



Exploration of the Digitally Empowered PDCA Teaching Model in Computer Practical Teaching

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Abstract. To address the pain points of traditional teaching in traditional computer practical teaching—such as lack of personalization, low efficiency, and vague evaluation—a digitally empowered PDCA teaching model is constructed. With PDCA closed-loop management at its core, the model integrates technologies including AI recommendation algorithms and big data analysis, and incorporates tools such as Educoder's knowledge graph, China University MOOC's intelligent recommendation, and Tongyi Lingma. It builds a full-process system of "personalized planning - efficient implementation - precise evaluation - continuous optimization". Verification through teaching practice in universities shows that the model significantly improves students' programming skills and teaching quality, providing a replicable solution for the reform of computer-related practical courses.

Keywords: PDCA; Digital Intelligence Empowerment; Computer Practical Teaching; Personalized Teaching; Precise Evaluation

1 Introduction

As a classic quality management method, the PDCA cycle has long been applied in the field of education [1]. It provides a theoretical framework for the iterative optimization of teaching through the closed loop of "Plan-Do-Check-Act" [2]. However, in traditional scenarios of computer practical courses, the PDCA cycle has long faced implementation bottlenecks: it over-relies on teachers' subjective experience, making it difficult to adapt to individual differences among students [3]; and it lacks technical support in task design, process guidance, and quality evaluation, resulting in "a cycle that fails to form a closed loop and unsustained improvement".

In recent years, the rapid development of digital intelligence technologies has provided key support for the implementation of PDCA [4]. The maturity of AI recommendation algorithms, big data analysis, and online programming platforms [5], along with the construction of the "teacher-machine-student" ternary intelligent education ecosystem [6], has enabled the PDCA cycle to transform from a theoretical framework into actionable teaching practice. The integrated application of tools such as Educoder,

China University MOOC, Tongyi Lingma, and Wisdom Tree [7] has built a digital support environment covering the entire teaching process, breaking the implementation barriers of traditional PDCA.

Taking the practical course of C Language Programming as an example, this paper constructs a digitally empowered PDCA teaching model. By deeply integrating digital intelligence technologies with teaching processes, it addresses the pain points of traditional teaching and realizes the full-cycle optimization of teaching.

2 Design of the Digitally Empowered PDCA Teaching Model

Based on the concept of PDCA closed-loop management and combined with the teaching characteristics of C Language Programming, a four-in-one teaching model of "technical support - platform empowerment - process implementation - goal achievement" is constructed, with the overall framework shown in Figure 1. The model integrates AI and big data technologies throughout all PDCA stages, leverages the synergy of tools such as Educoder and China University MOOC, and achieves personalized, efficient, precise, and sustainable teaching.

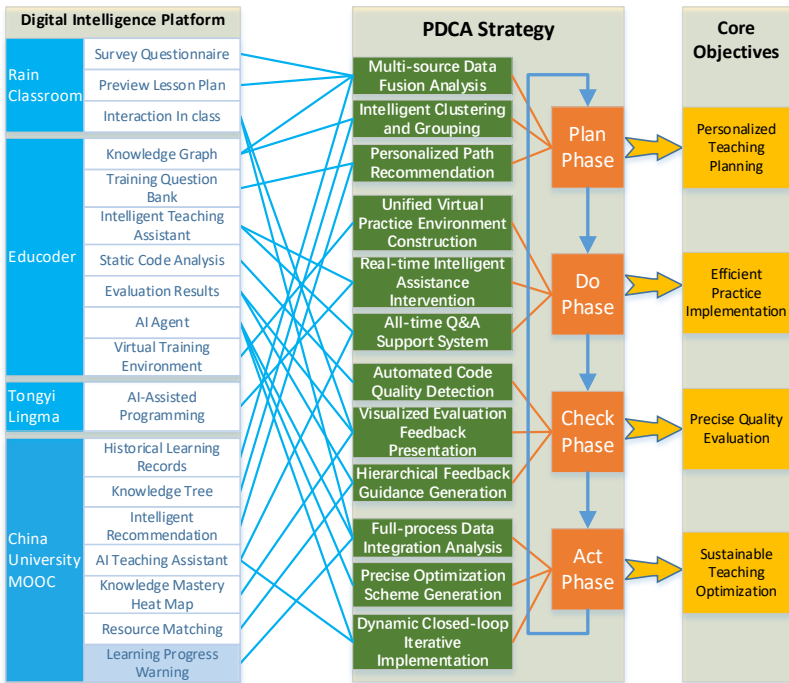


Fig. 1. Overall Framework of the Digitally Empowered PDCA Computer Practical Teaching Model

2.1 Plan: From Experience-Based Preset to Data-Driven Personalized Planning

Guided by the theories of educational data mining and cognitive load, the Plan stage accurately identifies learners' knowledge gaps and cognitive levels through data mining, and matches them with appropriate learning tasks. This avoids cognitive imbalance—where "underperforming students feel overwhelmed and top students feel unchallenged"—and realizes differentiated teaching planning. The following digital empowerment strategies can be adopted in this stage.

Multi-source Data Fusion Analysis.

Breaking the limitation of single-performance data, pre-class preview behavior data (duration, interaction level, error distribution in exercises) is collected via Rain Classroom; core knowledge point mastery is scanned through Educoder's knowledge graph; and historical learning records (resource preferences, quiz accuracy, learning rhythm) are extracted from China University MOOC. This builds a three-dimensional profile covering "behavior + ability + preference".

Intelligent Clustering and Grouping.

Based on the K-Means algorithm, students are divided into three groups—"foundation-weak", "intermediate-level", and "advanced-progressive"—using indicators such as the breadth of knowledge mastery, knowledge association ability, and self-directed learning efficiency. Compared with traditional subjective grouping by teachers, algorithm-based grouping is objective, comprehensive, and reproducible.

Personalized Path Recommendation.

In line with the theory of differentiated teaching, adaptive learning paths are designed for different groups: foundation-weak students focus on knowledge supplementation, matching basic tasks and micro-courses with low cognitive load; advanced-progressive students focus on ability expansion, with recommendations of high-challenge comprehensive projects and innovative tasks.

In this process, teachers' "planning" shifts from "experience-based speculative design" to "data-driven precise diagnosis". Teaching planning transforms from "teacher-centered experience-led" to "student-centered needs-led", aligning with the development trend of personalization and precision in modern education.

2.2 Do: from Passive Waiting to Real-Time Supported Efficient Practice

Centered on constructivist learning theory and scaffolding instruction theory, the Do stage ensures students "continuously construct knowledge without detours" in programming practice through real-time environment support and immediate guidance. It fo-

cuses on core competency development and avoids interruptions to knowledge construction due to obstacles. The following digital empowerment strategies can be adopted:

Construction of a Unified Virtual Practice Environment.

Relying on Educoder's virtual programming environment, a unified C language compilation environment, test case system, and code management functions are provided. This solves problems in traditional offline environments—such as inconsistent configurations, easy code loss, and difficult practice tracking—and eliminates interference from tool barriers in knowledge construction.

Real-Time Intelligent Assistance Intervention.

Tongyi Lingma is integrated as an intelligent auxiliary tool, providing real-time syntax error correction, logical prompts, and code optimization suggestions during programming. Following the "scaffolding" principle of "supporting while guiding", it offers guidance rather than direct answers, avoiding over-reliance on assistance.

All-Time Q&A Support System.

A collaborative Q&A network combining "intelligence + human assistance" is built: basic questions are answered instantly by Educoder's intelligent teaching assistant; complex logical questions are analyzed step-by-step by China University MOOC's AI teaching assistant; and personalized difficult questions are referred to teachers for supplementary support. This ensures the continuity of the practice process.

In this process, students' "practice" shifts from "passive waiting and frequent interruptions" to "active construction and continuous progress". Practice obstacles are transformed from "barriers to competency development" into "opportunities for breakthrough with support", achieving the dual goals of improving practice efficiency and competency.

2.3 Check: from Single Evaluation to Multi-Dimensional Feedback for Precise Assessment

Supported by Bloom's Taxonomy of Educational Objectives and educational evaluation theory, the Check stage builds a multi-dimensional evaluation system covering "result + process + ability". It breaks the traditional single "result-only" model and realizes the core function of "evaluation as guidance". The following digital empowerment strategies can be adopted.

Automated Code Quality Detection.

Based on Bloom's Taxonomy, code quality is evaluated from three dimensions—"correctness (application level), efficiency (analysis level), and readability (evaluation level)". This covers core elements of programming ability and avoids the limitations of superficial evaluation that only focuses on "whether the code runs correctly".

Visualized Evaluation Feedback Presentation.

Using China University MOOC's "knowledge point mastery heat map" and Educoder's personal evaluation report, abstract data is converted into intuitive charts. At the class level, common weak knowledge points are presented; at the individual level, specific problems and associated knowledge points are marked. This reduces the cost of data interpretation for teachers and students.

Hierarchical Feedback Guidance Generation.

Adaptive improvement suggestions are provided for students at different levels: foundation-weak students focus on knowledge supplementation; intermediate-level students focus on ability enhancement; advanced-progressive students emphasize innovation and expansion. This avoids the ineffectiveness of "one-size-fits-all" suggestions.

In this process, evaluation shifts from "vague scoring" to "diagnostic feedback", transforming from a "summative judgment tool" to a "formative development tool". This aligns with the modern educational concept of "promoting learning and teaching through evaluation".

2.4 Act: from Experience Summary to Data-Driven Continuous Optimization

Supported by continuous improvement theory and learning analytics technology theory, the Act stage builds a closed loop of "problem identification → solution generation → implementation verification → re-optimization" based on full-process data. It breaks the discontinuity of traditional "experience-summary-based optimization" and realizes the spiral improvement of teaching quality. The following digital empowerment strategies can be adopted.

Full-Process Data Integration and Analysis.

Educoder's AI agent integrates data such as the completion rate of hierarchical tasks in the Plan stage, practice behavior data (debugging duration, error types) in the Do stage, and evaluation results in the Check stage. It also associates learning resource data from China University MOOC and interaction data from Rain Classroom, forming a full-process dataset covering "planning - practice - evaluation".

Precise Optimization Solution Generation.

Through an intelligent decision-making system, analysis results are converted into three types of optimization solutions: solutions for common problems (e.g., adding special tasks and micro-courses), interventions for individual problems (e.g., pushing personalized exercises), and adjustments for process problems (e.g., splitting task difficulty). This ensures solutions are targeted and actionable.

Dynamic Closed-Loop Iterative Implementation.

Optimization solutions are integrated into the next PDCA cycle, with adjustments to teaching content, task design, and support methods. After the next round of practice, data is collected to verify effectiveness, and further adjustments are made based on new data—realizing a closed loop of "data → optimization → practice → new data".

Teaching optimization shifts from "discontinuous experience summary" to "data-driven closed-loop iteration", enabling the PDCA cycle's core value of "iterative optimization" to transform from a theoretical concept to practical action, and achieving dynamic improvement of teaching quality through continuous closed loops.

3 Teaching Practice Effects

Through a semester of comparative teaching practice, the model has shown significant advantages in stimulating students' learning initiative, improving code quality, and enhancing comprehensive abilities. More importantly, teachers are freed from heavy repetitive work and can focus more on teaching design and personalized guidance, achieving dual improvements in the efficiency of "teaching" and "learning". Practice confirms that when the PDCA teaching method is empowered by digital intelligence, its inherent potential for iterative optimization is unleashed unprecedentedly.

4 Conclusion

This study shows that the classic PDCA teaching method has not become obsolete in the digital age; instead, it has gained new vitality due to its high compatibility with digital intelligence technologies. The core value of digital intelligence technologies is not to subvert traditional teaching methods, but to serve as an empowering tool to break the implementation bottlenecks of these methods in traditional scenarios.

In the future, we will deepen the integration of PDCA stages with intelligent technologies, explore the potential of generative AI in automated teaching design and dynamic generation of personalized content, and promote the application of this "methodology-technology" integration model in a wider range of engineering education fields to facilitate the innovation of practical teaching paradigms.

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