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Practical Paths of Low-Cost AI Digital Tools Empowering Precise Orienteering Teaching

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Abstract: Against the backdrop of digital transformation in university physical education, high equipment costs and complex operation restrict the large-scale application of intelligent teaching in orienteering courses. This study constructs a low-cost AI digital empowerment teaching framework based on the MTE three-dimensional model (Motivation-Technology-Evaluation), integrating free mobile AI assistants, campus learning platforms and lightweight trajectory analysis tools to solve prominent pain points including single teaching evaluation, inefficient manual data processing and disconnection between technology and classroom teaching. Taking 250 undergraduates from a private university in Shaanxi as research objects, this research adopts mixed research methods of questionnaires, teaching experiments and action research to design a three-stage closed-loop teaching path of pre-class AI preview, in-class real-time data collection and post-class personalized feedback. The results show that the proposed low-cost AI system cuts teachers' manual data sorting time by over 62%, raises students' orienteering skill compliance rate to 87.2%, and boosts overall course satisfaction to 91.6%. The constructed multi-dimensional differentiated formative evaluation system fully stimulates learning motivation of students with different physical and logical strengths. This paper forms a replicable low-cost digital teaching implementation path for orienteering, providing practical references for sports teaching reform in colleges and universities with limited educational funds.

1. Introduction

1.1 Research Background

Orienteering integrates physical endurance, spatial logic judgment and team collaboration, which fits the core goal of "Health First, Lifelong Sports" in university physical education curriculum reform. Traditional orienteering teaching mainly relies on manual timing and subjective scoring, with three prominent drawbacks: over-reliance on final running speed for assessment, heavy manual data sorting burden for teachers, and unaffordable high-end intelligent positioning equipment for

budget-strapped private universities.

Lightweight free educational AI tools provide a low-cost technical solution for precise sports teaching. However, existing studies mostly rely on paid commercial software or high-cost hardware, lacking systematic low-budget teaching paths matched with differentiated formative evaluation[6][4].Few papers construct a full-process closed-loop teaching model combining low-cost AI and multi-dimensional evaluation, failing to supply operable reform schemes for frontline physical education teachers. Many digital teaching practices simply superimpose intelligent tools without matching curriculum content and evaluation reform, leading to disconnection between technology and classroom teaching[6]. Some scholars have developed mobile orienteering teaching tools, but most require paid deployment and cannot be popularized in resource-limited colleges[2]. In terms of intelligent trajectory tracking technology, existing algorithms mostly rely on expensive professional positioning hardware, which cannot be applied to daily university physical education teaching on a large scale[9].

1.2 Research Questions

1) How to integrate free lightweight AI digital tools to build a low-cost technical support system for orienteering precise teaching under funding constraints?

2) What closed-loop teaching path guided by MTE three-dimensional empowerment logic can low-cost AI tools form to empower orienteering courses?

3) What teaching effects can the low-cost AI teaching system exert on students' learning motivation, skill mastery and course satisfaction?

1.3 Research Significance

Theoretically, this study expands the application boundary of low-cost educational AI in outdoor sports teaching, constructs the MTE collaborative theoretical framework of "motivation traction-technology support-evaluation guarantee", and enriches the research system of digital orienteering teaching reform. Practically, the research adopts zero-fee public AI tools and existing campus platforms without purchasing expensive dedicated equipment, forming an operable, low-budget and replicable teaching path that can be promoted to resource-limited private and vocational colleges[6].

2. Theoretical Framework and Core Concept Definition

2.1 MTE Three-Dimensional Empowerment Theoretical Framework

The core framework of this research includes three mutually coupled dimensions:

1) Motivation Stimulation (M): Design three-tier hierarchical orienteering content (basic adaptation layer, ability improvement layer, interest expansion layer) and differentiated incentive evaluation to eliminate learning burnout caused by mismatched task difficulty[7][3];

2) Technology Empowerment (T): Take low-cost free AI digital tools as carriers to automatically collect trajectory, checkpoint time consumption and route deviation data, reduce teachers' repetitive manual work and provide objective data support for targeted teaching diagnosis[9];

3) Evaluation Guarantee (E): Establish a multi-dimensional formative evaluation system covering theoretical cognition, technical operation, physical fitness and team collaboration, set differentiated scoring weights for students with different strengths, and deliver personalized learning feedback within 24 hours, optimizing the single speed-oriented evaluation mode of traditional orienteering courses[7].

The three dimensions form an organic closed loop: low-cost AI provides data support for differentiated evaluation; evaluation results generate personalized training tasks to activate internal learning motivation; hierarchical learning tasks produce new teaching data to optimize AI analysis logic, realizing mutual promotion of technology, evaluation and motivation.

2.2 Definition and Classification of Low-Cost AI Digital Tools

Low-cost AI digital tools refer to free or low-expense lightweight software and hardware deployable on teachers' and students' mobile phones, campus cameras and existing learning platforms, without purchasing dedicated intelligent sports equipment. The tool combination adopted in this study is shown in Table 1.

Table 1 Classification and Functions of Low-Cost AI Digital Tools for Orienteering Teaching

Tool Category	Specific Tools	Core Teaching Functions	Cost Expense
AI Trajectory Analysis Tools	Tencent Education AI Assistant, Mobile Phone Camera Video Capture	Automatically identify running tracks, calculate route deviation rate, generate individual skill defect reports	Free of charge
Campus Cloud Teaching Platform	Chaoxing Learning Platform	Data archiving, preview material push, real-time teacher-student interaction	Included in campus annual platform fee
Auxiliary Interactive Tools	WeChat Mini Program, Open VR Map Resources	Pre-class VR venue preview, after-class team review, online honor ranking display	Open-source free resources
Hardware Upgrade	Existing 20 sets of campus electronic checkpoints	Firmware upgrade to realize trajectory data export	One-time maintenance cost: 2,000 RMB

2.3 Precise Orienteering Teaching

Different from traditional unified indoctrination teaching, precise orienteering teaching relies on student motion data captured by AI tools to arrange differentiated learning tasks, carry out targeted technical guidance and implement personalized evaluation, realizing student-centered adaptive teaching for groups with different physical fitness and spatial logic abilities.

3. Research Methods

3.1 Literature Analysis Method

This study retrieves domestic and foreign literatures on digital orienteering teaching, AI physical education application and multi-dimensional formative evaluation from Web of Science, CNKI and other databases. It sorts out the limitations of existing intelligent sports teaching relying on high-cost equipment, and draws on NASPE physical education evaluation standards and DNA dual-spiral evaluation model to lay theoretical support for the construction of MTE framework[8].

3.2 Mixed Quantitative-Qualitative Research Method

3.2.1 Research Objects

A total of 250 non-sports major undergraduates taking orienteering elective courses in a private

university in Shaanxi are selected as samples, randomly divided into experimental group (125 students, low-cost AI digital teaching) and control group (125 students, traditional manual teaching). Pre-test data show no significant difference in orienteering theory, physical endurance and map reading ability between the two groups (P>0.05). Five PE teachers and three outdoor sports industry experts are invited for semi-structured interviews.

3.2.2 Measurement Instruments

1) Orienteering Learning Motivation Questionnaire (Cronbach's α=0.872), covering learning interest, sense of gain, self-efficacy and participation initiative;

2) Course Satisfaction Scale (Cronbach's α=0.849), including teaching content, technical assistance and evaluation rationality;

3) Objective skill test indicators: map reading accuracy, route planning rationality, checkpoint completion rate and team collaboration performance.

3.3 Action Research Method

Following the "Plan-Implement-Observation-Reflection" cycle, three rounds of pilot teaching are carried out: small-scale pilot to test AI tool matching, large-scale pilot to optimize differentiated evaluation weights, cross-school pilot to verify the universality of the teaching path, with iterative adjustment after each round based on data and expert suggestions.

3.4 Mathematical Statistics Method

SPSS 26.0 is adopted for independent sample t-test, descriptive statistics and correlation analysis to compare the teaching outcome differences between the experimental group and the control group.

4. Construction of Low-Cost AI Digital Empowerment Closed-Loop Teaching Path

Based on MTE three-dimensional empowerment logic, this study builds a whole-process precise teaching path covering pre-class, in-class and post-class with low-cost AI digital tools as the core carrier (Path logic: Pre-class AI preview → In-class real-time data collection & AI analysis → Post-class differentiated evaluation & motivational feedback → Hierarchical task optimization for next teaching cycle).

4.1 Pre-class: Low-cost AI Preview Module for Differentiated Teaching Preparation

Relying on free open VR map resources and Chaoxing platform to realize zero-cost pre-class preview: Teachers upload electronic orienteering maps and map recognition exercises; students complete VR venue roaming on mobile phones, and AI automatically marks wrong operation points to generate personal pre-learning defect lists. Teachers divide students into basic, intermediate and advanced levels based on preview data and release matched hierarchical tasks in advance to avoid difficulty mismatch.

4.2 In-class: Real-time AI Data Collection for Dynamic Precise Guidance

This is the core technical link of low-cost empowerment. After upgrading existing electronic checkpoints with 2,000 RMB, teachers use mobile phones to record students' running trajectories, upload videos and checkpoint data to free AI assistants to automatically calculate route deviation rate and checkpoint dwell time, and output real-time skill defect labels. Teachers view AI analysis results on mobile terminals and provide targeted one-on-one guidance instead of unified general explanations. The test proves that AI automatic analysis reduces teachers' per-class data sorting time

from 8.2 hours to 2.9 hours, cutting labor cost by 64.6%.

4.3 Post-class: AI-Assisted Differentiated Formative Evaluation and Motivational Closed Loop

Breaking the single speed-oriented scoring mode, this study designs differentiated evaluation weight standards for logic-dominant and fitness-dominant students (Table 2). All data are automatically summarized by the campus platform, and AI generates individual formative evaluation reports within 24 hours to mark students' strengths and weaknesses. Meanwhile, multi-dimensional honors including Logic Star, Collaboration Star and Progress Star are set to replace single speed awards, fully stimulating learning motivation of students with weak physical fitness.

Table 2 Differentiated Formative Evaluation Index Weight System Assisted by Low-Cost AI

Primary Dimension	Secondary Indicators	Weight for Logic-dominant Students	Weight for Fitness-dominant Students	Data Source
Cognitive & Strategic Ability	Map reading accuracy, route planning rationality	45%	20%	AI trajectory analysis, pre-class test
Sports Technical Performance	Checkpoint speed, running standardization	20%	45%	Electronic checkpoint timing, video recognition
Learning Process Performance	Class participation, progress value, teamwork	35%	35%	Platform learning records, WeChat clock-in data

4.4 Project Budget Control

The total special fund for digital reform is 10,000 RMB, allocated as follows: 800 RMB for printing, 2,000 RMB for checkpoint hardware upgrade, 6,000 RMB for paper publication, expert consultation and cross-school exchange, and 1,200 RMB as emergency reserve.

This budget strictly follows the low-cost research orientation and eliminates costly specialized intelligent sports facilities like professional GPS trackers and commercial paid teaching platforms. The 2,000 RMB hardware fund only upgrades the school's existing 20 sets of checkpoints instead of buying new devices, cutting at least 15,000 RMB in equipment procurement costs. The 6,000 RMB comprehensive fund balances academic publishing, expert consultation and inter-college exchange, supporting the formation of replicable teaching guidelines for other institutions. The small emergency fund covers unexpected equipment maintenance and temporary pilot expansion without extra budget approval. Most core teaching links adopt free open AI tools and the campus's existing learning platform, requiring no additional technical service fees. Conventional intelligent orienteering reforms usually cost over 30,000 RMB; this scheme slashes total investment by two-thirds, offering a feasible digital transformation path for colleges with tight sports budgets.

The whole reform relies on free public tools without purchasing high-end positioning equipment, greatly lowering the threshold of digital teaching reform.

5. Empirical Results and Analysis of Teaching Effects

5.1 Comparison of Teaching Efficiency Indicators

As shown in Table 3, the low-cost AI system significantly reduces teachers' manual workload and statistical errors, and realizes timely student feedback within 24 hours, effectively solving the pain point of delayed diagnosis in traditional teaching.

Table 3 Comparison of Teachers' Data Processing Indicators between Two Groups

Indicator	Experimental Group	Control Group	Reduction Rate
Average per-class data sorting time	2.9 h	8.2 h	64.6%
Trajectory statistics manual error rate	2.1%	16.8%	—
Student feedback cycle	Within 24 h	7–14 days	—

5.2 Comparison of Students' Learning Outcomes

Independent sample t-test results (Table 4) show that all core indicators of the experimental group are significantly superior to the control group ($P<0.001$). The proportion of students with low learning motivation drops to 12.8%, skill compliance rate reaches 87.2%, and course satisfaction rises to 91.6%, fully meeting the preset research targets.

Table 4 Post-test Learning Outcome Comparison (Mean ± SD)

Measurement Index	Experimental Group (n=125)	Control Group (n=125)	t-value	P-value
Orienteering skill compliance rate	87.2%	63.5%	11.362	<0.001
Total learning motivation score (100 full)	86.43 ± 5.12	72.18 ± 6.35	18.745	<0.001
Course satisfaction score (100 full)	91.61 ± 4.87	70.54 ± 7.21	21.093	<0.001
Proportion of low-motivation students	12.8%	38.4%	—	—

5.3 Qualitative Interview Findings and Practical Limitations

Interviews with teachers and experts confirm that the low-cost AI path has low deployment threshold and strong operability; the differentiated evaluation system realizes inclusive teaching for students with different strengths. Student feedback reflects that personalized AI defect reports clarify learning objectives, and diversified honor incentives reduce the frustration of students with poor physical fitness.

Typical feedback from interviewed PE teachers further reflects the practical value of this set of tools. One teacher stated that before adopting the AI-assisted system, he had to stay after class for nearly one workday to sort out hundreds of students' manual timing records, and frequent handwritten recording errors made it impossible to accurately locate students' weak points in map reading and route selection. After applying free AI trajectory analysis tools, all trajectory data and checkpoint consumption data can be automatically summarized within ten minutes after class, which greatly releases teachers' energy for targeted individual tutoring.

From the student interview perspective, students with weak physical fitness mentioned that the original single speed scoring rule made them lose interest in orienteering after several classes, while

the multi-dimensional evaluation gives them chances to win the “Logic Star” and “Progress Star” by optimizing route schemes, which significantly enhances their sense of learning achievement. Outdoor industry experts also pointed out that most college orienteering digital reform schemes ignore the actual budget constraints of private universities, and this low-cost technical integration mode provides a down-to-earth implementation template for grassroots sports teaching.

There are three practical limitations: free AI tools have single video upload capacity limits; trajectory analysis accuracy declines slightly under complex campus terrain; the research sample is limited to non-sports majors in private universities, requiring targeted adjustment when promoted to other types of colleges.

6. Discussion, Conclusion and Promotion Suggestions

6.1 Core Discussion of Research Findings

First, low-cost AI digital tools break the fund barrier of intelligent physical education. Most previous AI-assisted orienteering teaching studies rely on expensive professional positioning equipment and paid commercial software, which cannot be popularized in grassroots colleges with tight sports budgets. This research only invests a small amount of maintenance cost for existing electronic checkpoints, with the main technical carriers being zero-cost mobile AI tools and existing campus platforms. The replicable low-budget path effectively solves the high-cost bottleneck of outdoor sports digital teaching.[1]

Second, MTE three-dimensional synergy avoids the formalized trap of “technology stacking”. Many digital teaching practices simply superimpose intelligent tools without matching curriculum content and evaluation reform, leading to disconnection between technology and classroom teaching[6]. This research takes MTE three-dimensional empowerment as the core logic, with motivation stimulation as the teaching design starting point, low-cost AI as the data support carrier, and differentiated multi-dimensional evaluation as the quality guarantee. The three dimensions restrict and promote each other, realizing deep integration of technology and pedagogy rather than superficial technical display[5].

Third, AI-assisted differentiated formative evaluation conforms to the goal of all-round student development. Traditional orienteering evaluation overemphasizes running speed and ignores spatial logic thinking and team collaboration ability. The variable-weight evaluation system constructed in this study fully recognizes the respective advantages of logic-oriented students with weak physical fitness and endurance-oriented students with ordinary planning ability, forms a multi-dimensional incentive mechanism, and completes the transformation from single result evaluation to whole-process formative evaluation, echoing the “Health First” educational concept[7].

6.2 Main Research Conclusions

1) This research constructs a set of operable low-cost AI digital tool combinations suitable for university orienteering teaching, with total reform investment controlled within 10,000 RMB. The system reduces teachers’ manual data processing workload by over 60%, and improves the objectivity and timeliness of teaching diagnosis.

2) Guided by MTE three-dimensional empowerment framework, a closed-loop precise teaching path covering pre-class AI preview, in-class real-time trajectory analysis and post-class differentiated formative evaluation is formed, realizing organic coupling of technology, evaluation and learning motivation stimulation.

3) Teaching experiments verify that the low-cost AI empowerment path can significantly improve students’ orienteering skill mastery and course satisfaction, reduce the proportion of

low-motivation students below 15%, and build a benign cycle of "evaluation promotes participation, participation improves learning interest".

4) The multi-dimensional differentiated evaluation system breaks the single speed scoring mode of traditional orienteering courses, realizes inclusive adaptive teaching for students with different physical and logical characteristics, and enriches the practical system of formative evaluation in university physical education.

6.3 Promotion and Optimization Suggestions

1) For colleges without electronic checkpoints: Rely entirely on mobile phone GPS recording and free AI trajectory analysis, cancel hardware upgrade expenditure and lower total reform cost below 5,000 RMB[2].

2) Compile simplified operation guidelines for PE teachers to reduce the technical learning threshold of lightweight AI tools and optimize video segmentation operation flow.

3) Expand research samples to public undergraduate colleges and vocational schools, adjust evaluation index weights according to student groups with different sports foundations to form differentiated promotion versions of the teaching path.

4) Integrate open-source map generation plug-ins into the campus learning platform to realize one-click automatic generation of electronic orienteering maps and further improve pre-class preview efficiency.

6.4 Research Prospect

Subsequent research can introduce low-cost lightweight wearable bracelets to collect real-time heart rate data of students, expand AI multi-dimensional data analysis indicators, and build a comprehensive precise teaching early warning system integrating trajectory, speed and physiological indicators. In addition, the MTE three-dimensional empowerment path can be transplanted to cross-country running, ball games and other outdoor physical education courses to form a universal low-cost AI digital reform model for university physical education.

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