully creates such an environment through the use of stories, imaginative characters, and gradual challenges that make children feel safe and confident to interact with the aquatic medium progressively (Petrass & Blitvich, 2014; Sundan et al., 2021).

From a developmental theory perspective, the effectiveness of the AEM model can be explained through Vygotsky's concept of the zone of proximal development (ZPD). Each game in the model is designed to operate precisely within the child's ZPD: challenging enough to promote skill growth, yet achievable with support from instructors and peers so that children can complete them without experiencing excessive frustration (Mashud, Arifin, et al., 2023; van Duijn et al., 2021; Warni et al., 2023, van Duijn et al., 2025). Scaffolding provided through assistive devices (floats, kickboards), simple verbal instructions, and a reward system in the form of praise and group applause ensures that each child progresses along their own learning continuum, in line with their developmental capacity (Mardesia et al., 2021; Mashud et al., 2018).

The aspect of differentiation in the AEM model has also proven crucial in the context of heterogeneous learning groups. In one pilot group, there was significant variation in initial motor skills among the children (Prawira et al., 2021; Santos et al., 2023). Alotaibi (2024) emphasizes in his meta-analysis that one of the greatest strengths of game-based learning is its ability to accommodate individual differences through adaptive and flexible game design. The AEM model applies this principle by providing varying levels of challenge within each game, allowing children with different initial abilities to meaningfully participate in the same activity, ensuring no child feels left behind or too far behind their group.

The findings of this study also have direct relevance to the context of Indonesia's national education policy. The Merdeka ECE Curriculum Kemendikbudristek (2022) emphasizes the importance of holistic gross motor stimulation based on play-based activities as one of the fundamental aspects of development that must be facilitated by every ECE institution. The AEM model is philosophically and operationally highly aligned with the principles advocated by the Merdeka ECE Curriculum, making it not only scientifically relevant but also policy-applicable within the context of Indonesia's transforming education system.

Limitations

This study has several limitations. First, the study was conducted only with preschool children in Palopo City, which may limit the generalizability of the findings to other regions with different educational and socio-cultural contexts. Second, the effectiveness evaluation focused on short-term improvements in aquatic motor skills, so the long-term retention of freestyle swimming skills was not examined. Third, the study primarily assessed motor performance and did not investigate other important outcomes, such as water confidence, cognitive development, or psychosocial aspects that may also be influenced by play-based swimming instruction. Future studies should include more diverse populations, longitudinal follow-up, and broader developmental outcomes to provide more comprehensive evidence regarding the effectiveness of the proposed learning model.

Conclusions

Based on the research findings and discussion, three main conclusions can be drawn. First, this study successfully developed the Aquatic Eduplay Model (AEM), an educational motor skills game model for teaching freestyle swimming to young children in Palopo City, consisting of six educational games arranged in a hierarchical and progressive sequence: Brave Submarine, Little Frog Race, Magic Sailboat, Swimming Starfish, Shark Taking a Breath, and Dolphin Swimming Race. Second, the AEM model was deemed Highly Feasible based on validation by four experts with an average score of 4.31 (86.1%), indicating that the model meets standards for pedagogical quality, child development appropriateness, and practical implementation. Third, the AEM model was proven to be significantly effective in improving the aquatic motor skills of young children, with an increase in the score from 48.9% to 71.6% (delta = 22.7 points), supported by the results of the Wilcoxon Signed-Rank Test ($p < 0.001$)

and a large effect size (Cohen's d = 1.23). This study offers two main contributions: theoretically, it produces the Aquatic Eduplay Model conceptual framework, which integrates Gallahue's motor development theory with Vygotsky's ZPD principles within the context of early childhood aquatic learning—a synthesis previously unexplored in the Indonesian literature; practically, this study produces a ready-to-use implementation guide for ECE teachers, swimming coaches, and managers of children's sports institutions.

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Conflict of interest

No conflicts of interest to declare.

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