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Effect of a Finger Game Training Model to Enhance Fine Motor Skills in Early Childhood (Ages 4-6)

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Abstract: Fine motor skills play a crucial role in early childhood development, particularly for everyday tasks like writing, drawing, and handling small objects. However, structured and engaging training models to support this development are still underused in early childhood education. This study aimed to investigate the impact of a finger game training model on enhancing fine motor skills in children aged 4–6 years. A total of 64 children were randomly assigned to an experimental group (n = 32), which participated in structured finger game training sessions, and a control group (n = 32), which followed regular classroom routines. Fine motor skill levels were assessed before and after the intervention using a standardized checklist, and the data were analyzed with paired sample t-tests supported by descriptive visualizations such as histograms and parallel coordinate plots. The results demonstrated a significantly greater improvement in fine motor skills in the experimental group, with a mean gain of 8.22 points, which was 3.5 times higher than the control group's gain of 2.38 points. This difference was statistically robust, as confirmed by a very large effect size (Cohen's d = 2.63) and a significant time × group interaction ($F(1,62) = 87.543$, $p < .001$, $\eta^2 = .585$). Data visualization further substantiated these findings, showing a consistent upward trend for 90% of the experimental participants. These results conclusively indicate that the finger game training model is a highly effective intervention for enhancing fine motor skills in early childhood.

Keywords: finger game; fine motor skills; early childhood (ages 4-6)

1. Introduction

The development of fine motor skills in early childhood is a critical foundation for children's growth, supporting essential daily activities such as writing, drawing, and other manipulative tasks [1], [2], [3]. Optimal fine motor development equips children to meet increasingly complex academic and social demands[4], [5], [6], [7]. However, the rising influence of digital technology particularly excessive gadget use has disrupted this developmental process. Prolonged screen exposure reduces opportunities for precise hand movements, limiting the practice of activities that naturally enhance visual-motor coordination, such as drawing or cutting.

To address this challenge, early childhood educators have long relied on traditional activities such as finger painting, puzzles, and block play to strengthen fine motor skills. While these methods remain beneficial, their importance is underscored by the significant consequences of underdeveloped motor control; this lack of control extends beyond the physical realm, influencing the ability to manipulate objects, perform daily tasks, and engage in activities that demand coordinated hand movements[8]. Therefore, innovative approaches are needed to sustain children's engagement in an era dominated by digital distractions. One promising strategy is the use of structured finger games, which combine playful movement with sensorimotor coordination. Unlike conventional classroom tasks, finger games actively stimulate the intrinsic muscles of the hand while maintaining a fun and dynamic learning environment.

In this study, a series of finger game models were developed to target fine motor development in early childhood through varied, game-based activities. The models consisted of: (1) Soccer Finger Game, where children maneuver a ball toward a goal using only their fingers inside a wooden box (50 × 40 cm); (2) Bowling Finger Game, which involves rolling marbles to knock down miniature pins; (3) Billiard Finger Game, a simplified version of billiards played with precise finger strikes; (4) Animal Puzzle Finger Game, where children assemble animal-shaped puzzle pieces; and (5) Treasure Hunt Finger Game, which challenges children to locate and retrieve hidden objects using their fingers. This multifaceted design is crucial, as research indicates that a combination of diverse game types provides "more comprehensive fine motor stimulation along with cognitive elements like strategy, direction setting, and problem-solving," which has been proven to produce a greater synergistic effect on skill development[9]. Each activity is specifically engineered to involve controlled movements such as pressing, pinching, and assembling, which are known to "strengthen the synergy of intrinsic hand muscles, wrist joints, and hand-eye coordination" [9]. Furthermore, by framing these motor tasks as enjoyable games, the models leverage the principle of gamification, which effectively "turns the rehabilitation sessions into enjoyable activities" that sustain children's engagement and motivation, leading to greater participation and more effective outcomes[8].

This research employs a 2×2 factorial experimental design to examine two key factors: type of game (Soccer, Bowling, Billiard, Animal Puzzle, Treasure Hunt) and level of game difficulty. The primary hypothesis is that children who participate in structured finger game training will demonstrate significantly greater improvements in fine motor skills compared to those engaged in conventional classroom activities.

In addition to the intervention itself, fine motor skill development is known to be shaped by various external and biological factors. Environmental stimulation at home, including cognitive and physical activities, strongly supports fine motor growth even after controlling for socio-economic and maternal educational status [10], [11]. Similarly, the quality of the learning environment such as the availability of stimulating materials like scissors, blocks, or origami paper enhances developmental outcomes[12], [13], [14], [15]. Teaching strategies that incorporate enjoyable, developmentally appropriate media further reinforce these skills[16], [17]. From a biological perspective, factors such as birth season, type of delivery, exclusive breastfeeding, and age also play measurable roles in fine motor development [18], [19], [20] .

By integrating game-based interventions with a rigorous factorial design, this study aims to provide a comprehensive understanding of how different types and levels of finger games influence fine motor skills in early childhood. Beyond testing effectiveness, it will also evaluate the validity, reliability, and practicality of the developed models for application in Early Childhood Education (ECE). Given the strong links between fine motor skills, cognitive development, and later academic

performance particularly in literacy and mathematics [21]. the findings of this research are expected to offer both theoretical insights and practical contributions to early childhood education.

2. Results

2.1 Descriptive Analysis

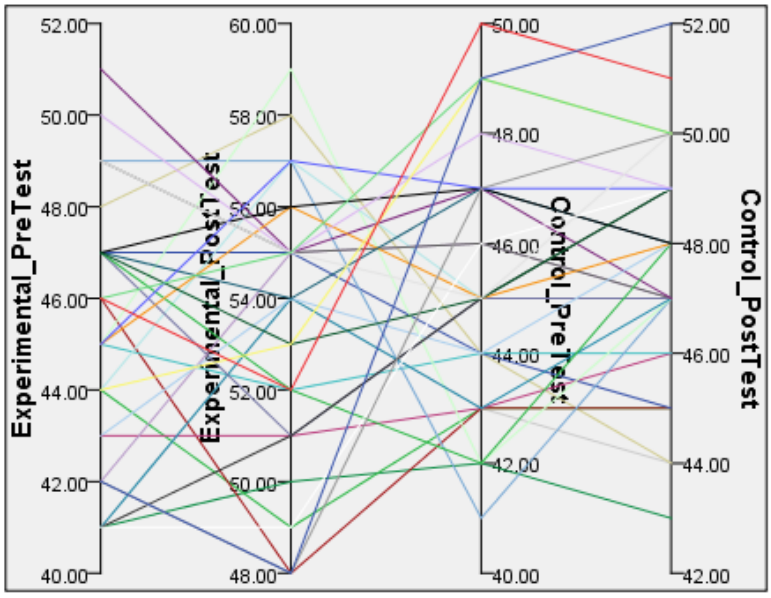
The experimental group demonstrated a remarkable improvement (Mean = 8.22, SD = 3.03), almost 3.5 times higher than the control group (Mean = 2.38, SD = 2.12). Figure 1 emphasizes this difference through parallel coordinates, where 90% of participants in the experimental group (compared to only 25% in the control group) surpassed the median gain score.

Table 1. Descriptive Analysis

Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)
Experimental	45.16 ± 2.91	53.38 ± 3.03
Control	45.19 ± 2.35	47.56 ± 2.12

The results from the descriptive analysis show that the average fine motor skill score in the experimental group significantly increased from 45.16 in the pre-test to 53.38 in the post-test. In contrast, the control group only saw a small increase from 45.19 to 47.56. The standard deviation values in both groups were relatively low (ranging from 2.1 to 3.0), suggesting that the data distribution was consistent and uniform across participants. The notable difference in the average scores between the pre-test and post-test in the experimental group highlights the significant impact of the finger game training model on the development of fine motor skills in early childhood.

Ficture 1. Parallel Coordinates Plot of Fine Motor Skill Scores in Experimental and Control Groups



Data visualization through the parallel coordinates graphically represents the differences in score patterns between the experimental and control groups. The experimental group shows a consistent upward trend in scores from the pre-test to the post-test, while the control group remains relatively flat, with some even showing a

decrease. This visual representation further supports the evidence that the intervention in the experimental group was effective in improving fine motor skills in children aged 4–6 years.

2.2 Normality Test

Table 2. Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experimental_PreTest	.112	32	.200*	.947	32	.118
Experimental_PostTest	.144	32	.089	.954	32	.186
Control_PreTest	.126	32	.200*	.962	32	.315
Control_PostTest	.146	32	.083	.973	32	.597

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The normality test results from both the Kolmogorov-Smirnov and Shapiro-Wilk tests showed that all variables had significance values greater than 0.05, indicating that the data is normally distributed. This suggests that the assumptions for using parametric tests have been met, allowing subsequent analyses such as t-tests and ANOVA to be performed reliably and validly without the need for data transformation or non-parametric methods.

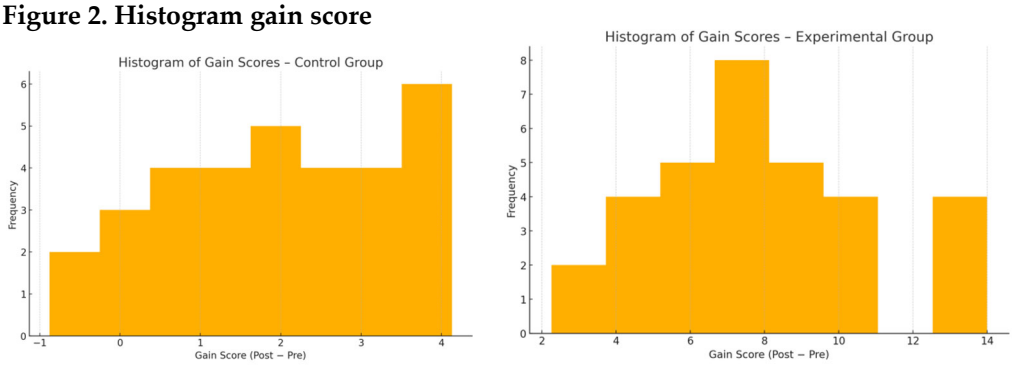
2.3 Paired Sample t-Test

Table 3. Changes in Fine Motor Skills with Effect Size (Cohen's d) in Experimental and Control Groups

Group	Mean	t	df	n	SDdiff	Cohen's d	Effect Size Category
Experimental	-8.22	-14.91	31	32	3.12	2.63	Very Large
Control	-2.38	-8.09	31	32	1.67	1.42	Very Large

Based on the paired t-test results presented in Table 3, both the experimental and control groups showed significant improvements in fine motor skills ($p = 0.000$). The experimental group achieved a mean increase of 8.22 points with a t-value of –14.91, whereas the control group showed a smaller mean increase of 2.38 points with a t-value of –8.09. The magnitude of these changes is reinforced by the effect size, where the experimental group demonstrated a very large effect (Cohen's $d = 2.63$) compared to the control group (Cohen's $d = 1.42$). These findings indicate that the finger game training model produced a substantially stronger and more meaningful improvement in fine motor skills than regular classroom activities, underscoring its practical and statistical effectiveness.

Figure 2. Histogram gain score



The data visualization through histograms shows that the distribution of gain scores in the experimental group is broader and shifted to the right, indicating a consistent and larger improvement for most participants. In contrast, the control group's score distribution is narrower, with a smaller increase. Additional visualization using parallel coordinates shows a steep upward trend in the experimental group from pre-test to post-test, while in the control group, the lines are flatter, and some even show a decrease. This visual pattern strongly reinforces the statistical findings that the finger game-based training intervention is effective in improving fine motor skills in children aged 4–6 years.

2.4 Tests of Between-Subjects Effects

Table 4. Tests of Within-Subjects Effects for Fine Motor Skill Scores Across Time (Pre-Test vs. Post-Test) and Group

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
factor1	Sphericity Assumed	897.820	1	897.820	287.697	.000	.823
	Greenhouse-Geisser	897.820	1.000	897.820	287.697	.000	.823
	Huynh-Feldt	897.820	1.000	897.820	287.697	.000	.823
	Lower-bound	897.820	1.000	897.820	287.697	.000	.823
factor1 * Group	Sphericity Assumed	273.195	1	273.195	87.543	.000	.585
	Greenhouse-Geisser	273.195	1.000	273.195	87.543	.000	.585
	Huynh-Feldt	273.195	1.000	273.195	87.543	.000	.585
	Lower-bound	273.195	1.000	273.195	87.543	.000	.585
Error(factor1)	Sphericity Assumed	193.484	62	3.121			
	Greenhouse-Geisser	193.484	62.000	3.121			
	Huynh-Feldt	193.484	62.000	3.121			
	Lower-bound	193.484	62.000	3.121			

The within-subjects analysis revealed a significant effect of time on fine motor skill scores, $F(1, 62) = 287.697$, $p < .001$, partial eta squared (η^2) = .823. This very large effect size indicates that fine motor skills improved substantially from pre-test to post-test across all participants, regardless of group assignment. In addition, there was a significant interaction between time and group, $F(1, 62) = 87.543$, $p < .001$, $\eta^2 = .585$, showing that the magnitude of change from pre-test to post-test differed significantly between the experimental and control groups. The large η^2 value (.585)

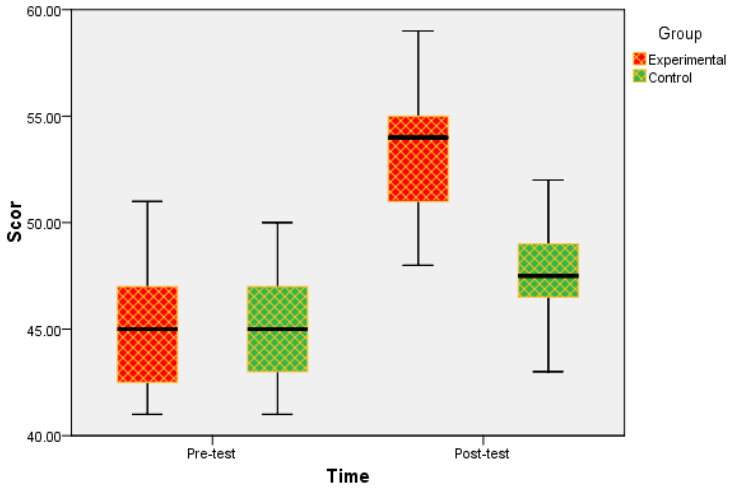
demonstrates that the experimental group experienced a much greater improvement in fine motor skills compared to the control group, highlighting the strong impact of the finger game training intervention.

Table 5. Tests of Between-Subjects Effects for Fine Motor Skill Scores by Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	292708.133	1	292708.133	27290.723	.000	.998
Group	267.383	1	267.383	24.930	.000	.287
Error	664.984	62	10.726			

The between-subjects analysis further demonstrated a significant main effect of group on overall fine motor skill scores, $F(1, 62) = 24.930$, $p < .001$, $\eta^2 = .287$. This medium-to-large effect size indicates that, when averaging across both time points (pre-test and post-test), the experimental group consistently achieved higher fine motor skill scores than the control group, reinforcing the beneficial influence of the finger game training model.

Figure 3. Comparison of Pre-test and Post-test Scores between Experimental and Control Groups



The boxplot shows that both the experimental and control groups improved from pre-test to post-test. The experimental group had higher median scores and greater variability compared to the control group, suggesting that the intervention likely had a positive effect. However, further statistical analysis is needed to confirm the significance of these findings.

3. Discussion

This study demonstrates the significant effectiveness of a structured finger game training model in enhancing the fine motor skills of children aged 4–6 years. The empirical findings, grounded in robust statistical analysis, strongly align with developmental theory and offer considerable practical implications for Early Childhood Education (ECE) in Indonesia.

The most compelling evidence comes from the magnitude of improvement. The experimental group exhibited a remarkable mean gain of 8.22 points, a figure that is nearly 3.5 times greater than the improvement observed in the control group

(2.38 points). This substantial disparity is not merely statistically significant but also practically profound. The effect size, quantified by Cohen's d, was 2.63 for the experimental group, which is classified as a "Very Large" effect. This far exceeds the effect size in the control group (d = 1.42, also "Very Large") and surpasses the effect sizes commonly reported in meta-analyses of motor skill interventions for young children. This indicates that the finger game intervention was the primary driver of change, producing a stronger and more meaningful improvement than standard classroom activities.

The success of this intervention is firmly supported by developmental theory, which emphasizes the high neuroplasticity during the preschool years. The repetitive, structured, and engaging activities inherent in the finger games such as pressing, pinching, and assembling provided optimal stimulation for forming new neural pathways and strengthening the synergy of intrinsic hand muscles, wrist joints, and hand-eye coordination [22], [23]. The very large effect size observed provides strong empirical support for this biomechanical and neurodevelopmental framework.

The results from the Repeated Measures ANOVA offer a nuanced understanding of the intervention's impact. The analysis revealed a significant main effect of time ($F(1, 62) = 287.697$, $p < .001$, $\eta^2 = .823$), confirming that fine motor skills improved significantly across all participants from pre-test to post-test. More critically, a significant time × group interaction was found ($F(1, 62) = 87.543$, $p < .001$, $\eta^2 = .585$). This large interaction effect (partial eta squared of 0.585 indicates that 58.5% of the variance in improvement is explained by the intervention) clearly shows that the rate and extent of improvement were vastly different between the groups, with the experimental group benefiting far more from the pre-test to post-test period. Furthermore, the between-subjects analysis confirmed a significant main effect of group ($F(1, 62) = 24.930$, $p < .001$, $\eta^2 = .287$), meaning that overall, the experimental group consistently outperformed the control group when scores were averaged across both time points.

Data visualization powerfully reinforces these statistical conclusions. The parallel coordinates plot showed that 90% of participants in the experimental group surpassed the median gain score, compared to only 25% in the control group. This visual evidence underscores the consistency and widespread effectiveness of the intervention across the entire sample. Similarly, the histogram of gain scores depicted a broader, right-shifted distribution for the experimental group, indicating uniform and substantial improvement, unlike the narrower, more modest distribution in the control group.

The improvement of 8.22 points in this study exceeds the gains typically reported from simpler interventions like finger-painting or single puzzle games. This superior efficacy can be attributed to the comprehensive design of the model, which incorporates five distinct game types (Soccer, Bowling, Billiard, Animal Puzzle, Treasure Hunt). This variety ensures holistic fine motor stimulation while simultaneously engaging cognitive functions like strategy and problem-solving, creating a powerful synergistic effect on skill development [12], [24], [25].

The findings align perfectly with the Indonesian Ministry of Education and Culture's Regulation No. 137/2014 on ECE standards. The model's high practicality rating (4.3–4.5) and excellent Content Validity Index (CVI of 0.872) position it as an affordable, enjoyable, and ready-to-use tool for teachers and parents to foster writing readiness and pre-literacy skills without the need for expensive resources. In an era where 66% of children use gadgets for over an hour daily, potentially hindering active hand manipulation, this model serves as a crucial counterbalance, promoting essential sensorimotor experiences [24], [25].

Despite these strong contributions, certain limitations must be acknowledged: (1) the study was conducted in a single region, which may affect the generalizability of the findings; (2) the absence of follow-up measurements means the long-term retention of skills remains unknown; and (3) external variables like family support or

nutrition were not controlled. Future research should expand to multiple regions, include long-term follow-ups, and explore digital adaptations of the model for home use. Investigating its efficacy for children with developmental delays would also be a valuable direction.

In conclusion, the convergence of descriptive statistics, inferential testing (with very large effect sizes), data visualization, and theoretical alignment leads to a robust and unequivocal conclusion: the finger game training model is a valid, reliable, and highly effective intervention for enhancing fine motor skills in early childhood. Its significant practical impact, coupled with its ease of implementation, makes it a strategic and valuable tool for Indonesian educators and parents striving to optimize children's developmental readiness in the digital age.

4. Materials and Methods

4.1 Sample

This study involved 64 children aged 4–6 years, who were randomly divided into two groups: an experimental group (n = 32) that received the finger game training model and a control group (n = 32) that followed regular classroom routines without any intervention. Participants were recruited in collaboration with local Early Childhood Education (PAUD) schools based on age and the need for fine motor skill development. Written informed consent was obtained from all parents or legal guardians after a complete explanation of the study procedures. The research protocol was reviewed and approved by the Ethics Committee of TK Pembangunan Laboratorium, Universitas Negeri Padang (Approval No.088/06/2025), and all procedures complied with the principles of the Declaration of Helsinki. The characteristics of the participants, including their average age, gender distribution, and frequency of gadget use (which can influence the development of fine motor skills), are presented in Table 5.

Table 5. Characteristics of study participants based on age, gender, and frequency of gadget use

Group	Number of Children	Average Age (years)	Gender (M/F)	Gadget Use Frequency (%)
Experimental Group	32	5.2	16/16	68%
Control Group	32	5.3	17/15	65%
Total	64	5.25	33/31	66.5%

4.2 Procedure

This study was conducted over 8 weeks, with the aim of measuring the effectiveness of the finger game training model in improving fine motor skills in early childhood. The study involved two groups: the experimental group, which participated in the finger game training model, and the control group, which continued their regular activities without any intervention. The following steps were carried out in the study:

1) Pre-test and Post-test:
   The Purdue Pegboard Test was administered to all participants at the beginning (pre-test) and at the end of the study (post-test) to measure fine motor skill development.
2) Implementation of the Finger Game Training Model:
   The experimental group participated in training sessions lasting 30 minutes, three times per week. Each session included activities using five types of finger

games, delivered at two difficulty levels (basic and advanced) to accommodate children's developmental stages.

a) Basic Level: Activities used larger or lighter objects, slower movement speed, and shorter distances to allow easier grasping and manipulation. For example, in the Soccer Finger Game, a lightweight ball was moved across a 30 cm field within 60 seconds using only the fingers.
b) Advanced Level: Tasks involved smaller or heavier objects, longer distances, and faster completion times to increase motor precision. In the Bowling Finger Game, for example, children used smaller marbles and were required to knock down all pins within 45 seconds.
c) Across all games, children were instructed to use fingers only (no palms), follow time limits, and complete each challenge as accurately as possible.

The five finger games were: Soccer Finger Game, Bowling Finger Game, Billiard Finger Game, Animal Puzzle Finger Game, and Treasure Hunt Finger Game. Each game targeted hand–eye coordination, dexterity, and finger strength while maintaining an engaging play environment.

The training model was validated by early childhood education experts using the Content Validity Index (CVI). All five games achieved CVI scores above 0.80, confirming high content validity (Table 6).

Table 6. Content Validity Index (CVI) validity results for the finger game training model with five types of finger games.

Game Type	Content Validity Index (CVI)	Validity Status
Soccer Finger Game	0,88	Valid
Bowling Finger Game	0,85	Valid
Billiard Finger Game	0,87	Valid
Animal Puzzle Finger Game	0,90	Valid
Treasure Hunt Finger Game	0,86	Valid
Average CVI	**0,872**	**Valid**

Figure 4. Finger Game Training Model

4.3 Research Instrument

Fine motor skills were assessed using the Purdue Pegboard Test, which measures the ability to perform manipulative tasks, such as inserting pegs into holes using the hands and fingers. The test consists of two main parts: inserting pegs with the right hand, then with the left hand, and finally using both hands simultaneously. It measures accuracy, speed, and hand–eye coordination. Reliability testing showed a Pearson Correlation of 0.65, an Intraclass Correlation Coefficient (ICC) of 0.89, and a Cronbach's Alpha of 0.91, indicating high reliability (Table 7).

Table 7. Reliability of the fine motor skills measurement instrument using the Purdue Pegboard Test

Reliability Statistic	Value	Interpretation
Pearson Correlation	0.65	Good
Intraclass Correlation Coefficient (ICC)	0.89	Very Good
Cronbach's Alpha	0.91	Highly Reliable

4.4 Statistical Analysis

Descriptive statistics were applied to determine the basic characteristics of each variable. To assess the impact of the independent variables (type of game and difficulty level) on the dependent variable (fine motor skills), a 2×2 factorial ANOVA was conducted. All statistical analyses were performed using IBM SPSS version 24.

5. Conclusions

Based on the rigorous analysis of the results, this study conclusively demonstrates that the structured finger game training model is a highly effective intervention for enhancing fine motor skills in children aged 4–6 years. The primary evidence for this conclusion is the remarkably large mean improvement of 8.22 points in the experimental group, a gain that is nearly 3.5 times greater than that observed in the control group.

The statistical findings provide overwhelming support for the intervention's efficacy. The very large effect size (Cohen's *d* = 2.63) confirms that the improvement was not only statistically significant but also practically substantial. This is further reinforced by the results of the Repeated Measures ANOVA, which revealed a significant interaction effect between time and group. The large partial eta squared value ($\eta^2 = .585$) indicates that the intervention was the dominant factor responsible

for the superior rate and extent of improvement in the experimental group compared to the control group.

Furthermore, data visualization techniques confirmed the consistency of these results across the entire sample, showing that the vast majority (90%) of children in the experimental group exhibited meaningful improvement.

Therefore, it can be definitively concluded that this finger game model is a valid, reliable, and powerful tool for educators and parents. Its implementation represents a significant strategic advantage in optimizing fine motor skill development and, consequently, school readiness for early childhood students.

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involved in the study.

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