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THE APPLICATION PERFORMANCE OF STRUCTURED MOVEMENT TRAINING IN CALLIGRAPHY INSTRUCTION

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ABSTRACT

This study aims to explore the effects of structured movement training on novice calligraphy skills and learning psychological factors. Using a quasi-experimental design, independent samples t-tests were conducted to compare the differences in technical indicators and survey results between the experimental group (which received systematic movement training) and the control group (which underwent traditional teaching). In terms of methodology, the experimental group engaged in a systematic movement training program that included modules on posture correction, muscle activation, and stroke decomposition. This training also incorporated "breath-action-stroke" rhythmic training and cognitive-behavioral feedback strategies, while the control group received conventional instruction. The results indicated that the experimental group significantly outperformed the control group in most technical indicators of strokes (such as force, rhythm, and path accuracy) with P-values less than 0.05 or 0.01. Additionally, the experimental group showed clear advantages in five dimensions: learning motivation, skill improvement, teaching practicality, participation satisfaction, self-efficacy, and transfer ability. The discussion suggests that structured movement training, through progressive teaching and cognitive-physiological collaborative intervention, effectively enhances the stability, coordination, and expressiveness of writing movements. This validates its empirical effectiveness in Chinese calligraphy education and provides a theoretical basis and practical pathways for future calligraphy teaching.

KEYWORDS: Movement Training, Application Performance, Calligraphy.

1. INTRODUCTION

In China, calligraphy has been revered for over 2,000 years as a core component of cultural heritage, embodying both aesthetic and philosophical significance. It expresses aesthetic value through rhythmic lines and explores human emotion through poetic metaphor (Tregear, 1980). The accumulation of techniques across generations has formed a rich and systematic approach to brushwork, incorporating methods such as lifting, pressing, pausing, and turning. Classical concepts like "cone carving in sand" and "leaking trace" reflect a deeply embodied aesthetic (Zhu, T., 2015).

Since ancient times, calligraphy has been integral to education, serving both practical and artistic purposes. It was considered essential for civil service and self-cultivation, especially within the imperial examination system (Bai, Q., 2015). Moreover, it incorporates philosophical ideas from Confucianism, Buddhism, and Taoism, embodying profound cultural meaning. As calligraphy educator Shen Yimo noted, calligraphy transcends visual form to evoke spiritual and emotional resonance "colorless yet splendid as painting, soundless yet harmonious as music" (Shen, Y., 1980).

In modern higher education, calligraphy remains highly valued. It is offered as a major in 69 universities and as a public elective in many more (Peng, M. & Zhang, 2022). National policies, such as the 1999 guideline issued by the Central Committee of the Communist Party of China and the State Council, emphasize the importance of arts and humanities education for cultivating aesthetic capability. Public calligraphy courses often align with the Guidelines for Primary and Secondary Calligraphy Education, focusing on technique, model copying, and appreciation to strengthen pedagogical competence (Li, W.L., 2018).

Calligraphy education plays a unique role in fostering comprehensive humanistic qualities among university students. It interconnects with poetry, painting, music, and dance, forming what Fu Baoshi described as "the fundamental source of Chinese art." Furthermore, it facilitates emotional expression as captured in the Confucian idea that "poetry articulates intent" enabling learners to convey inner feelings through abstract yet expressive lines (Huang, J., 1979). It also bridges art and daily life, seen in practices such as writing Spring Festival couplets and incorporating calligraphy into modern design, thereby strengthening community interaction and aesthetic engagement.

The traditional master–apprentice teaching model remains central to calligraphy instruction, emphasizing demonstration, individualized feedback, and embodied transmission of technique. However, university courses often face constraints: limited class time (e.g., 100-minute sessions), large class sizes, and students' entrenched writing habits formed early in life. These issues highlight the need for pedagogical innovation.

This study focuses on students with no prior calligraphy experience and examines how instruction centered on writing gestures informed by holistic bodily movement as noted by Billeter (1990) and Lady Wei's emphasis on "full strength of the entire body" (Cui, E., 2015) can help correct structural errors, accelerate skill acquisition, and improve learning efficiency. By emphasizing physical awareness and gesture-based practice, this approach aims to enhance engagement and outcomes in calligraphy education.

1.1. Population and Sample

Population: As a key regular university in Guangdong Province, Hanshan Normal University has a typical teacher training system. Second-year full-time undergraduate students were selected because this group is at a critical transition stage in the development of their teaching skills. They have an urgent need for training in teaching skills, and their calligraphy learning trajectory clearly reflects the entire process from skill acquisition to teaching application. The characteristics of this population are highly comparable to those of similar normal universities nationwide, and the research conclusions have generalize value. The second year is a critical juncture in the professional development of teacher education students: cognitively, they have developed preliminary aesthetic judgment in calligraphy; skill-wise, they possess the ability to copy but have not yet solidified their writing habits; pedagogically, they begin to transform calligraphy techniques into teachable content, making this an ideal window period for observing the effects of calligraphy education interventions. Selecting a group of students from the same grade effectively controls variables such as age, years of study, and course structure. The college's unified calligraphy course standards (two class hours per week) provide a standardized backdrop for the research, minimizing external interference. This group will directly enter the field of basic education in the future, and their calligraphy literacy directly impacts the quality of calligraphy education in primary and secondary schools. By studying their skill development patterns, this research provides empirical evidence for calligraphy curriculum

reform in teacher training institutions, holding significant educational practical value.

Sample: Quasi-experimental student sample Undergraduate second-year Normal students of Hanshan Normal University: Full-time undergraduate second-year regular program students of the 2022 cohort at Hanshan Normal University in Chaozhou, Guangdong Province, totaling 2,521 students. The sample size required in the study was analyzed using the power package in R. The preset presence of a medium effect size f = 0.5 (Cohen, 1988), statistical test power 1- β = 0.95, and significance level α = 0.01 indicated that at least 78 participants are needed, requiring no history of fracture, trauma, tendon injury, or nerve damage to the arm, no congenital deformities of the arm, fingers, or hand. There were no neuromuscular or skeletal-muscular disorders; joint mobility (range of motion, ROM) was within the normal range. All of them were right-handed (recurved thumb, genetically recessive trait). Students will be required to sign an informed consent form and confirm that they have not received any relevant calligraphy training prior to participation（Table 1）.

Table 1: Sample Criteria.

Sample classification	Sample Standards
Professional background	Science students: Physics class 2022160011; Liberal Arts students: Chinese International Education Class 20222140321;Art students: Fine Arts 2022080112 class
Sample size	78 (39 boys, 39 girls)
Selection method	Random sampling: randomly selected from different majors in a grade to ensure a representative sample. Stratified sampling: stratification based on factors such as specialization to gain a more comprehensive perspective.
Fundamentals of Calligraphy	Confirmation that all sample participants were not grounded in calligraphy ensured the relevance of the study
Source: Huang Baorong (2024)	

1.2. Research Tools

Description: To rigorously evaluate the effectiveness of movement-based training interventions on beginner calligraphy learners, this study implemented a quasi-experimental design. The procedure was systematically divided into the following stages:

1. Participant recruitment and grouping A total of 78 undergraduate students enrolled in foundational calligraphy courses were recruited. Participants were stratified by gender, major, and grade level, and randomly assigned to: Experimental group (n = 39): Received traditional instruction and targeted movement training. Control group (n = 39): Received traditional instruction only. All participants signed informed consent forms prior to participation.

2. Pre-test (baseline assessment) Participants completed a standardized calligraphy copying task, including eight basic brushstrokes (dot, horizontal, vertical, hook, etc.), and one Regular Script character selected from classical models. The previous test paper was the Chinese character writing course exam paper for Hanshan Normal University, which experts assessed. Experts generally agree that this test question aligns with core themes such as 'calligraphy writing tests' and is highly consistent with the research objectives. The questionnaire has passed the International Olympic Committee (IOC) and Cronbach's alpha coefficient tests（Table 2）, meeting the standards for academic research tools. It can be directly used for data collection without further revision.

Table 2: Expert Evaluation of Reliability Testing.

	Cronbach's Alpha Terms	Item Count
Survey statistics	0.956	9
Source: Huang Baorong (2024		

3. Intervention implementation (6 Weeks) The experimental group received movement training designed based on ergonomic and calligraphy principles: Posture correction drills, upper limb muscle activation exercises, brushstroke simulation routines, and rhythm and flow coordination tasks, integrated into regular calligraphy classes. The control group continued with standard calligraphy instruction based on the syllabus, with no additional **intervention.**

4. Post-test assent After the intervention period, both groups completed the same calligraphy copying task as in the pre-test. Experts re-evaluated the writing samples under the same conditions and rubric.

5. Subjective feedback collection To complement the quantitative assessment of training effectiveness, a structured feedback mechanism was designed to capture participants' subjective experiences during the intervention process. The goal was to better understand learners' psychological engagement, perceived value of the training, and areas for improvement in future instructional design. After all participants in the experimental group and control group completed the test, they were each given a structured questionnaire. The questionnaire consisted of five sections, each using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), accompanied by open-ended questions for qualitative analysis. The questionnaire dimensions were as follows: motivation for learning calligraphy, perceived improvement in writing skills, clarity and

practicality of training movements, participation and satisfaction, and self-confidence and transfer ability. The specific implementation process was as follows: Step 1: Develop the research questionnaire model. Step 2: Develop the IOC plan for the assessment questionnaire. Step 3: Submit the developed assessment questionnaire and IOC plan to the thesis supervisor for review of accuracy and applicability, and revise and improve as needed. Step 4: Based on the supervisor's suggestions, submit the revised questionnaire IOC plan to five experts for evaluation, including three professors in the field of art research and two doctoral students, to assess the project objective consistency index. The reliability test of interviews is primarily used to evaluate the reliability or stability of interviews. This study primarily employs the overall consistency analysis of the indicator system to calculate Cronbach's alpha coefficient. When Cronbach's alpha coefficient is greater than 0.7, the scale is considered to meet reliability requirements. As shown in the table, all reliability coefficients are above 0.7, indicating that the questionnaire's reliability meets the requirements. The results indicate that the α coefficients for all dimensions and the overall questionnaire are higher than 0.80, demonstrating high reliability, which suggests that the scale is stable and reliable in measuring subjective experiences in calligraphy learning.

6. Data analysis and interpretation, we conducted a descriptive statistical analysis of the pre- and post-test data for the experimental group and the control group, including indicators such as mean, standard deviation (SD), and range. This step aimed to gain an initial understanding of the overall performance trends and data distribution of the two groups before and after the intervention. An air-sample T-test was conducted on the experimental group to compare the differences in writing assessment scores before and after the intervention, verifying whether the training movements significantly improved students' writing ability. This test can explore whether the movement training produced substantial changes at the individual level of the participants. An independent-sample T-test was used to compare the post-test data of the experimental group and the control group to explore whether there were significant differences between the two teaching strategies (traditional teaching vs. traditional teaching and movement training), thereby further validating the effectiveness of the intervention strategy.

2. DATA COLLECTION

This stage combines traditional teaching with movement training to improve beginners' posture control, stroke stability, and muscle coordination. Before and after the intervention, writing performance tests were conducted on the experimental and control groups, and teacher scores and student feedback questionnaires were analyzed. The assessment included writing fluency, structural accuracy, posture improvement, and changes in learning motivation, using quantitative and qualitative methods to crossvalidate the results.

1. Time and location of the experiment starting from the course schedule, the calligraphy course spans six weeks, following the curriculum guidelines to teach traditional calligraphy writing techniques, interspersed with action training exercises to ensure the completion of the course content. Based on the course schedule, this study employs a teaching experiment divided into a control group and an experimental group. One group uses traditional calligraphy teaching methods in instruction, while the other group combines action training teaching methods with traditional calligraphy teaching methods. Both groups were consistent in terms of traditional teaching methods, organizational form, and teaching hours (12 hours), with other aspects remaining essentially unchanged. The action training intervention was conducted from 5 September to 14 October 2024, lasting six weeks. Training sessions were held three times per week, each lasting 10 minutes, with training times scheduled during class and after class (ideally every other day). The experimental location was the calligraphy classroom at Hanshan Normal University. The pre-test was conducted from September 3rd to 4th, 2024, and the post-test was conducted from October 15th to 16th, 2024.

2. Control of experimental conditions Control during the pre-experimental preparation phase (control of experimental subjects and teachers). The experimental subjects were randomly selected, with both classes having students of similar baseline levels. Height and weight were measured for each participant. Writing posture and the execution of the eight basic strokes serve as the independent variables for training. Therefore, prior to the experiment, both the experimental and control groups were tested on the eight basic strokes. The average test results of the writers were used for analysis. The subject teachers were assigned by the researcher, who strictly controlled the teaching quality and progress of both classes. Control of the teaching implementation phase in the experiment. The teaching implementation phase began on 5 September 2024,

with instruction starting simultaneously for the experimental and control groups. The teaching syllabi, lesson objectives, preparatory activities, teaching methods, time allocation, and total teaching duration for both groups are identical. Classroom records will be prepared for each lesson to ensure teaching control. Post-lesson summaries will be conducted, including practical issues encountered during writing exercises, with timely adjustments made to address any problems, ensuring the comprehensive and effective implementation of the action teaching method in instruction. Control of teaching objectives. To enable students to establish correct socialist core values and artistic perspectives. To master the basic techniques and norms of calligraphy, including brushwork, structure, and composition, and acquire the relevant knowledge and skills for educational practice. The goal is to develop aesthetic appreciation, cultural understanding, comprehensive literacy, and creative abilities in calligraphy. These are the teaching objectives of the calligraphy course at Hanshan Normal University, and the objectives for both the experimental and control classes are the same. Control of teaching content. The focus of this study is on the teaching methods of calligraphy in higher education institutions in general. The curriculum and teaching content are mainly determined according to the actual situation of the institutions. The experimental school has 20 years of experience in teaching calligraphy. According to the syllabus of the calligraphy course, this study chooses the fundamental stroke training part as the experimental teaching content, and the teaching content of the control class and the experimental class is the same. Control of teaching methods. The conventional teaching methods used in the control class were explanation and demonstration. In the experimental class, in addition to action training, the other teaching methods used were similar to those in the control class. Both classes followed the duplicate teaching content, schedule, and assessment criteria to ensure consistency. This design aimed to isolate the effect of the action training intervention by minimizing other instructional differences. Control of teachers' instruction, students' learning, and class density. Teachers' instruction and students' learning are the primary factors influencing teaching effectiveness. In classroom instruction, the author controlled various time segments to reflect the basic situation of teachers' instruction and students' learning. The preparation, main, and conclusion segments of the lessons in both the experimental and control classes had similar duration. In the experimental class, students conducted action exercises during the central segment of the lesson. The time allocation for each teaching component of the experimental and control classes throughout the entire experiment is shown in Table 3. The comparison of teaching and learning time in the basic component between the control and experimental classes is shown in Table 4. Since any skill is formed through practice, the density of practice for both groups of students must be strictly controlled during the teaching process. The density of the two groups' lessons is shown in Table 4, and the density verification is shown in Table 3.

Table 3: Comparison of Teaching Time for the Basic Part of the Two Classes.

Basic Part (seconds)	N	Experimental Class $\bar{x}$	S	N	Comparison Class $\bar{x}$	S	T	P
The teacher demonstrates, explains, and corrects mistakes	6	1440.0	81.8	6	1368.0	122.5	0.655	>0.05
Teachers led and students practice	6	2344.0	80.1	6	2556.0	127.9	0.018	<0.05
Teacher Organization and Invalid Time	6	236.0	42.2	6	172.0	59.4	0.732	>0.05
Note: * denotes significant difference at P<0.05; ** denotes highly significant difference at P<0.01. Source: Huang Baorong (2024)								

Table 4 Comparison of the Ratio of Practical Time to Total Time.

N	Experimental Class $\bar{x}$	S	Comparison Class $\bar{x}$	S	T	P
6	0.423	0.148	0.473	0.237	0.026	<0.05

As shown in Table 4, there were significant differences between the experimental class and the control class in terms of teacher guidance and student practice time, as well as lesson density in the fundamental teaching component. The main reason for this difference was that the experimental class used action training methods in the fundamental teaching component, resulting in significantly less actual practice time for students in the experimental class than in the control class when learning new lessons.

3. Experimental action intervention content The experimental group of students underwent the writing action training developed in this study,

which consisted of three stages: sitting posture training, hand and wrist training, and stroke form action training. Each stage was systematically designed based on bio mechanical principles, with progressive difficulty levels to ensure gradual skill acquisition. The training incorporated visual demonstrations, mirror feedback techniques, and proprioceptive conditioning methods. Special attention was paid to transitioning between different movement patterns to enhance neuromuscular coordination. Due to the differences in training tasks across stages, the training content and methods were arranged differently. Sitting posture action training arrangement. Hand and wrist action training arrangement. Stroke action training arrangement.

4. Control of the teaching environment The venue used was the calligraphy classroom in the Arts Building of Hanshan Normal University. The classroom was equipped with computers, projectors, electronic screens, and calligraphy practice desks (with a distance of 1.5 meters between desks), providing the necessary hardware facilities for calligraphy instruction. All equipment was calibrated weekly to maintain consistency, and the same classroom was used for both groups to eliminate venue-related variables. Both the experimental class and the control class have the same teaching schedule: the first and second periods in the morning (during this time slot, no other courses are held in the building, ensuring a relatively quiet teaching environment).

5. Control of the teaching evaluation phase The primary focus of this experimental yoga programmer's teaching evaluation is the assessment of writing posture and basic stroke techniques. The assessment content includes an evaluation of the eight basic strokes learned by the students, with technical assessments conducted individually. A standardized assessment protocol was developed using a 10-point Likert scale covering five dimensions: posture stability, wrist flexibility, stroke precision, rhythm consistency, and overall coordination. In accordance with the requirements of the Chinese Ministry of Education and calligraphy textbooks regarding sitting posture and pen grip, a writing posture assessment project for university students with no prior experience was designated. The evaluation criteria are based on the calligraphy course grading standards of Hanshan Normal University and the test results of measurement method experts. Following the conclusion of the course, the testing phase will take place from October 15th to 16th, 2024. Students will complete the examination independently. Three calligraphy specialists (not instructors of this experiment) will evaluate students from both classes under identical conditions based on the scoring criteria. The average score from three evaluators will be taken as the final score, and the results of both classes will be compared and analyzed.

3. RESULTS

To evaluate the effectiveness of enhanced calligraphy practice teaching materials, this study combined traditional teaching with movement training to improve beginners' posture control, stroke stability, and muscle coordination. Before and after the intervention, calligraphy performance tests were conducted on the experimental group and control group, and teacher scores and student feedback questionnaires were analyzed. The evaluation content included writing fluency, structural accuracy, posture improvement, and changes in learning motivation, using quantitative and qualitative methods to cross-validate the results. This study aims to evaluate the effectiveness of combining traditional teaching methods with motor training to improve the practice efficiency of beginner calligraphers, with a particular focus on posture control, stroke stability, and muscle coordination. The experimental design involved randomly selecting participants to ensure similar baseline levels, and conducting baseline measurements of height, weight, and writing ability, as well as tests of eight basic strokes prior to the experiment. Participants were divided into an experimental group (using movement training) and a control group (traditional methods), with the experiment lasting six weeks, three times a week, each session lasting ten minutes. During instruction, both groups followed the same curriculum and methods to ensure consistency, with teaching conducted by the same instructor in a dedicated calligraphy classroom to minimize distractions. During the assessment phase, the focus was on writing posture and the execution of basic strokes, evaluated by three independent calligraphy experts. The experimental objectives included enabling students to master basic calligraphy techniques, improve writing posture, cultivate aesthetic and cultural appreciation, and assess changes in learning motivation and participation. Additionally, the study will conduct pre- and post-intervention writing performance tests, using mixed-methods analysis to quantify improvements, and collect student feedback to understand learning experiences and the effectiveness of teaching methods. This structured approach aims to clarify the impact of motor training

and determine its effectiveness in enhancing calligraphy practice among beginners.

1. Analysis of the results of basic writing skills before the experiment Before the experiment began, the height, weight, and age of the students in both groups were subjected to a difference test to ensure the homogeneity of the experiment. To ensure homogeneity of the experiment, the learning outcomes of the experimental and control groups were evaluated before the experiment.As shown in Table 5 above, an independent T-test was conducted on the technical ability indicators of the experimental group and the control group before the experiment. The results indicate that the T-test P > 0.05 for all nine indicators.

Table 5: Writing Ability before the Experiment: Independent Samples T-test.

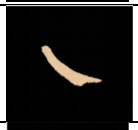
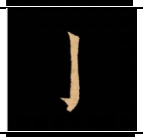
Indicator	Experimental Group	Control Group	T	P
Yoki (basic strokes)	2.600±0.894	2.000±0.707	1.177	0.273
Vertical (basic strokes)	3.200±0.837	2.800±1.304	0.577	0.580
Skimming (basic strokes)	2.600±1.140	2.800±0.837	0.316	0.760
Press (basic strokes)	2.400±1.140	3.200±0.447	1.461	0.182
Dots (basic strokes)	2.800±0.837	2.400±1.140	0.632	0.545
Horizontal folds (basic strokes)	2.000±0.707	2.200±0.837	0.408	0.694
Vertical hook (basic stroke)	3.000±1.000	2.800±0.837	0.343	0.740
Ti (basic strokes)	2.200±0.837	2.800±0.837	1.134	0.290
Yong (monogram)	3.000±1.000	2.600±0.894	0.667	0.524

Therefore, there is no significant difference in technical ability indicators between the experimental group and the control group, indicating that the teaching experiment can proceed. In this study, both the experimental group and the control group consisted of students who were beginners in calligraphy and had not received systematic calligraphy training. Since the students'

understanding and ability to express calligraphy structure, rhythm, and brushstroke patterns were still in their early stages of development, there were no significant differences between the two groups in terms of basic control abilities and stroke execution performance before the implementation of the auxiliary training (experimental group). Overall, the two groups started at a similar level.

2. Analysis of writing results before and after learning in the experimental group Students in the experimental group underwent a 6-week prop-based teaching method training program. Their pre- and post-training performance metrics were then compared using paired-sample T-tests to evaluate the specific learning outcomes of the prop-based teaching method. The results of the data analysis are as follows

Table 7: Pre-test and Post-test Paired Sample T-tests for the Experimental Group.

Indicator		Before the Experiment	After the Experiment	T	P
Yoki (basic strokes)		2.600±0.894	5.600±0.894	5.477	0.005
Vertical (basic strokes)		3.200±0.837	6.600±1.140	4.185	0.014
Skimming (basic strokes)		2.600±1.140	5.800±0.837	8.552	0.001
Press (basic strokes)		2.400±1.140	6.800±1.789	8.629	0.001
Dots (basic strokes)		2.800±0.837	7.400±0.548	18.779	***
Horizontal folds (basic strokes)		2.000±0.707	6.400±1.140	11.000	***
Vertical hook (basic stroke)		3.000±1.000	7.200±0.837	11.225	***
Ti (basic strokes)		2.200±0.837	7.400±0.894	26.000	***
Yong (monogram)		3.000±1.000	7.800±0.8374	24.000	***

Note: * P <0.050, **P<0.010, ***P<0.001
Source: Huang Baorong (2024)

Data Analysis: As shown in Table 7 above, the experimental group students demonstrated significant improvements in their writing skill indicators both before and after the action-based teaching training. The results of paired-sample T-tests on these indicators show that the P-value for vertical strokes in technical ability was P=0.014 < 0.05, indicating a significant difference; the P-values for horizontal strokes, slanted strokes, and horizontal strokes with a hook were 0.005, 0.001, and 0.001, respectively; and the P-values for dots, horizontal folds, vertical hooks, and lifting strokes were all <

0.001, indicating that the experimental group students demonstrated significant differences with the assistance of action training. According to the results of the paired-sample T-test, it can be observed that students in the experimental group demonstrated significant improvements in their writing skills for multiple basic strokes after receiving motion-based training (P values were all < 0.05), indicating that motion training has a positive promotional effect on improving calligraphy performance. This phenomenon can be analyzed from the following aspects: 1) Movement intervention strengthens muscle control and stability The upper limb muscle activation, finger-wrist coordination, and stroke path simulation designed in the movement instruction training effectively improved students' control of small muscle groups and pen tip stability, thereby improving the start and end control, stroke direction, and force balance of strokes, especially in complex strokes such as pressing, sweeping, and dotting. 2) Movement decomposition training enhances stroke structure cognition Through step-by-step movement design of basic strokes such as 'horizontal,' 'vertical,' 'slash,' 'press,' and 'horizontal fold,' students establish clearer stroke writing paths and rhythm. This structured training using movement as a medium reduces the cognitive load of beginners in processing the overall character shape, thereby improving writing consistency and structural clarity. 3) Multi-sensory intervention enhances learning efficiency The training integrates audio-visual guidance, muscle movement, and action rhythm control, enabling students to not only 'understand' and 'hear' during the learning process, but also 'do' effectively.

This perception-action-feedback closed-loop model improves learners' memory efficiency and execution accuracy of stroke movements. 4) Initial optimization of neuromuscular adaptability After systematic training, the experimental group students formed a more efficient motor control pattern, with some writing movements exhibiting expert-like temporal coordination and electromyographic stability. For example, in technical movements such as 'vertical hook' and 'lift,' the control of stroke initiation and termination demonstrated greater rhythm and force, reflecting the preliminary adaptation and optimization of the central motor control system. 5) Enhanced motivational and participatory teaching methods Compared to traditional repetitive demonstration and explanation, action training places greater emphasis on student participation and self-perception. Through kin-esthetic engagement and individualized adjustments, students' sense of involvement in the classroom is enhanced, leading to improved learning motivation and behavioral participation, which in turn positively impacts skill development.

3. Analysis of writing results before and after learning in the control group As can be seen from Table 8, a paired sample T-test was performed on the technical capability indicators of the control group before and after the experiment. The results showed that the P-values for the stroke indicators of the control group were 0.189 and 0.099, respectively, which were >0.05 and did not indicate significant differences. However, the P-values for the seven indicators of horizontal strokes, vertical strokes, horizontal hooks, dots, horizontal folds, lifts, and the character 'Yong' were all <0.05, indicating significant differences. This suggests that the students in the control group showed no significant improvement in stroke extension and back compression before and after the experiment, while all other indicators improved.

1) Traditional teaching still has a positive effect on basic strokes. Although the control group did not receive specialized training, in traditional calligraphy teaching, teachers still guided students through explanation, demonstration, and repeated copying to complete writing exercises for basic strokes such as horizontal, vertical, hook, and dot strokes. These elements are core components of the curriculum, so students can achieve a certain level of improvement through imitation and repetition, leading to significant improvements in these stroke metrics.2) Limited improvement in strokes constrained by motor control ability. Strokes such as the 'vertical hook' (extension) and 'returning stroke' (reverse pressure) are complex, higher-level movements that demand greater coordination between the wrist and fingers, as well as precise control of force and direction.

Since the control group did not undergo targeted movement training, their improvements in muscle coordination, force stability, and movement rhythm were limited, resulting in limited progress in these complex movements. 3) Teaching focus may not have covered high-difficulty movements in traditional teaching; teachers typically place greater emphasis on basic requirements, such as clear structure and steady brushwork, while systematic training in advanced movements, such as force variations, curve transitions, and lifting, pressing, and pausing in strokes, is relatively scarce. Therefore, although students showed improvements in superficial writing performance, they still exhibited insufficient

learning transfer and mastery in strokes with higher technical difficulty. 4) Disconnect between cognitive understanding and action execution. Students in the control group may have gained some improvement in understanding the structural and stylistic features of calligraphy strokes.

However, due to the lack of specific and systematic guidance on physical movements, the cognitive understanding failed to translate into concrete action performance effectively.

This disconnect between cognition and action is an important factor limiting the improvement of complex strokes. 5) Lack of feedback mechanisms limits improvement. Traditional teaching often lacks immediate feedback mechanisms for actions, making it difficult for students to perceive problems in their actions clearly..

Table 8: Pre-test and Post-test Paired Sample T-tests for the Control Group.

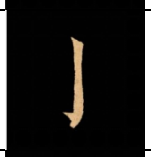
Indicator	Before the Control	After the Control	T	P
Yoki (basic strokes)	2.000±0.707	3.300±0.447	3.474	0.025
Vertical (basic strokes)	2.800±1.304	4.200±0.908	2.997	0.040
Skimming (basic strokes)	2.800±0.837	3.300±0.447	1.581	0.189
Press (basic strokes)	3.200±0.447	4.200±0.908	3.651	0.022
Dots (basic strokes)	2.400±1.140	3.400±0.894	3.162	0.034
Horizontal folds (basic strokes)	2.200±0.837	3.200±1.303	3.063	0.031
Vertical hook (basic stroke)	2.800±0.837	3.200±1.036	2.138	0.099
Ti (basic strokes)	2.800±0.837	4.400±0.418	3.720	0.020
Yong (monogram)	2.600±0.894	3.800±1.151	3.539	0.024

In specialized training, however, various methods such as videos, action explanations, and electromyography feedback are often combined to help students identify and correct problems, thereby improving training efficiency. The control group has obvious shortcomings in this regard. In summary,

while the control group achieved significant progress in some basic strokes, their improvement was limited in strokes requiring high technical skill and precise control due to constraints in teaching methods and training tools. If future efforts integrate action guidance and physiological feedback mechanisms into traditional teaching methods, this could further enhance overall teaching effectiveness.

4. Analysis of the results of calligraphy learning outcomes between the experimental group and the control group after the experiment After the experiment, a detailed analysis was conducted on the data of various indicators, including technical skills, line posture, and basic musical abilities, for both the experimental group and the control group. The data results indicate that there were significant differences after independent sample T-tests. The detailed results of the experimental group and the control group after the experiment are shown in Table 9.

Table 9: Paired Sample T-tests for the Two Groups.

Indicator		After the Experiment Group	After the Control Group	T	P
Yoki (basic strokes)		5.600±0.894	3.300±0.447	5.143	0.001
Vertical (basic strokes)		6.600±1.140	4.200±0.908	2.846	0.022
Skimming (basic strokes)		5.800±0.837	3.300±0.447	5.893	***
Press (basic strokes)		6.800±1.789	4.200±0.908	2.898	0.020
Dots (basic strokes)		7.400±0.548	3.400±0.894	8.528	***
Horizontal folds (basic strokes)		6.400±1.140	3.200±1.303	3.550	0.008
Vertical hook (basic stroke)		7.200±0.837	3.200±1.036	6.713	***
Ti (basic strokes)		7.400±0.894	4.400±0.418	6.794	***
Yong (monogram)		7.800±0.8374	3.800±1.151	6.285	***

Data analysis: As shown in the table above, an independent samples T-test was conducted on the technical ability indicators of the experimental group and the control group after the experiment.

The results showed that the P-values for the vertical and horizontal stroke indicators were 0.022 and 0.020, respectively, both of which were less than 0.05, indicating a significant difference.

The P-values for the horizontal, slant, dot, horizontal fold, vertical hook, lift, and 'Yong' character indicators were all less than 0.01, indicating a significant difference. For the results of the independent samples T-test, significant differences were observed between the experimental group and the control group in multiple technical ability indicators ($P < 0.05$ or $P < 0.01$):

1) Specialized movement training improved muscle control ability During the intervention, the experimental group underwent systematic movement training covering modules such as posture correction, muscle activation, and stroke path decomposition, effectively activating key muscle groups (e.g., FDS, FCR, EDC) involved in the writing process.

This not only improved upper limb stability and finger-wrist control ability but also made stroke performance more precise in terms of force, rhythm, and path, resulting in superior performance on most stroke metrics compared to the control group.

2) Progressive training optimized stroke execution

The experimental group's training content followed a progressive, step-by-step approach, starting with basic movement control and then guiding students into the simulation and practical application of complex strokes, such as horizontal folds and vertical hooks.

This phased teaching method reduced the cognitive and motor load between learning and execution, enabling students to naturally perform complex strokes after mastering basic movements, thereby achieving a significant improvement in overall technical proficiency.

3) Training enhanced movement perception and rhythm control Calligraphy writing relies not only on technique but also on the control of movement rhythm.

The experimental group incorporated the rhythm training concept of 'breathing-movement-stroke' into the training, helping students establish an internal connection between movements and rhythm, thereby improving the fluency and expressiveness of strokes.

Especially in movements such as 'dot, press, and lift,' rhythm control directly affects the momentum and quality of lines.

Hence, the experimental group scored significantly higher than the control group in these strokes. 4) Higher efficiency of cognitive-motor coupling The experimental group's training did not stop at the level of overt movements, but also combined expert explanations, movement demonstrations, and video feedback to guide students' cognitive understanding of stroke structure and movement paths.

This cognitive-behavioral feedback loop internalized the training effects into stable motor performance, resulting in superior performance in comprehensive stroke structures such as the character

"Yong". In summary, the experimental group achieved significant advantages over the control group in all stroke technical indicators, attributed to their participation in a systematic, progressive, and cognitive-physiological integrated action training intervention programme, which effectively improved action stability, coordination, and expressiveness during the writing process. These results validate the empirical efficacy of specialized action training in enhancing calligraphy skills.

5. Analyze topics for learners The dimensional design of this questionnaire is based on the core psychological and behavioral variables in the calligraphy learning process, combined with experimental teaching objectives, and systematically constructs five assessment dimensions, namely: learning motivation, improvement in writing skills, clarity and practicality of training movements, participation satisfaction, and self-confidence and transfer ability.

The learning motivation dimension draws on the 'expectancy-value theory,' focusing on students' interest in and willingness to engage in calligraphy learning;

the improvement of writing skills dimension incorporates the concept of self efficacy from cognitive behavior theory to assess students' perceptions of their ability to control strokes and master rhythm; the clarity and practicality of training movements dimension is based on the instructional design effectiveness model, focusing on the teaching visibility and functional suitability of training movements; the participation satisfaction dimension originates from the learner satisfaction model, assessing students' emotional feedback and sense of identification with the course process; the self-confidence and transfer ability dimension refers to Bandura's self-efficacy theory, assessing students' confidence and ability to transfer the learned skills to complex writing tasks.

This structure not only facilitates the collection of quantitative data but also provides theoretical

support for subsequent teaching feedback and strategy optimization.

Table 10: Survey Questionnaire Results Statistics.

Dimension	Item	Experimental Mean ± SD	Control Mean ± SD	T/U	P	
Learning motivation	2.1	4.22 ± 0.32	3.18 ± 0.64			
Learning motivation	2.2	4.22 ± 0.42	3.33 ± 0.71			
Learning motivation	2.3	4.24 ± 0.50	3.16 ± 0.64			
Learning motivation	2.4	4.31 ± 0.48	3.30 ± 0.71			
Average		4.28 ± 0.47	3.17 ± 0.68	t=7.21	<0.001	1.32
Perceived skill improvement	3.1	4.35 ± 0.40	3.22 ± 0.77			
Perceived skill improvement	3.2	4.24 ± 0.33	3.35 ± 0.66			
Perceived skill improvement	3.3	4.35 ± 0.52	3.26 ± 0.83			
Perceived skill improvement	3.4	4.23 ± 0.43	3.13 ± 0.65			
Average		4.28 ± 0.37	3.19 ± 0.72	t=6.54	<0.001	1.18
Instructional usability	4.1	4.27 ± 0.45	2.96 ± 0.64			
Instructional usability	4.2	4.11 ± 0.39	3.41 ± 0.64			
Instructional usability	4.3	4.32 ± 0.42	3.28 ± 0.70			
Instructional usability	4.4	4.35 ± 0.36	3.24 ± 0.72			
Average		4.19 ± 0.47	3.21 ± 0.68	u=1024	<0.003	0.97
Engagement and satisfaction	5.1	4.19 ± 0.47	3.31 ± 0.75			
Engagement and satisfaction	5.2	4.18 ± 0.44	3.34 ± 0.68			
Engagement and satisfaction	5.3	4.22 ± 0.46	3.39 ± 0.69			
Engagement and satisfaction	5.4	4.16 ± 0.42	3.43 ± 0.73			
Average		4.18 ± 0.45	3.36 ± 0.71	t=4.89	<0.001	0.94
Confidence and transferability	6.1	4.17 ± 0.40	3.26 ± 0.71			
Confidence and transferability	6.2	4.15 ± 0.48	3.18 ± 0.69			
Confidence and transferability	6.3	4.18 ± 0.42	3.36 ± 0.76			
Confidence and transferability	6.4	4.22 ± 0.39	3.30 ± 0.73			
Average		4.19 ± 0.43	3.19 ± 0.74	t=5.12	<0.001	0.87

This study used independent sample T-tests and Mann-Whitney U tests to statistically compare the average scores of the experimental group and the control group in five dimensions. The results showed that (see Table 10): 1) Learning motivation. The experimental group scored significantly higher on learning motivation than the control group ($t=7.21$, $p<0.001$, $d=1.32$), indicating that the new teaching methods (such as combining movement training with videos) effectively stimulated students' willingness to explore actively. Qualitative analysis further supported this finding: the experimental group mentioned "interesting course design" (frequency=45%) and "clear objectives" (32%), while the control group frequently reported "lack of novelty" (28%). 2) Improvement in writing skills.The experimental group scored higher in the skill improvement dimension ($t=6.54$, $p<0.001$, $d=1.18$), particularly in 'stroke control' (experimental group M=4.28 vs. control group M=3.19) and 'writing rhythm' (M=4.2 vs. 3.0). In open-ended questions, students in the experimental group emphasized that

'decomposing actions reduced learning difficulty' (typical response example). 3) Clarity and practicality of training actions. The experimental group perceived training actions as clearer and more practical ($U = 1024$, $p < 0.003$), with 82% mentioning that 'teaching videos clearly demonstrated details,' while the control group complained that 'traditional demonstrations were not detailed enough' (55%). Although both groups perceived difficulty as appropriate (experimental group M=4.19 vs. 3.21, control group M=3.21, d=0.97), the experimental group more highly valued the training's specificity (e.g., 'directly addressed my penholding issues'). 4) In terms of participation satisfaction, the experimental group significantly outperformed the control group ($M = 4.18$ vs. 3.36, $t = 4.89$, $p < 0.001$, $d = 0.94$), with feedback consistently highlighting that the exercises were more engaging and the training pace was more reasonable. 5) Confidence and transfer ability. The experimental group demonstrated stronger confidence in skill transfer ($t=5.12$, $p<0.001$), with 35% actively mentioning 'trying other fonts' in open-ended questions, compared to only 8% in the control group. However, there was no significant difference between the two groups in terms of 'anxiety about completing tasks independently' ($p=0.15$), possibly due to the higher challenge level of tasks in the experimental group. According to the results of statistical analysis, this study validated the superiority of structured action teaching in calligraphy instruction for beginners. Specifically, the experimental group scored significantly higher than the control group in five core dimensions (learning motivation, skill improvement, teaching practicality, participation satisfaction, and self-confidence and transfer ability), indicating that action training not only improved students' writing skills but also enhanced their learning motivation and self-efficacy. In terms of learning motivation, students in the experimental group were more proactive and demonstrated a stronger willingness to continue learning. In terms of skill mastery, action training effectively improved students' performance in stroke control and rhythm. In terms of teaching practicality, structured action design was more precise and more targeted, facilitating learners' understanding and operation. In terms of participation experience, students in the experimental group were more positive about the course arrangement and learning process feedback, with significantly improved satisfaction levels; in terms of confidence and transfer ability, experimental group students demonstrated a greater ability to apply what they learned to more complex writing tasks, exhibiting strong transfer and self-directed learning capabilities. Overall, structured movement training demonstrates significant advantages over traditional teaching methods in terms of stimulating learning motivation, enhancing movement performance, and improving teaching effectiveness, providing empirical evidence and practical references for future calligraphy instruction.

4. DISCUSSION

In a quasi-experimental study employing independent samples T-tests, significant differences were found between an experimental group and a control group across various technical skill indicators in calligraphy ($P < 0.05$ or $P < 0.01$). The experimental group engaged in systematic motor training that included posture correction, muscle activation, and stroke path decomposition, leading to improved upper limb stability, finger-wrist control, and enhanced performance in stroke metrics such as force, rhythm, and path accuracy.The training employed a progressive, step-by-step teaching method, beginning with basic movements and advancing to complex strokes. This approach minimized cognitive and motor load, allowing students to execute intricate strokes more naturally after mastering the fundamentals, significantly boosting their overall technical proficiency. Incorporating a 'breathing-movement-stroke' rhythm training concept, the experimental group fostered an internal connection between movement and rhythm, enhancing stroke fluency and expressiveness. This was particularly effective in strokes requiring precise rhythm control, where the experimental group outperformed the control group.

The training also included expert explanations, movement demonstrations, and video feedback, promoting cognitive understanding of stroke structure and movement paths. This cognitive-behavioral feedback loop solidified the training effects into stable motor performance, leading to superior execution of complex character structures. Overall, the experimental group significantly outperformed the control group in all technical indicators, attributed to a systematic and integrated training approach that improved action stability, coordination, and expressiveness. Additionally, survey results confirmed that structured movement instruction enhanced learning motivation, skill improvement, teaching practicality, participation satisfaction, and self-efficacy, highlighting the multifaceted benefits of the training program. Participants showed increased enthusiasm for

learning, improved stroke control, and greater satisfaction with the course, along with enhanced self-confidence and transfer ability of skills to more complex tasks.

5. CONCLUSION

This study confirms the effectiveness of a teaching pathway based on action-perception feedback. While traditional calligraphy instruction research has predominantly treated the body as an instrumental entity, neglecting the cognitive and somatic dimensions of motor skill acquisition, this study introduces "action cognition" as a critical mediator between perceptual input and motor output. This approach enriches the constructive teaching model in calligraphy education and affirms the role of embodied cognition in skill development.The research advocates for incorporating systematic movement training modules into traditional brushwork instruction addressing a gap in existing studies that focus on post-writing outcomes rather than real-time motor processes. The training system developed here, inspired by Tai Chi coordination, Laban Movement Analysis, and physiological awareness techniques, provides an operational framework for enhancing the "perception-transformation-expression" loop. The study bridges classical calligraphy theory and contemporary science. For instance, improvements in stroke rhythm and coordination reflect the traditional concept of "vivid rhythmic vitality" discussed by Li Zehou and Zong Baihua, while physiological corroboration is provided through quantitative metrics. Moreover, the establishment of an evidence-based database for calligraphic movement lays the foundation for exploring the relationship between neuromuscular activity and artistic expression. In summary, the findings not only validate the proposed training system but also advance calligraphy pedagogy by integrating historical wisdom with modern scientific methodologies, thereby offering a holistic, scalable, and evidence-based approach to skill development in traditional arts.

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