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ABSTRACT

This study examined the effects of AI-augmented Tai Chi instruction on students' performance and learning outcomes in secondary vocational physical education. A post-test-only quasi-experimental design was employed with 91 first-year vocational students in China, who were randomly assigned to an experimental group ($n = 46$) and a control group ($n = 45$). During an eight-week intervention, the experimental group received AI-supported Tai Chi instruction featuring motion capture and real-time corrective feedback, whereas the control group received traditional demonstration-imitation teaching. Tai Chi performance was evaluated using an IWUF-based rubric rated by three trained judges, and learning satisfaction, self-directed learning attitude, behavioral intention, and self-efficacy were measured using validated Likert-scale instruments. The results showed that the AI-assisted group achieved significantly higher overall Tai Chi performance ($p = .040$), particularly in action quality ($p = .020$). The experimental group also reported significantly greater learning satisfaction, self-directed learning attitude, and self-efficacy ($p < .05$) than the control group. However, no statistically significant difference was observed in behavioral intention. These findings suggest that AI-augmented instruction is effective in enhancing movement quality and selected psychological outcomes in vocational physical education and may serve as a valuable instructional support tool for skill-based teaching. Nevertheless, longer-term interventions may be necessary to influence students' sustained participation intentions.

Keywords: AI-assisted physical education, Tai Chi instruction,
Secondary vocational education, Self-efficacy, Learning satisfaction

I. INTRODUCTION

The profound transformative influence of artificial intelligence (AI) across diverse industries has been widely recognized, and the field of education is similarly undergoing such changes (Harry, 2023, p. 260), including physical education (PE). In recent years, AI-based motion analysis, real-time feedback systems, and intelligent coaching tools have been increasingly integrated into skill-based instruction to enhance learning efficiency and personalization (Kotte et al., 2024, p. 230). In sports scenarios, such technologies provide real-time support for athletes' training and competitions through data collection infrastructure. (Suo et al., 2024, pp. 8-9), making them particularly suitable for movement-based courses that rely on accurate action execution and posture control. However, conventional Tai Chi instruction centers on teacher demonstration and student imitation, which renders the teaching process tedious. Given the intrinsic difficulty of Tai Chi movements, students present low learning interest and efficiency, thus leading to poor teaching effectiveness. (Ren, 2021, p. 2774).

Lee and Lee (2021, p. 9) found that AI-assisted physical education courses had significant positive effects on both students' perceived physical competence [$F(1, 176) = 25.899, p < 0.001$] and physical self-expression confidence [$F(1, 176) = 15.059, p < 0.001$]. Related studies have also shown that artificial intelligence technology can improve student engagement and learning effectiveness (Zhang et al., 2025, p. 85). In parallel, motor learning theory highlights the importance of augmented feedback during early skill acquisition (Fitts & Posner, 1967, pp. 30-33), while self-efficacy theory emphasizes the role of performance-related information in shaping learners' confidence (Bandura, 1986, pp. 391-417). Together, these perspectives indicate that AI-augmented feedback may influence both performance and learner-related outcomes in technology-enhanced environments.

Despite these contributions, several limitations remain. First, empirical evidence on AI-assisted learning remains limited for culturally and technically complex skills such as Tai Chi, which demand precise movement, rhythm, and full-body coordination. Such characteristics make Tai Chi particularly suitable for AI-assisted instruction, which can provide timely and individualized movement feedback. Second, existing studies have largely overlooked secondary vocational education (SVE) students, who often lack learning motivation and classroom engagement (Fang et al., 2022, p. 1). To address these gaps, this study uses an AI-based Digital Sports Assessment Machine (AI-DSAM) to provide real-time motion feedback in Tai Chi instruction and examine AI-assisted motor learning in context.

AI-supported instructional technologies have shown increasing potential for enhancing skill acquisition in vocational education settings. Therefore, this study aims to investigate the effects of AI-augmented Tai Chi instruction in a secondary vocational PE context. Specifically, it compares AI-supported teaching with traditional demonstration-imitation instruction, examining both objective performance outcomes and learner-related variables, including learning satisfaction, self-learning attitude, behavioral intention, and self-efficacy. By situating AI-assisted instruction within a culturally meaningful motor skill and an underexplored educational population, this study seeks to provide empirical evidence for the pedagogical integration of intelligent technologies in physical education.



II. LITERATURE REVIEW

Artificial intelligence (AI) has increasingly been integrated into physical education (PE) to enhance motor learning through real-time feedback, motion analysis, and personalized guidance. Prior studies have demonstrated that technology-enhanced feedback environments can improve students' skill accuracy, engagement, and learning efficiency (Atatekin & Kara, 2024, p. 843; Zhao, 2024, p. 833). Specifically, AI systems can analyze movement data and provide instant, personalized feedback via motion capture technology (Kotte et al., 2024, p. 223). Empirical research has also documented the positive effects of video feedback, intelligent coaching systems, and AI-supported platforms on motor performance and learner motivation across various sport settings (BenitezSantiago & Miltenberger, 2016, pp. 12-27; Migliaccio et al., 2024, pp. 8-9). However, existing studies have largely focused on general fitness training, exergaming, or high-intensity sport skills, with relatively limited attention to culturally grounded and technique-sensitive activities such as Tai Chi. Moreover, research involving secondary vocational education (SVE) students remains scarce. Given the slow, coordination-intensive nature of Tai Chi and the strong feedback demands of novice learners, the pedagogical value of AI-assisted instruction in this context warrants further empirical investigation. Collectively, this evidence suggests that technology-supported physical education can improve students' motivation, engagement, and performance, particularly in skill-based learning contexts where digital tools provide instructional support and feedback (Maněnová et al., 2022).

Grounded in motor learning theory and social cognitive theory, augmented feedback can improve movement accuracy as well as enhance learning satisfaction, self-directed learning attitude, and self-efficacy (Bandura, 1986, pp. 391- 417; Fitts & Posner, 1967, pp. 30-33). To fill the identified research gaps, this study adopted a quasi-experimental design to compare the effects of AI-assisted Tai Chi instruction with traditional teaching methods among secondary vocational education (SVE) students. The following hypotheses were tested: H1: AI-assisted instruction would significantly improve students' Tai Chi performance; H2: AI-assisted instruction would significantly enhance learning satisfaction; H3: AI-assisted instruction would significantly strengthen self-directed learning attitude; H4: AI-assisted instruction would significantly increase behavioral intention toward Tai Chi participation; and H5: AI-assisted instruction would significantly improve students' self-efficacy.

III. RESEARCH METHODOLOGY

A. Research Design

This study adopted a quasi-experimental post-test-only control group design to examine the effects of AI-augmented Tai Chi instruction on secondary vocational students' skill performance and learning-related attitudes. A post-test-only approach was considered appropriate because preliminary screening confirmed that all participants had no prior formal Tai Chi learning experience, ensuring no established Tai Chi performance foundation at baseline. For psychological variables, random assignment helped reduce potential pre-existing differences, while avoiding a pre-test minimized pre-test sensitization in the natural classroom setting.

To enhance internal validity and reproducibility, a two-stage randomization procedure was implemented using R statistical software with a fixed random seed. First, two intact classes were randomly selected from the eligible Grade-1 population. Second, students within the selected classes who met the inclusion criteria were randomly assigned to the experimental and control groups. Because the study was conducted in a natural school setting using intact classes as the initial sampling units, the design is classified as quasi-experimental despite the use of reproducible random assignment procedures. The intervention lasted eight weeks. The independent variable was instructional mode (AI-assisted vs. traditional instruction), and the dependent variables



included Tai Chi performance, learning satisfaction, self-directed learning attitude, behavioral intention, and self-efficacy.

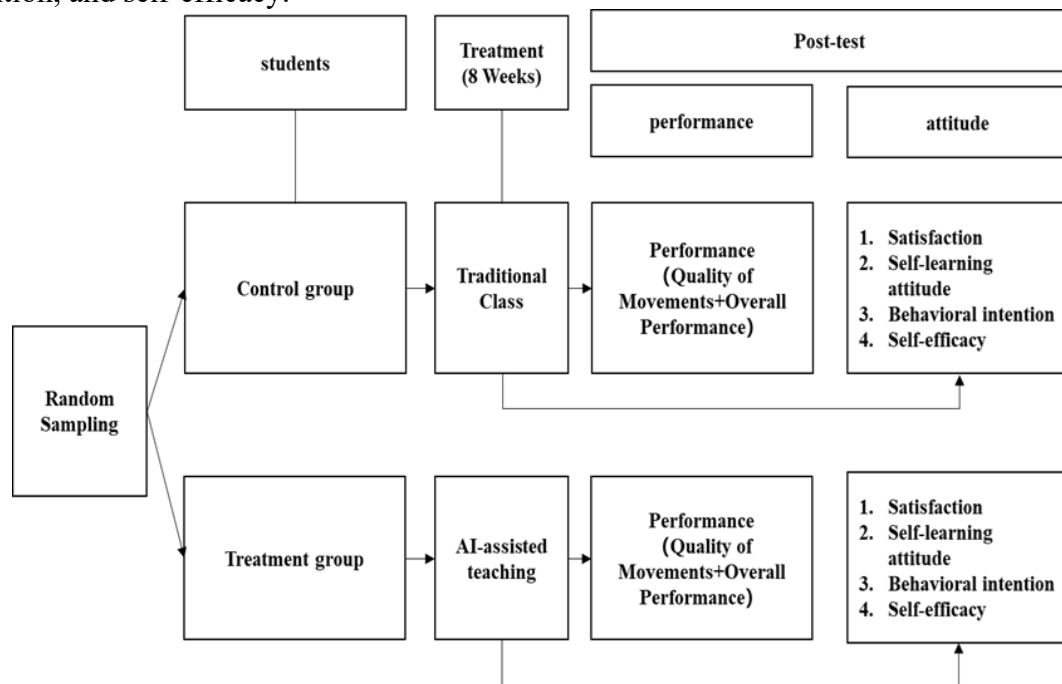


Figure 1: Research design and experimental procedure

B. Population and Participants

The study population consisted of first-year students enrolled in a secondary vocational education (SVE) school in Sichuan, China. Inclusion criteria required that students (a) were full-time vocational students aged 16–18 years, (b) regularly attended physical education classes, (c) had no prior Tai Chi or martial arts training, (d) were physically fit to participate in sports activities, and (e) provided informed consent (with guardian consent obtained for minors).

A total of 91 eligible students participated in the study. Using reproducible random assignment in R, students were allocated to the experimental group ($n = 46$) and the control group ($n = 45$). Power analysis indicated that the sample size achieved statistical power exceeding .80, suggesting adequacy for detecting medium-sized effects.

C. Instructional Intervention

Both groups completed an eight-week Tai Chi instructional program (one 90-minute session per week) based on the standardized 24-form Tai Chi routine required by the school curriculum. To ensure treatment fidelity, instructional content, duration, teacher, and learning objectives were kept consistent across groups.

The control group received traditional teacher-centered instruction consisting of live demonstration, verbal explanation, and repeated student imitation with teacher-provided corrective feedback.

The experimental group received AI-assisted instruction supported by an AI Digital Sports All-in-one Machine (AI-DSAM). The system provided 3D motion demonstrations, skeletal motion capture, real-time error prompts, and automated visual feedback. The AI-DSAM system captured students' real-time skeletal movement trajectories, compared them with standard Tai Chi movement models, scored detected deviations, and generated visual and audio prompts. Students practiced in rotating small groups using six AI devices while the teacher remained present to provide pedagogical guidance. In this study, the AI system functioned as a feedback enhancement tool rather than a replacement for the instructor. To minimize contamination,

the two groups were taught at different times and locations, and only the experimental group used the AI-DSAM devices during the intervention.

D. Research Instruments and Quality Inspection of Instruments

Tai Chi performance was assessed using a rubric adapted from the International Wushu Federation (IWUF) competition rules, covering two dimensions: action quality and performance level (5 points each; total score = 10). Students' performances were video-recorded and independently evaluated by three certified martial arts teachers.

Inter-rater reliability was examined using the intraclass correlation coefficient (ICC) based on a two-way random-effects model with average measures. The average-measures ICC showed good agreement among raters (ICC = .84, 95% CI [.78, .89]), supporting the reliability of the performance assessment. The mean of the three raters' scores was used for subsequent analyses.

Learning satisfaction was measured using a 12-item scale adapted from the Student Evaluation of Educational Quality (SEEQ) (Vernadakis et al., 2012, pp. 141-142). Self-directed learning attitude and behavioral intention were measured using 3-item scales adapted from Zheng et al. (2021, p. 8). Self-efficacy was assessed using the General Self-Efficacy Scale (Chen et al., 2001, p. 79). All items were rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Prior to the main study, three experts in physical education and martial arts reviewed the instruments to ensure content validity. A pilot test (n = 30) demonstrated satisfactory internal consistency, with Cronbach's α values exceeding the recommended threshold of .70.

Table 1: Reliability statistics of questionnaire instruments (pilot test, n = 30)

Variable	Number of Items	Previous Research α	Pilot Test α
Satisfaction	12	0.90	0.908
Self-learning Attitude	3	0.898	0.867
Behavioral Intention	3	0.902	0.925
Self-efficacy	8	0.90	0.938

Note. Cronbach's α values above .70 indicate acceptable internal consistency.

E. Data Collection

Ethical approval was obtained prior to data collection (Approval No. 120/2025). Participation was voluntary, and parental consent was secured for underage students.

Data collection followed three stages. First, students were randomly assigned and completed the eight-week instructional intervention. Second, Tai Chi performance assessments were conducted in a standardized gymnasium setting using video recording. Third, questionnaires measuring satisfaction, self-directed learning attitude, behavioral intention, and self-efficacy were administered during regular class time. All 91 returned questionnaires were complete and valid for analysis.

F. Data Analysis

Data were analysed using Jamovi. Descriptive statistics (means and standard deviations) were computed for all variables. Normality and homogeneity of variance were examined using Shapiro-Wilk tests and Levene's tests before group comparisons. Independent samples t-tests were conducted to examine group differences between the AI-assisted and traditional instruction conditions. When Levene's test indicated violation of the homogeneity of variance assumption, Welch's t-test results were consulted.



The significance level was set at $\alpha = .05$. Effect sizes (Cohen's d) were reported to evaluate the magnitude of observed differences.

IV. RESULTS

A. Descriptive Statistics

Descriptive statistics for the primary study variables are presented in Table 2. Overall, students in the AI-assisted group demonstrated slightly higher mean scores than those in the traditional instruction group across most outcome variables. The differences were most evident in action quality, learning satisfaction, self-directed learning attitude, and self-efficacy, whereas the gap in behavioral intention was relatively modest.

Table 2: Descriptive Statistics of Major Variables by Group

Variable	Group	Mean	SD
Action Quality	Control	3.38	0.23
	Experimental	3.48	0.18
Practice Level	Control	3.39	0.28
	Experimental	3.44	0.22
Total Performance	Control	6.77	0.42
	Experimental	6.92	0.29
Learning Satisfaction	Control	3.49	0.38
	Experimental	3.73	0.32
Self-directed Learning Attitude	Control	3.69	0.59
	Experimental	3.96	0.51
Behavioral Intention	Control	3.38	0.69
	Experimental	3.58	0.35
Self-efficacy	Control	3.39	0.55
	Experimental	3.59	0.28

Note. Control group ($n = 45$); experimental group ($n = 46$).

B. Effects on Tai Chi Performance

Independent samples t -tests were conducted to examine whether AI-assisted instruction significantly improved Tai Chi performance (Table 3).

Results indicated that the experimental group scored significantly higher than the control group in total performance. A significant between-group difference was also found in action quality, with a medium effect size.

However, the difference in practice level was not statistically significant, suggesting that the AI intervention mainly improved movement precision rather than overall practice fluency. This may be because action quality reflects discrete movement accuracy, whereas practice level involves broader rhythm, fluency, and overall performance stability that may require a longer training period.



Table 3: Independent Samples t-Test Results for Tai Chi Performance

Variable	t	df	p	Cohen's d	Interpretation
Action Quality	-2.37	89	.020*	0.50	Significant
Practice Level	-1.08	89	.285	0.23	Not significant
Total Performance	-2.09	89	.040*	0.44	Significant

C. Effects on Learning Attitudes

To evaluate the broader psychological impact of AI-assisted instruction, independent samples t-tests were conducted on learning satisfaction, self-directed learning attitude, behavioral intention, and self-efficacy (see Table 4). The results revealed that students in the AI-assisted group scored significantly higher in learning satisfaction, self-directed learning attitude, and self-efficacy, with all effect sizes in the small-to-medium range. In contrast, no statistically significant difference was found in behavioral intention between the two groups, though the experimental group had a descriptively higher mean score.

Table 4: Independent Samples t-Test Results for Learning Attitude Variables

Variable	t	df	p	Cohen's d	Interpretation
Learning Satisfaction	-2.09	89	.020*	0.44	Significant
Self-directed Learning	-2.31	89	.023*	0.49	Significant
Behavioral Intention	-1.74	89	.084	0.37	Not significant
Self-efficacy	-2.19	89	.031*	0.46	Significant

D. Summary of Findings

Taken together, the results demonstrate that AI-assisted Tai Chi instruction produced statistically significant improvements in students' technical performance and several key learning-related attitudes. Specifically, the AI-supported group showed superior outcomes in total performance, action quality, learning satisfaction, self-directed learning attitude, and self-efficacy.

However, the intervention did not yield a statistically significant effect on behavioral intention. This pattern suggests that AI-enhanced motion feedback may be particularly effective in improving proximal learning outcomes, whereas influencing students' longer-term participation intentions may require more sustained or comprehensive interventions.

V. CONCLUSION AND DISCUSSION

The present study investigated the effects of AI-augmented Tai Chi instruction on secondary vocational students' motor performance and learning-related attitudes. The findings indicate that students who received AI-supported instruction demonstrated significantly higher overall Tai Chi performance, particularly in action quality, compared with those receiving traditional teaching. In addition, the experimental group reported significantly greater learning satisfaction, self-directed learning attitude, and self-efficacy. However, no statistically significant difference was observed in behavioral intention. Overall, the results suggest that integrating AI-based motion feedback into Tai Chi instruction can effectively enhance proximal learning outcomes in vocational physical education, especially in terms of movement precision and learner psychological engagement.

The observed performance and attitudinal advantages may be attributed to the real-time feedback, visualized movement analysis, and individualized error correction provided by the AI system, which together strengthened the feedback loop essential for motor learning. From the perspective of motor learning theory, such augmented feedback may help learners identify movement errors and refine motor execution during skill acquisition (Fitts & Posner, 1967, pp. 30-33). The improvement in self-efficacy also aligns with self-efficacy theory, as timely



performance feedback may strengthen learners' confidence in completing Tai Chi movements (Bandura, 1986, pp. 391-417). This result is consistent with studies on AI-supported physical education and motion-based feedback systems, which suggest that digital feedback can support motor skill development and learning experiences (Atatekin & Kara, 2024, p. 843; Kotte et al., 2024, p. 223; Lee & Lee, 2021, p. 9; Chen et al., 2020, p. 75275). At the same time, the non-significant change in behavioral intention suggests that short-term instructional interventions-even when technologically enhanced-may have limited influence on students' longer-term exercise intentions, which are often shaped by broader motivational and contextual factors. This finding may also be related to the novelty effect of AI-assisted learning, in which students' attention may have been directed more toward the immediate experience of using new technology than toward forming stable long-term participation intentions. This pattern aligns with earlier studies noting that while digital supports can improve immediate learning experiences, sustained behavioral change typically requires longer exposure and ecological reinforcement. Therefore, AI-assisted physical education should be viewed as a powerful instructional support rather than a standalone solution for promoting long-term physical activity engagement.

VI. SUGGESTION

Based on the findings of this study, several practical and research-oriented suggestions can be proposed. From an instructional perspective, educators in vocational physical education may consider integrating AI-supported motion feedback systems as a supplementary tool to enhance movement accuracy and learner engagement, particularly during the early stages of skill acquisition. However, successful implementation requires appropriate alignment among class size, equipment availability, and teaching organization to ensure that technological support translates into meaningful learning benefits. AI systems should be positioned as feedback-enhancement tools that complement, rather than replace, teacher guidance. Because this study was conducted in one secondary vocational school in Sichuan, China, the findings should be interpreted within this specific context. For future research, longer intervention periods and longitudinal designs are recommended to better examine whether AI-assisted instruction can influence students' sustained participation intentions in Tai Chi and other physical activities. Expanding the sample to multiple schools and learner populations would also help strengthen the generalizability of the findings. In addition, future studies may incorporate mixed-method designs, such as classroom observations or learner interviews, to further explore how students interact with AI feedback during motor learning. Such efforts would contribute to a more comprehensive understanding of the pedagogical role of artificial intelligence in skill-based physical education.

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