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Professional Development Workshop for Physical Education Teachers in Southwest China: Benefiting Tai Chi Students with Pedagogical Content Knowledge

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Abstract: Researchers have examined the common and specialized content knowledge (CCK/SCK) of physical education (PE) teachers and compared their pedagogical content knowledge (PCK) with student learning outcomes globally. However, little research has been reported in China on the relationship between PCK and student learning in PE settings. The aims of the study were (i) to investigate the influence of teacher content knowledge (CCK/SCK) on student development stages in PE settings and (ii) to examine the impact of teachers' PCK on students' performance in Tai Chi techniques (TCTs) after six days of instruction. Two PE teachers were chosen from two urban, public, mid-sized middle schools located in Chengdu, Sichuan Province, China. This study involved 332 students from six 5th and six 6th grade classes. The study consisted of 185 5th-grade students (98 boys and 87 girls) and 147 6th-grade students (70 boys and 77 girls). We examined how teacher PCK and student TCT changed after a professional development workshop (PDW). Each PE teacher had two classes randomly assigned to the control or experimental condition groups. This study had three phases. Initially, the control condition was introduced; then, a PDW was provided for the teachers; and finally, the experimental condition was implemented. Teaching behaviors were described using mean values, and *t*-tests based on the highest TCT scores were conducted to examine the effect of teachers' PCK on students' TCT learning. Furthermore, PCK effect sizes were calculated using Cohen's *d*. Significant relationships existed between teachers' PCK, CK, and students' knowledge, with effect sizes ranging from 1.92 to 6.82. Additionally, improvements in teachers' PCK were associated with improved TCT performance in students ($p < 0.05$). Increased knowledge and skills can improve teachers' PCK behavior, resulting in improved student performance in TCTs. These findings may provide evidence for future recommendations regarding knowledge and skill training programs for physical education teachers.

Keywords: direct instruction; schools in China; self-efficacy; educational interventions; teachers; children

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1. Introduction

Developing learning skills (DLS) refers to functional abilities necessary for students to move independently in their surroundings [1–3]. In this context, object control skills can be categorized under DLS and are viewed as essential components of sports-specific skills. Most children do not naturally develop DLS; rather, they progress through developmental sequences of motion, gaining efficiency and maturity as they progress [4–6]. Component analysis identifies the developmental characteristics of individual physiological elements [7]. Competence in DLS is essential as it contributes to the mechanisms that influence children's behavior during childhood and adolescence [8]. Researchers have proposed a conceptual model suggesting that children proficient in DLS are likely to be physically active [9]. In addition to improving health outcomes for children proficient in DLS, this engagement is expected to improve self-perception among those children [10]. Research shows links between DLS proficiency in childhood and physical activity, fitness, and

competence [11–13]. Early childhood acquisition of DLS competence is extremely valuable. The development of such programs falls under the umbrella of education for sustainable development and is directly related to goal 4 of the 17 Sustainable Development Goals.

Physical education (PE) standards for children throughout the world [8], particularly in China [14], highlight DLS as an aspect of the recognized guidelines for physical activity for preschoolers. DLS is a vital part of the middle school PE curriculum. Therefore, schools at every level may provide an ideal opportunity for developing DLS competencies [7]. Although DLS training is highly beneficial for young students [15], teachers often struggle to achieve satisfactory results in the outcomes of DLS-related students because they use strategies that are less efficient than DLS-related strategies [8,16]. Researchers found that PE teachers failed to deliver effective feedback to their students due to their inability to distinguish between effective and ineffective performances [16]. They also failed to identify students' current skill levels. Teachers' content knowledge (CK) contributes to less effective instruction in PE and education in general [17,18]. In addition, the knowledge they are taught in their teacher education program is not applied in practice since they are unfamiliar with their students' developmental stages/sequences [7]. It has been reported that CK profoundly affects teacher pedagogical content knowledge (PCK) [8]. PCK has been defined in PE as an event when teachers make content-related decisions using knowledge from multiple sources [18].

CK must be considered a significant variable that can be adapted to improve performance [19,20]. Moreover, awareness of rules, techniques, and tactics is an example of common content knowledge (CCK). It is also possible to acquire specialized content knowledge (SCK) by having error-free knowledge representations, instructional tasks, and challenges related to a particular activity [8]. It is pertinent to consider this distinction when designing interventions to improve CK. Researchers have recently established that teachers' CCK and SCK improvements may improve PCK effectiveness and students' learning [18,21–23]. PCK measures include task demonstrations and representations, teacher feedback, and intra-task modifications [20]. However, there has been limited research on teachers' PCK. Only limited research has been conducted in China to demonstrate the effect of teacher knowledge on students' DLS. Student learning outcomes in PE can be evaluated based on the developmental stages of DLS and the student's outcomes [7,16].

Researchers have developed instructional interventions to align instructional tasks with developmental stages [24,25]. These studies confirmed the effectiveness of this technique by reporting that children who received feedback aligned with their personal needs performed better. This contrasted with the general feedback provided to children. Therefore, teachers must thoroughly understand their students' DLS to improve it. Furthermore, little research has examined the relationship between PCK and student achievement in middle school PE contexts based on DLS. These relationships have been explored at higher PE institutions [18,23]. Limited information on how PCK affects teachers' teaching behaviors in PE is available, and also on how PCK affects teachers' teaching behaviors. This change in teaching behavior may improve DLS student performance. By conducting this study, PCK variables could be influenced by student learning. Additionally, it can help researchers explore how teachers can adapt their teaching styles in the future. Furthermore, most studies employ DLS experts as instructors [24,25]. Very few studies have been conducted in China using PE teachers in middle schools. Such studies need to examine the effect of teacher PCK on students' outcomes by comparing their performance scores in Tai Chi techniques (TCTs).

Chinese Tai Chi is a traditional Chinese martial art and popular exercise [26–30]. It is an effective form of rehabilitative training that integrates physical, social, and psychosocial factors to promote general health [1,30–33]. Tai Chi has five forms: Chen, Sun, Wu, Yang, and Wu/Hao [34]. Tai Chi's positive effects have been examined in several studies [35–37]. Tai Chi enhances life quality by maintaining whole-body stability [10,33]. It has fewer negative effects on individuals than other kinds of activity [33]. Tai Chi promotes immune-boosting factors [38,39]. Tai Chi is widely acknowledged as the most effective traditional

Chinese method for improving quality of life at any age [26,40–42]. Previous systematic reviews have only summarized, in a rough manner, the effects of Tai Chi exercise on a small number of variables [28,29,38,42–45]. Furthermore, it was not discussed in detail how students performed Tai Chi in terms of proper technique during workouts. Students cannot formulate a reasonable exercise regimen under such circumstances. However, using Tai Chi as a potential alternative method to affect cognitive appraisal outcomes in DLS might be possible. By comparing their TCTs, it is not known whether Tai Chi is an effective treatment for DLS monitoring.

Researchers can use this approach to investigate PCK variables influencing students' learning skills. In addition, they can determine how teachers change their teaching methods. Similarly, some experts also teach DLS in their studies [24,25]. Other studies have examined the effectiveness of teachers' content knowledge (CCK and SCK) and their information about students' developmental stages before and following workshops designed to strengthen teachers' conceptual understanding of and knowledge about students [8]. Our study addresses the following research questions: (i) how do teachers' representations of the tasks, their demonstrations of the tasks, their feedback strategies, and their modifications of the tasks based on their developmental stage differ between the control and experimental groups; and (ii) whether this research improves student performance in a six-day Tai Chi unit implemented as professional development (PCK). This study aims to test the hypothesis that (i) teachers who participate in professional development workshops will gain better PCK; (ii) and it will enhance teachers' CK and students' knowledge to improve the comparability of control and experimental classes.

2. Methods

2.1. Participants

We obtained consent from the parents, teachers, students, and school administrators participating in the study. We also received approval from the City Institutional Review Board. Two PE teachers were intentionally selected to teach in two urban, public, mid-sized middle schools in Chengdu, Sichuan Province, China. The teachers were chosen based on their willingness to participate and availability to teach six classes of Tai Chi over six days. This study was conducted by a 42-year-old female teacher and a 48-year-old male teacher, both with 18 and 19 years of professional experience, respectively. According to the calculation result of sample size ($\alpha = 0.05$, effect size $f = 0.25$, and $1 - \beta = 0.8$) [24], 300 participants were estimated to be selected. The participating teachers selected 332 students from six 5th-grade classes and six 6th-grade classes for this study (Figure 1). This study involved 185 5th-grade students (98 boys and 87 girls) and 147 6th-grade students (70 boys and 77 girls) from the investigated schools. Students were aged 11.86 $\pm$ 1.25 (mean $\pm$ standard deviation), with 94% being Han and 6% belonging to other minority groups. There were 166 students in both the control and experimental groups. Students were randomly assigned to either the control group (n = 166, 86 boys and 80 girls) or the experimental group (n = 166, 84 boys and 82 girls).

2.2. Design of the Research

We examined teacher PCK changes before and following a professional development workshop (PDW) within the research domain. In addition, we examined improvements in student Tai Chi performance. Each middle school PE teacher taught six 5th- and six 6th-grade classes. Two classes were randomly assigned either to the control condition (one class in 5th grade and one class in 6th grade) or to the experimental condition (one class in 5th grade and one class in 6th grade) group. The study was divided into three sequential phases (Figure 2). As part of Phase 1, teachers taught a six-day (six lessons) Tai Chi unit following their preferred teaching method. Digital camcorders were used to document teacher teaching behaviors (PCK). Phase 2 of the program included three days of PDW designed to improve teachers' knowledge and skills with students. Each workshop consisted of 90 min of instruction per day. These teachers taught a six-day (six lessons) Tai

Chi unit during Phase 3 of the experimental condition. Their PCK was recorded during this period.

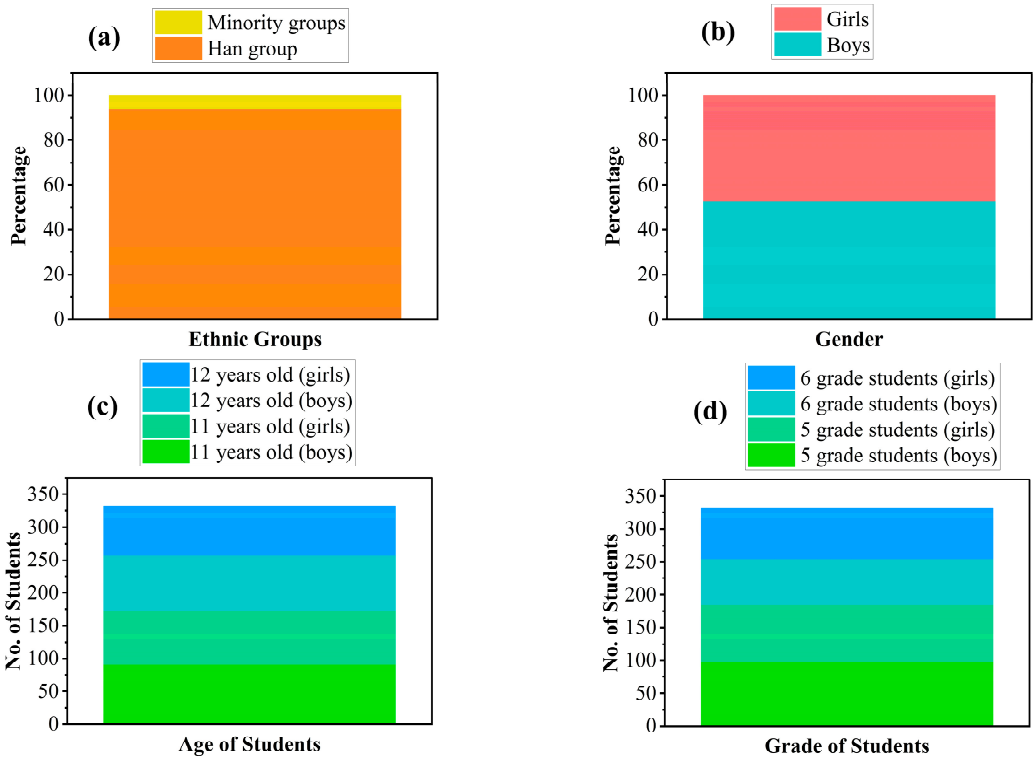

Figure 1. Sociodemographic characteristics (**a**–**d**) of the participants.

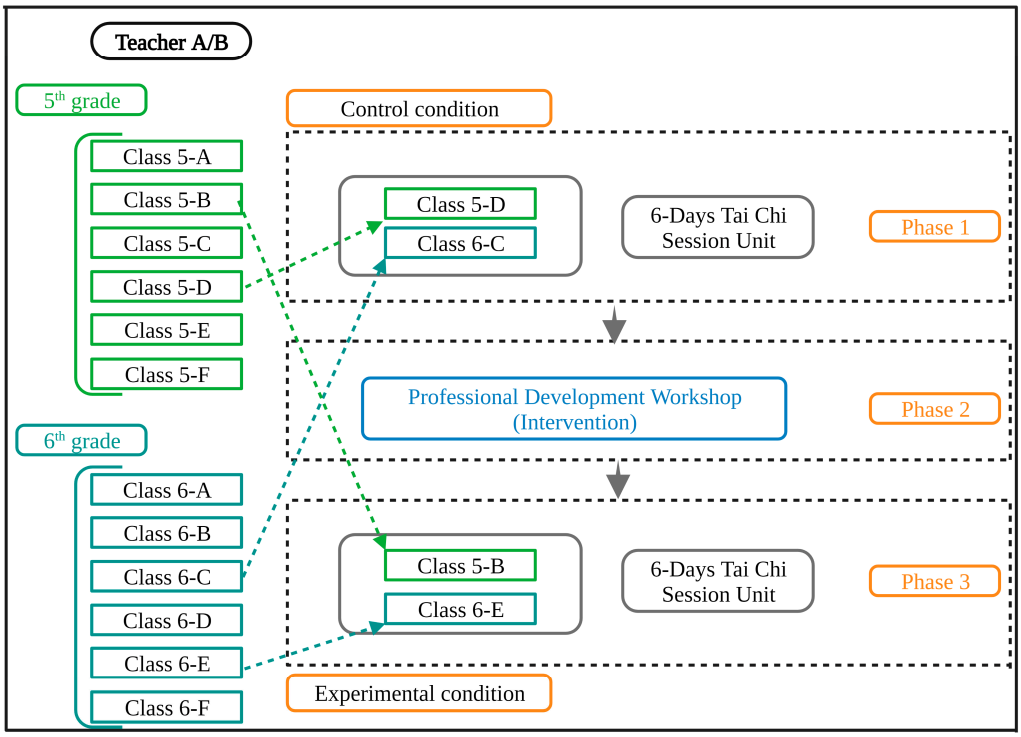

Figure 2. Research design diagram.

2.3. Independent Variables

PDW is an independent variable for both PE teachers. During the workshop, teachers received a knowledge packet covering TCTs and developmental sequences and stages.

Essentially, CCK refers to knowledge of the developmental stages; SCK refers to the differentiation between the various stages; and PCK refers to applying instructional tasks and feedback to specific students [46]. TCTs were emphasized in these materials. Various instructional activities and tasks were presented to students at different skill levels to reinforce key principles. Furthermore, the knowledge packet provided students at different skill levels with resources related to SCK. Four textbooks were used to create the knowledge packet [7,15,47,48]. Five experts in PE and TCTs reviewed the instructional task sequence to ensure its validity. Considering the feedback provided by the content experts, minor modifications to the instruction tasks were made. The knowledge packet was given to the teachers, who were asked to review it before the PDW. It was held after the Tai Chi control session and was conducted by an independent expert who was a certified physical educator with 15 years of teaching experience in PE. Each workshop lasted 90 min each day. Teachers were trained separately due to logistical constraints. The same expert provided workshops for both teachers. This PDW was composed of three components: an overview and introduction, learning materials relevant to teaching TCTs, and a check sheet and written test for evaluation. The workshop was summarized in terms of its purpose, objectives, and expectations. The expert provided an overview of each workshop content element after explaining it through video clips or photographs. A demonstration and images from the knowledge packet assisted the expert in guiding the teacher through the developmental sequences. Following the expert's demonstrations, the teacher was asked to demonstrate the different developmental stages of TCTs. Teachers were trained in teaching TCTs, including identifying and correcting errors. Furthermore, they guided common teaching cues and customized feedback statements to the students' current skill levels and expectations. As part of the evaluation process, questions were asked continuously, and observations were made of the teachers' performance in the workshop. After introducing each content element, teachers were instructed to explain and/or demonstrate it. Each phase of the workshop was monitored using checklists throughout the workshop. Furthermore, various tests were used during the workshop to ensure each teacher understood the material. The tests consisted of true–false questions, video tests, and written tests. Both teachers met the criteria (90% or better on each assessment) to complete the workshop. Figure 3 summarizes the PDW goals, processes, and content assessments.

2.4. Teacher Dependent Variables

Teachers' PCK was examined by measuring the four previously discussed variables. (A) The first one is called task representation [49]. This is one of the simplest means of communicating to students what they must do and how to do it. (B) Task demonstration [18], which is an aspect of task representation involving visual communication in PE. (C) feedback [16] that facilitates students' performance evaluation and improvement of their movement patterns. (D) Task modification alignment [18,21]: this refers to teachers' ability to determine the most appropriate task based on students' developmental stages to achieve a particular learning outcome. Earlier studies [16,18,46] have determined that these four PCK variables are appropriate. It was necessary to modify the criteria for each variable to meet the objectives of the current study. Variables were coded based on event recordings [50]. Task representation: it was determined whether teachers had incorporated the critical elements of the TCTs into their task representations to code correctly. For example, the teacher explained when a student must start performing and what steps to follow. Task demonstration: teachers were required to include all critical elements in a correctly represented task. Nevertheless, it was the teacher's responsibility to identify the critical elements appropriate to the educational objective of the activity. It is impossible to address TCT skills effectively when a task representation is incorrect. The teacher was coded as correct when all elements of the TCT form were included in the task demonstration. The teacher must demonstrate all elements of TCT for the demonstration to be considered correct. If errors were present in the teacher's demonstration, they were coded as incorrect. Feedback: there are three categories of teachers' feedback based on the list of appropriate feedback for

students at various developmental levels: developmentally appropriate feedback (DAF), developmentally inappropriate feedback (DIF), and general feedback (GF) [7,16]. DAF codes are assigned when the teacher provides feedback tailored to the student's skill level. The DIF code was used when the teacher provided feedback that was not aligned with the student's skill level. The GF code was assigned when feedback statements not directly related to TCT performance were reported. Task modification alignment: according to the student's performance on TCTs during the observed trial, task modification alignment was categorized as aligned task modification and not aligned task modification. Aligned task modifications were coded when the teacher modified the task to reflect the individual student's TCT performance based on the student's TCT stage. In cases where the teacher observed that a student's TCT performance did not change because of a task modification, it was coded as not aligned.

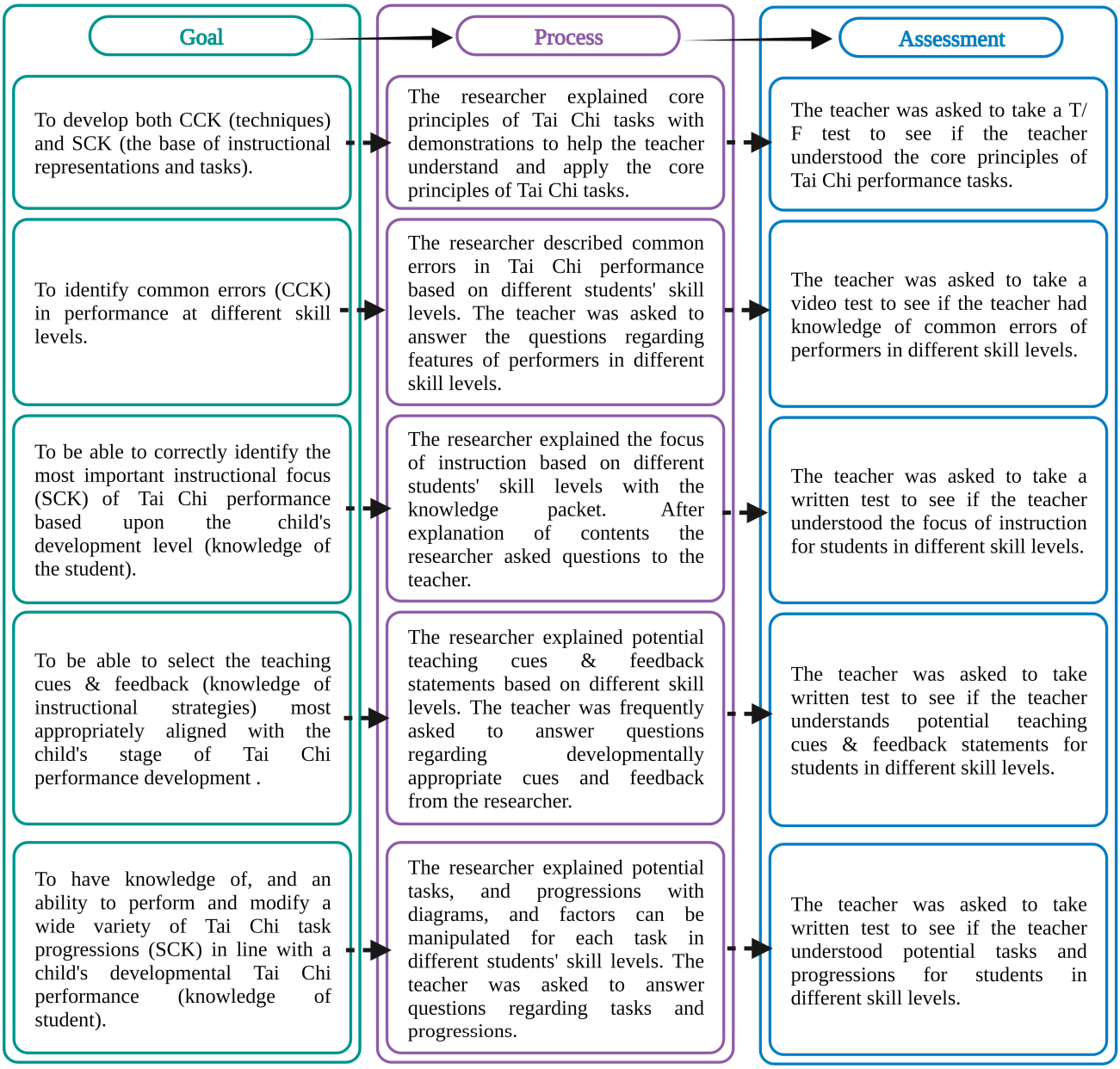

Figure 3. A description of each goal, its process, and assessment.

2.5. Student Dependent Variable

The performance of TCTs was used to measure the effectiveness of teachers' PCK implementations with students. The TCTs were measured using an independent expert method at the pretest, posttest, and retention tests. The recorder could see the perfection of each step made by the participants. TCT scores were recorded on a data sheet by the expert. Students were not given feedback or instructions regarding their TCT scores. The data analysis was based on each participant's maximum score during the pretest, posttest, and retention tests.

2.6. Data Collection Procedures

Training of coders: video measures (all teaching sessions of TCTs) in the study were coded by two blinded coders. Three training sessions were conducted, and participants passed a written test containing 31 questions regarding all the variables. In addition, they passed a practice test that involved coding using a rubric based on a 60 min video of the TCT lesson. The coders were required to score 90% on these tests before the study began. Interobserver agreement (IOA): 47% of control and experimental groups were assessed using IOA for teacher variables. It was decided that 85% agreement was an acceptable threshold for IOA [50]. The IOA is calculated by dividing the agreement numbers by the total agreement and disagreement numbers. Teacher data had an overall IOA of 87%. Treatment integrity: this workshop was rehearsed with graduate students to practice the workshop content and address any difficulties encountered. In order to ensure the effectiveness of the workshop, the investigator conducted a rehearsal session with the graduate students before the workshop. The workshop was implemented following fidelity checklists (Figure 4) to ensure that each phase was carried out with the appropriate rigor. An independent rater watched the workshop videotape and completed a fidelity checklist. Each workshop was delivered using these checklists to ensure treatment integrity. This study reported overall treatment integrity of 93%, 92%, and 92% on the first, second, and third days, respectively. Three sessions resulted in the compliance of 92% of the regiments.

2.7. Data Analyses

The total sample size was predetermined via a priori analyses using G* × Power version 3.1.9.2. Descriptive statistics were presented in the results as percentage (%) scores. Effect sizes were calculated for the teacher's PCK variables related to task representations, task demonstrations, feedback, and task modification alignment. Cohen's *d* [51] was calculated in both the control and experiment groups to determine whether teachers represented tasks correctly or incorrectly, provided feedback, and aligned task modifications. Cohen [51] defined a large effect size as one requiring more than 0.8. The TCT performance scores (%) were analyzed using independent sample *t*-tests to assess the impact of teachers' PCK on students' Tai Chi learning. TCT performance scores were analyzed using these *t*-tests to determine whether experimental and control condition groups differed from each other. We then calculated the gain scores by subtracting the posttest from the pretest. We also subtract the retention test score from the posttest and pretest scores. Under both conditions, three other independent sample *t*-tests were conducted to determine whether retention gains increased between pre- and post-retention gains. Cohen's *d* [51] was used to compare students' performance for control or experimental classes. The researcher chose a quantitative research method approach and statistical analysis was conducted using SPSS 22.0 (v. 22.0, IBM Corp, Armonk, NY, USA). OriginPro 2022 (Originlab Corporation, Northampton, MA, USA) was used to create the illustrations.

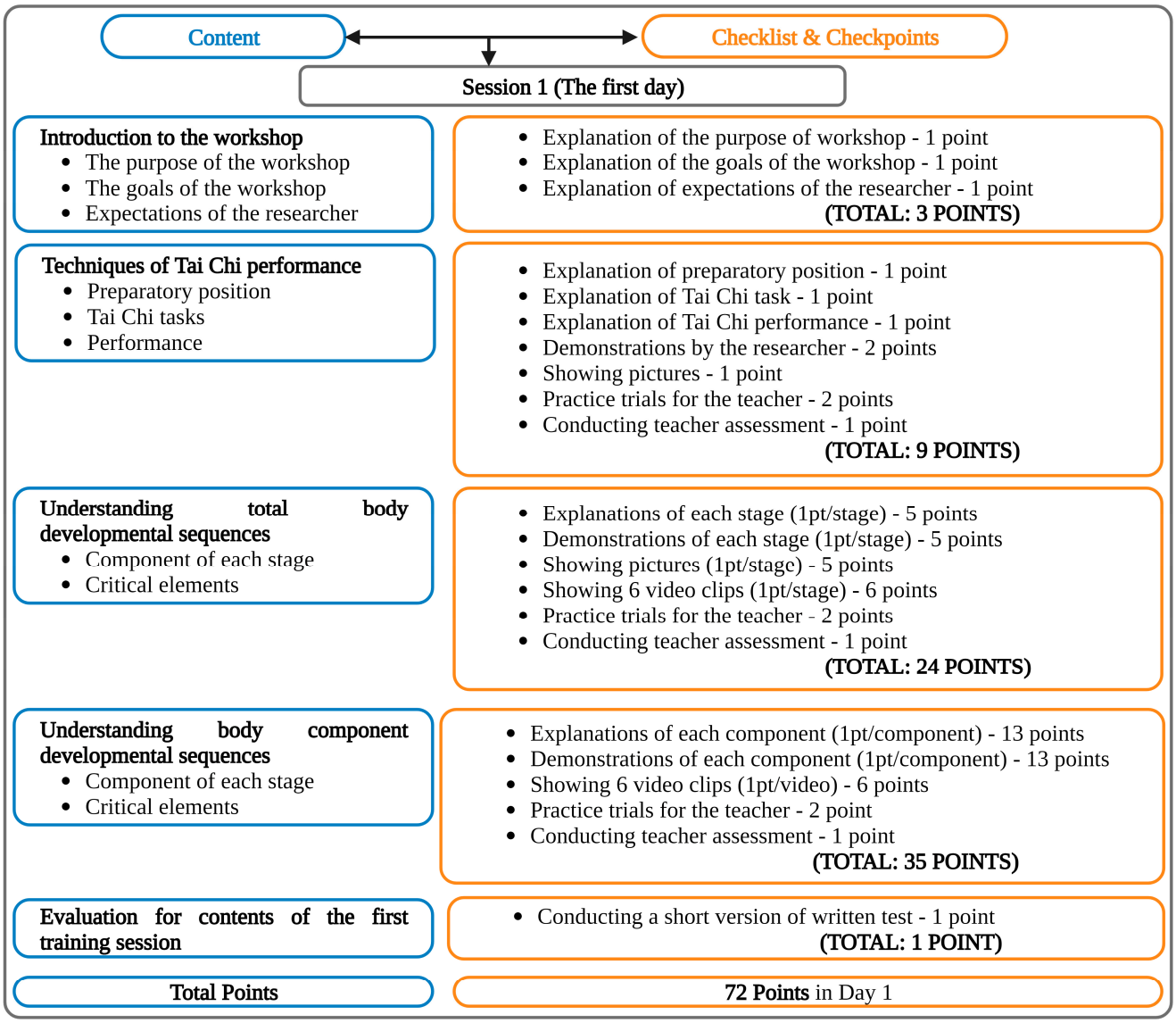

Figure 4. Checklist for ensuring treatment integrity.

3. Results

3.1. Teachers' Pedagogical Content Knowledge

The first goal of this study was to determine how teachers represented the tasks, demonstrated the tasks, used feedback strategies, and modified the tasks based on their developmental stage. This was compared to experimental groups. Based on the number and average percentage of correct task representations, Figure 5a illustrates the average percentage of correct task representations as a function of condition. The experimental groups displayed higher levels of correct task representation (92% compared to 61% in the control groups). Cohen's $d = 1.92$ showed a large effect size for correct task representations. We found that the percentage of teachers correctly demonstrating the task increased from 21% in the control groups to 94% in the experimental groups; this is based on a descriptive analysis of teachers' task demonstrations. Similarly, Cohen's d was 2.13 for task demonstrations. As summarized in the descriptive results of the teachers' feedback statements, both teachers reported using more DAF and less DIF and GF during TCT performance. This was after participating in the PDW. As a function of the total number of feedback statements, Figure 5b illustrates the average percentages of various types of feedback. Compared to the control groups, DAF frequency greatly increased, from 17% to 74%. The experimental

groups delivered significantly less DIF and GF (DIF = 5% and GF = 37%) than the control groups (DIF = 16% and GF = 83%). Feedback effect sizes were large for all three cases using Cohen's *d*: DAF = 6.82, DIA = 1.12, and GF = 0.98. Figure 5c presents the descriptive analysis of task modification alignment. Compared to the control groups, task modification alignment increased significantly from 21% to 94% in the experimental groups. Cohen's *d* = 4.93 showed a large effect size for task modification alignment.

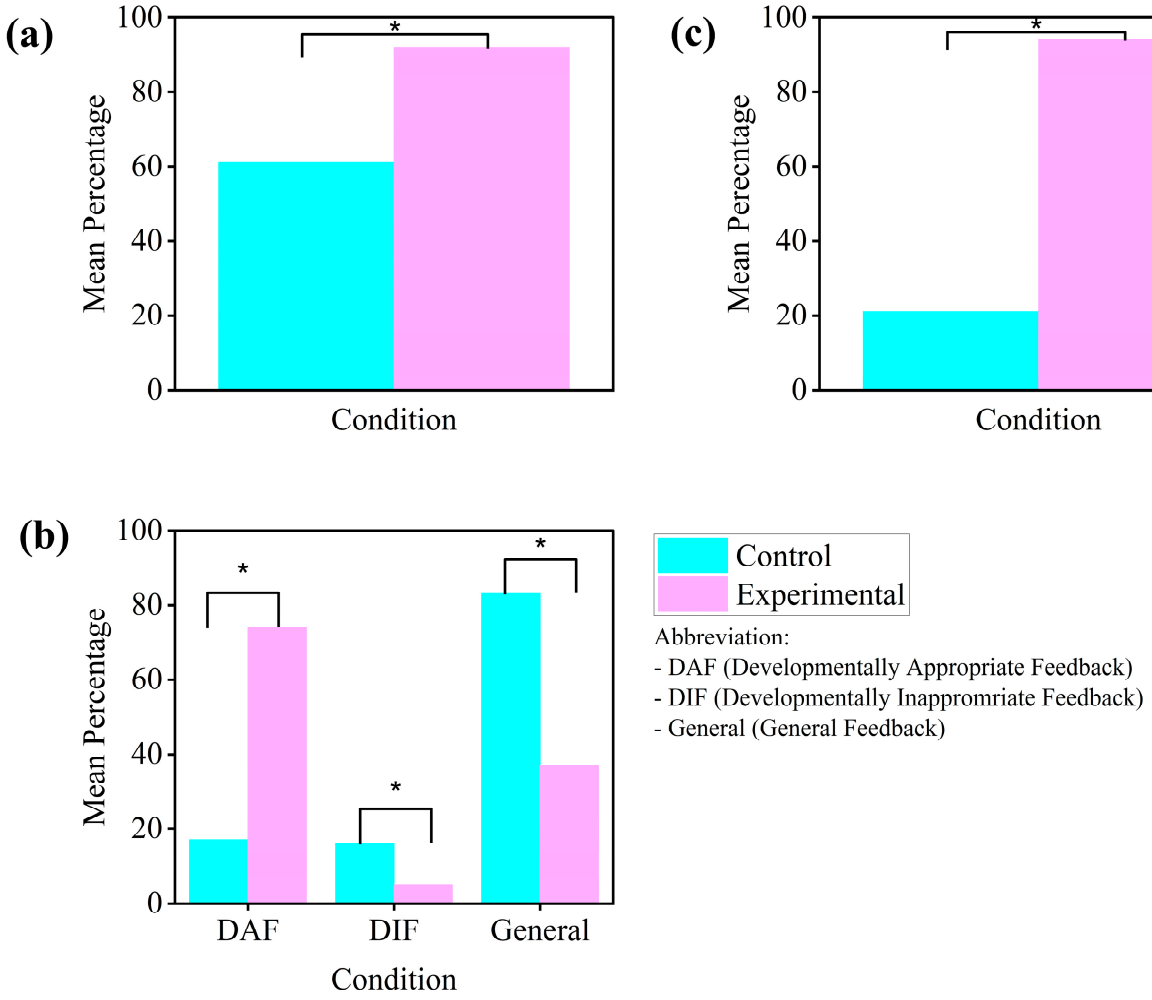

Figure 5. Bar graphs of correct task representation (**a**), different types of feedback (**b**), and aligned task modifications (**c**) by condition. The *y*-axis denotes the total score (%); * $p < 0.05$.

3.2. Students' Tai Chi Performance

As part of the second research question, whether a six-day Tai Chi program implemented as professional development (PCK) would improve student performance was determined. Figure 6 shows the mean performance scores for the control and experimental groups' pretest, posttest, and retention tests. There was no significant difference in TCT performance scores between the control (M = 55.6% ± 12.4%) and experimental (M = 51.9% ± 11.8%) classes in the pretest, $p > 0.5$, demonstrating statistical similarities between the control and experimental groups. We calculated TCT performance gain scores based on the difference between pretest and posttest scores for both control and experimental groups. The TCT performance gain scores from the pre-and posttest were statistically significantly higher for experimental (M = 14.4% ± 6.5%) groups than for control groups (M = 3.6% ± 4.8%). Cohen's *d* = 0.92 for the pre-posttest performance gain score of the TCT, which exceeds the convention of a large effect (i.e., *d* = 0.8). An assessment of whether the students retained any learning from the intervention was conducted by measuring a gain score from the post-intervention retention test. The gain score could be negative

if students' scores decreased. The TCT performance gain scores revealed a significant difference between the control (M = 4.9% ± 7.2%) and experimental (M = 3.4% ± 4.6%) groups, $p < 0.05$, and Cohen's $d = 0.67$. Performance scores for the TCTs decreased for both groups from the posttest to the retention test. Students appear to have lost some of the knowledge they gained after the TCT learning session. Based on the decreases in the students' TCTs performance scores from the post-retention test, a comparison between the gain scores from the pretest and the retention test was undertaken to determine whether there were still significant TCTs performance effects from the pre-retention test. The TCTs' performance differed significantly between the control (M = −1.33 ± 5.1%) and experimental (M = 11.3% ± 7.2%) groups, $p < 0.001$. Interestingly, the effect size of the TCTs performance unit was large, Cohen's $d = 0.91$, indicating that students benefited from the program.

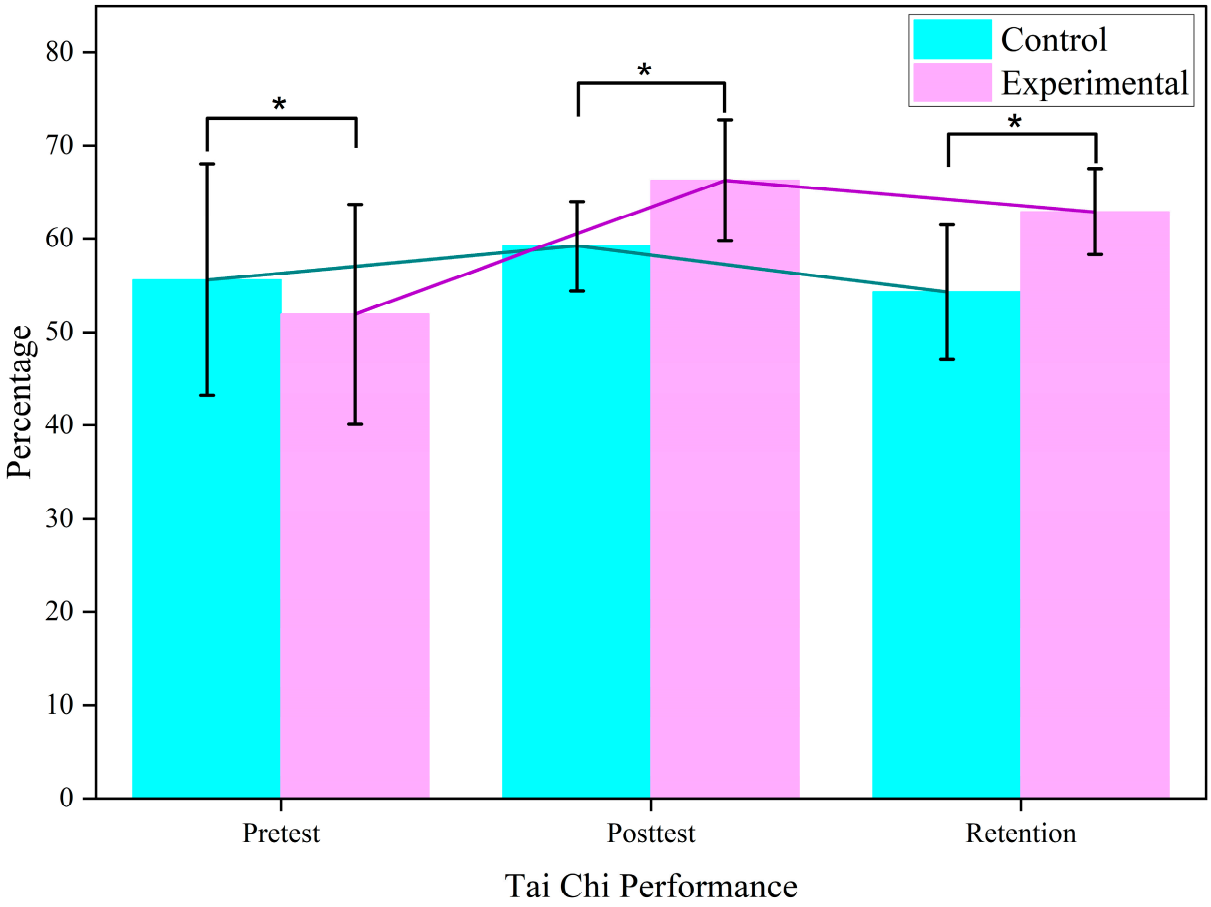

Figure 6. Bar graph comparing Tai Chai performance from pre- to posttest, and retention test between conditions. The *y*-axis denotes the total score (%). Standard deviations are represented by vertical bars, while lines represent connections between conditions. Note: An independent *t*-test was conducted to determine the significance of differences (at $p < 0.05$) between conditions; * $p < 0.05$.

4. Discussion

In this study, we investigated the influence of teacher content knowledge (CCK/SCK) on student development stages in PE settings and the impact of teachers' PCK on students' performance in TCTs after six days of instruction. Experimental groups showed higher levels of task representation than control groups in this study. Pre- and posttest scores of TCT performance gain were statistically significantly higher in experimental groups than in control groups. In both groups, performance scores for TCTs decreased from the posttest to the retention test. Teachers must better understand how PCK is described and defined to improve their proficiency with PCK. This discussion examines changes in PCK resulting

from the PDW implementation. In the subsequent section, the impact of TCTs on student learning is discussed by comparing their performance scores.

4.1. Pedagogical Content Knowledge Changes

The increased understanding of instructional strategies and a higher understanding of CCK are likely responsible for the increased number of correct task representations following the PDW. It is reported that accurately representing tasks in a classroom is essential to learning [49]. Teachers practice these skills frequently during PDW. The workshop focused on practice, discrimination of errors, and refinement of the correct content representation. Prior research established the importance of such training [18,21,22]. It appears that teachers' PCK may change over time as they represent PCK along a continuum from immature to mature phases [18,21,22].

The present study found that teachers in the experimental group performed the correct task more frequently than those in the control group. Teachers' CCK influences demonstration quality [20]. After acquiring CCK from the PDW, researchers observed an increase in teachers' correct demonstrations [18]. Teachers rehearsed demonstrations in the workshop as they did with task representations. During this process, errors were disregarded, and proper representations were refined. Perhaps teachers should demonstrate the task to visual learners [49]. When a teacher shows students how to do something, they can better comprehend what they see. Furthermore, the scholar argues that task demonstrations require CCK [20]. Importantly, teachers cannot demonstrate a skill correctly without knowing its CCK. The PDW likely contributed to the improvement in CCK because of implementing the PDW.

Study results indicate that the experimental group received more feedback than the control group. Furthermore, the experimental group had a higher frequency of DAF deliveries than the control group. Several types of feedback were not associated with certain skills or performance aspects common in the control group, such as "nice work" or "good job". This result is consistent with literature findings indicating that teachers deliver GFs in a straightforward, simple, and positive manner [19]. However, GF does not provide specific information to students regarding their technique or skills and cannot address varying skill levels [19]. There were also significant differences between the control and experimental groups regarding teachers' DAF. This may be attributed to teachers' limited ability to detect TCT errors. In addition, they may not have identified their TCT stage before the PDW. This meant that these teachers needed to learn how to assess each student's skill performance at the appropriate developmental stage with precision [16]. Additionally, the DAF should be matched to the developmental stages of the observed students. Children need specific, corrective feedback aligned with their developmental stage to learn. Several previous studies have confirmed these findings [16,18]. Other researchers found that feedback significantly differed after the PDW and DAF-related to students' performance stages [16]. In addition, scholars found that teachers gave more concurrent feedback after participating in the CK workshop [18]. This helped them know when and how to give feedback. Unlike previous studies [16,18], this study emphasizes the importance of teachers' ability to determine students' skill levels rather than just increasing CK. During the PDW, teachers were introduced to assessment tools. Examples of TCT performance (video clips) were provided based on different skill levels to enable them to make informed decisions about students' skill levels.

Both teachers followed the PDW by adjusting the tasks in the experimental group to be more aligned with the learning objectives than in the control group. Teachers provided group-based instructional tasks before the PDW that were group-oriented. After attending the workshop, the teachers modified their instructional methods based on the children's developmental stages. Consequently, most of the tasks modified by the teachers were aligned with the students' different skill levels (stages). Researchers say PCK consists of "organizing, representing, adapting, and presenting content for instruction to accommodate learners" diverse interests and abilities [52]. The most optimal way to describe PCK

is task modification alignment. This is related to the term DAF, which is a method of adapting content to students' knowledge. Teachers were trained in developmental TCTs during PDW. Their practice included the identification of students' performances and the correlation of those performances with developmental stages. As reported elsewhere in the literature [18,20,22], these study results support the proposition that teachers' content modifications enhance PCK.

4.2. Changes in Student Performance in Tai Chi

Pretest TCT performance was similar between the experimental and control groups. It was found that TCTs in experimental groups performed significantly better than control groups from pre- to posttests. This study revealed that PE teachers improved their teaching behaviors after the CK workshop. This is similar to previous studies' findings [18,22,23]. Consequently, student performance was positively impacted. This study demonstrates the utility of the independent variable within the study context. In addition, it illustrates that the PDW content was effective. In the literature, teacher-led instruction prompts that focus on forceful performance improve scores for students at various stages of their education [53]. This study indicates that teacher PCK regarding skill-focused feedback and modified tasks significantly increased student learning. The performance of the TCTs dropped in both groups from posttest to retention test; therefore, it was worth determining whether the TCTs improved from pretest to retention test. In addition, the gain score was significantly higher in the experimental groups than in the control groups from the pre-retention test. Evidence shows that students in the experimental groups learned the skill deeper and retained it longer than their counterparts in the control groups. Hence, the experimental students demonstrated learning effects on TCTs. In contrast, students in the control groups significantly improved their pre- and posttest performance in TCTs after receiving instruction and practice. In contrast, when tested for retention, they were back at almost the same level as before the test. This indicated that there had been no long-term learning in the control groups.

Studies on the relationship between CK and PCK have consistently shown that improvements in teachers' CK lead to improved PCK on the part of teachers. This study evaluated teacher knowledge of students and teacher competence to identify student learning and teacher competence changes. The task modifications were based on the DAF. The variables used in this study are more rigorous than those used in others. They measure teachers' adaptation of instruction to meet students' needs. Researchers have argued for PCK regarding changing content and instruction [52], but very few studies have looked at students' knowledge independently. Specifically, this study sought to distinguish between different developmental stages among students and provide appropriate tasks based on their developmental stage about TCTs. This article contributes significantly to the existing literature, which will serve as a basis for teacher training practices in the future. This study also utilized TCT performance scores to assess student learning objectively. In previous studies [18,22], it has been found that the higher the inference judgment, the better the indicator of student achievement. This study focuses on middle school curricula. Middle school curricula differ from those in elementary and high schools and are a valuable topic of study for research into teaching effectiveness and student achievement. Middle school students are unlikely to face the same challenges due to their learning goals and developmental levels. This study used intact classes in naturalistic settings like other researchers [54–61]. Classes are randomly assigned to conditions in a valid naturalistic setting. This study examines how teachers' PCK contributes to students' learning using TCT performance in Chinese middle school PE settings. Undoubtedly, education has a profound impact on economic development. Education makes individuals productive citizens and contributes to economic growth [62,63]. Strong and competitive economies require a well-educated population. The achievement of the intended economic growth in China depends on implementing PCK. Our study contributes in some way to achieving Sustainable Development Goals from a Chinese perspective. Performing physical activities

(such as TCTS) is an essential component of promoting equitable and quality education at the primary and secondary levels [64–67], which is the focus of our study.

4.3. Limitations

This study has limitations. Firstly, teacher experience and familiarity with teaching TCTs may have influenced the results. Researchers chose the school and classes for this study intentionally. Before participating in this study, both teachers had different PE experiences and varying levels of knowledge regarding teaching TCTs. Second, the teachers' preferences and teaching philosophies may have influenced this study. Among the teachers, one preferred to present information visually through demonstrations. Others might prefer verbal representations, such as explanations and feedback statements, to convey information to their students. According to one of the teachers, activities were to be conducted at training stations. This may have affected students' learning and teachers' teaching behaviors (PCK). Thirdly, the sample size for each class and teacher was very small. TCT conclusions are limited to school settings and sample characteristics. To generalize the results of this study for future research, an increased number of participants (both students and teachers) will be required.

5. Conclusions

Experimental groups showed higher levels of task representation than control groups in this study. The percentage of teachers correctly demonstrating the task increased from 21% in the control groups to 94% in the experimental groups. Additionally, task modification alignment increased significantly in the experimental groups, from 21% to 94%, compared to the control groups. The mean performance scores were used for these groups' pretest, posttest, and retention tests. Pretest TCT performance scores did not differ significantly between the control and experimental classes. These groups revealed statistical similarities. Pre- and posttest scores of TCT performance gain were statistically significantly higher in experimental groups than in control groups. The gain score obtained from the post-intervention retention test was used to evaluate whether the students retained any learning from the intervention. The control and experimental groups showed significant differences in TCT performance and gain scores. In both groups, performance scores for TCTs decreased from the posttest to the retention test. Some students appear to have lost some knowledge gained during the TCT learning session. Considering the decreases in TCT scores from the post-retention test, it was determined that there were still significant effects of the pre-retention test on the students' TCT performance scores. This was determined by comparing the pretest and retention gains. TCT performance differed significantly between the control and experimental groups. The effect size of the TCT performance unit was significant, indicating that the program positively impacted students' outcomes. The PDW can potentially promote training programs for PE teachers. This may provide evidence for future recommendations regarding knowledge and skills training programs for PE teachers.

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