Article

Teaching Mode Reform of C Programming Course Based on Intelligent Enhancement

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Abstract: Aiming at the core contradictions in the traditional teaching of the course C Language Programming, such as the disconnection between teaching content and industrial needs, the mismatch between teaching methods and students' ability differences, and the separation of evaluation methods from the learning process, this study constructs a comprehensive ternary collaborative teaching mode of "AI + Practical Training + Certification". As foundational programming skills become increasingly critical in modern computer science and engineering disciplines, addressing these pedagogical challenges is paramount. Driven by the dual cycle of the Plan-Do-Check-Act (PDCA) and Outcomes-Based Education (OBE) frameworks, this innovative mode realizes the intelligent diagnosis of learning status and personalized learning recommendations through the independently developed "Zhiyun" artificial intelligence teaching platform. Furthermore, it introduces real enterprise projects to reconstruct a robust content system integrating "post, course, competition and certification". It also establishes a diversified evaluation system that covers the entire educational process, emphasizes value-added learning outcomes, and aligns strictly with professional industry certifications. Practice shows that after the implementation of this reform, the average course score of students significantly increased by 8.5 points, while the failure rate decreased by an impressive 60%. Additionally, the number of award winners in academic competitions above the provincial level increased by 164%, and the pass rate of industry certifications rose to 82%. Ultimately, this research forms a highly replicable and promotable paradigm for curriculum reform, offering valuable insights for enhancing technical education and fostering industry-ready graduates.

Keywords: C Language Programming; ternary collaboration; PDCA-OBE Dual Cycle; industry-education integration; intelligent teaching

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1. Introduction

The demand for skilled professionals in the information technology sector is experiencing significant transformations. The conventional teaching approach to C Language Programming, which is a fundamental course for computer science students at universities, is encountering several core challenges and contradictions [1]. These challenges include adapting to rapidly evolving technological advancements, meeting the diverse learning needs of students, and integrating practical skills with theoretical knowledge. Addressing these issues requires innovative educational strategies that can effectively bridge the gap between academic instruction and industry requirements, ensuring that graduates are well-prepared for the dynamic IT landscape.

1.1. The contradiction between the dynamic nature of industrial needs and the static nature of teaching content.

Enterprises require graduates who not only have a firm grasp of C language syntax but also possess engineering thinking, problem-solving skills, and the ability to adapt swiftly to evolving technical environments. The traditional educational curriculum, however, often remains anchored in textbook knowledge, which can be outdated and disconnected from the latest industrial technologies and real-world project scenarios. This disconnect results in a gap between what students learn and their ability to apply this knowledge practically [2]. To bridge this gap, educational institutions must integrate more dynamic and industry-relevant content into their teaching methodologies, ensuring that students are better prepared to meet the demands of modern enterprises.

1.2. The contradiction between the diversity of students' abilities and the singularity of teaching methods.

There are significant differences in students' foundational knowledge, learning abilities, and areas of interest. The traditional teacher-centered classroom, which often employs a "one-size-fits-all" approach, fails to accommodate the diverse needs of individual learners. This lack of personalized teaching can result in underachieving students struggling to keep pace with the curriculum, while advanced learners may not find the material sufficiently challenging [3]. Consequently, this disparity can lead to a pronounced polarization in educational outcomes, where the gap between different levels of student performance becomes increasingly wide, ultimately hindering the overall effectiveness of the educational process.

1.3. The contradiction between the fuzziness of the learning process and the summative nature of evaluation methods.

Programming learning is inherently a continuous and iterative practical process. However, traditional assessment methods tend to overemphasize the final written examination. This approach lacks the ability to effectively track and evaluate key competencies such as the evolution of critical thinking, the debugging of code, and collaboration on projects throughout the learning journey. The feedback provided by these traditional methods is often delayed, which means it fails to offer timely and precise guidance necessary for the enhancement of both teaching and learning processes. This disconnect between the learning process and evaluation methods can hinder the development of essential skills in programming students [3].

To address these challenges, a new approach has been developed, leveraging the resources of the "Tencent Cloud Industry College," which is a collaborative initiative between the university and leading enterprises like Tencent Cloud and Chinasoft International. This approach is driven by industrial needs and is supported by various projects, including Quality Engineering, Industry-University Cooperation for Collaborative Education, and Smart Curriculum Construction [4]. Using the C Language Programming course as a foundational element for reform, this research explores and constructs an innovative ternary collaborative teaching model that integrates "AI + Practice + Certification." This model, as depicted in Figure 1, aims to reshape the educational ecosystem of the curriculum. It facilitates a transformation from mere knowledge indoctrination to the cultivation of abilities, from a closed classroom environment to an open industry-education integration, and from a singular evaluation method to a diversified certification system. This comprehensive approach seeks to enhance the educational experience and better prepare students for employment in relevant fields (As shown in Table 1).

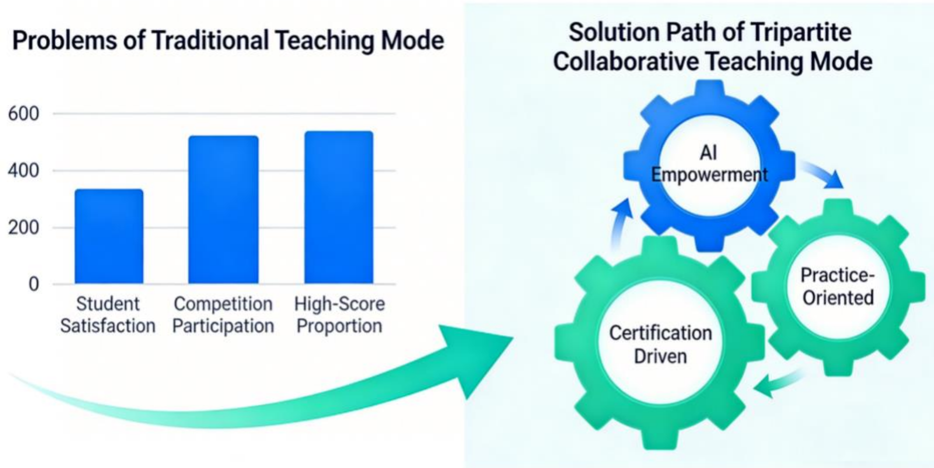

Figure 1. Solution Path of the Ternary Collaborative Teaching Model.

Table 1. Analysis of Employment Positions Strongly Correlated with the Course.

Job Category	Position	Application Scenario
System and Low-Level Development	Embedded Software Development Engineer	Develop embedded system programs for single-chip microcomputers and ARM architectures based on C language, applied to the control and driver development of IoT devices, smart hardware, automotive electronics, etc.
System and Low-Level Development	System Software Development Engineer	Participate in the development, transplantation and maintenance of underlying system software such as operating systems (e.g., Linux kernel modules), compilers and drivers.
Security and Performance Development	Information Security Engineer	Conduct software vulnerability analysis, virus analysis, software reverse engineering, etc. C language is the key to understanding memory management and the underlying mechanism of programs.
IoT Development	IoT Application Development Engineer	Be responsible for data collection of IoT terminal devices, firmware development and programming of communication programs with edge computing gateways.

2. Implementation Path and Main Measures

2.1. Independent R&D of the "Zhiyun" AI Teaching Platform: Realizing the Intellectualization of the Whole Teaching Process.

To address the challenges associated with accurately perceiving students' learning statuses and the difficulty in providing personalized guidance, the course team has taken the initiative to develop the "Zhiyun AI Teaching Platform". This platform is designed to enhance the educational experience by integrating advanced artificial intelligence technologies that facilitate a more intelligent and responsive teaching process [5]. By leveraging AI, the platform can analyze and interpret various learning patterns, thereby enabling educators to tailor their instructional methods to better suit individual student needs. This approach not only improves the overall effectiveness of teaching but also ensures that each student receives the attention and resources necessary to succeed in their academic pursuits (As shown in Figure 2).

Figure 2. Screenshot of the Core Function Interface of the "Zhiyun AI Teaching Platform".

2.1.1. Intelligent diagnosis of learning status.

The platform incorporates advanced technologies such as static code analysis, behavior trajectory analysis, and knowledge graph construction. This integration allows for a comprehensive real-time analysis of every line of code written by students, assessing its complexity, adherence to standards, and potential errors. Furthermore, the system is capable of automatically generating detailed heat maps that illustrate both individual and class-wide knowledge mastery. These visual representations provide educators with valuable insights into the learning progress and areas that may require additional focus, thereby enhancing the overall educational experience [1].

2.1.2. Adaptive learning recommendation.

The platform, utilizing an analysis of students' learning statuses, intelligently delivers a variety of tailored educational resources. These resources include micro-videos, challenging exercises, and supplementary reading materials. Additionally, it offers targeted practice exercises that focus on correcting previously incorrect answers [6]. This approach facilitates a highly personalized learning experience, embodying the concept of "one thousand learners, one thousand paths." By doing so, the platform ensures that each student receives a unique educational journey, tailored to their individual needs and learning pace, thereby enhancing the overall effectiveness of the learning process.

2.1.3. Process-oriented teaching management.

The process-oriented teaching management approach effectively integrates various educational activities, including pre-class preparation, interactive sessions during class, post-class assignments, and online experimental tasks. This comprehensive system ensures that all teaching activities are meticulously documented, creating digital teaching files that provide valuable insights into the learning progress of individual students as well as the overall course dynamics. By systematically recording these data, educators can better understand and enhance the educational experience, tailoring their teaching strategies to meet the diverse needs of students and improve educational outcomes [7].

2.2. Reconstructing the Integrated Content System of "Post, Course, Competition and Certification".

The integrated content system of "post, course, competition, and certification" is innovatively reconstructed by incorporating real-world enterprise practice projects. This approach transcends the traditional limitations imposed by textbook chapters. By focusing on actual enterprise project modules and subject competition questions, the teaching content is restructured to provide a more practical and engaging learning experience. This method not only enhances the applicability of the educational material but also aligns it more closely with industry standards and expectations [8]. Such a system aims to better prepare students for real-world challenges by integrating theoretical knowledge with practical skills, thereby fostering a more comprehensive educational framework (As shown in Figure 3).

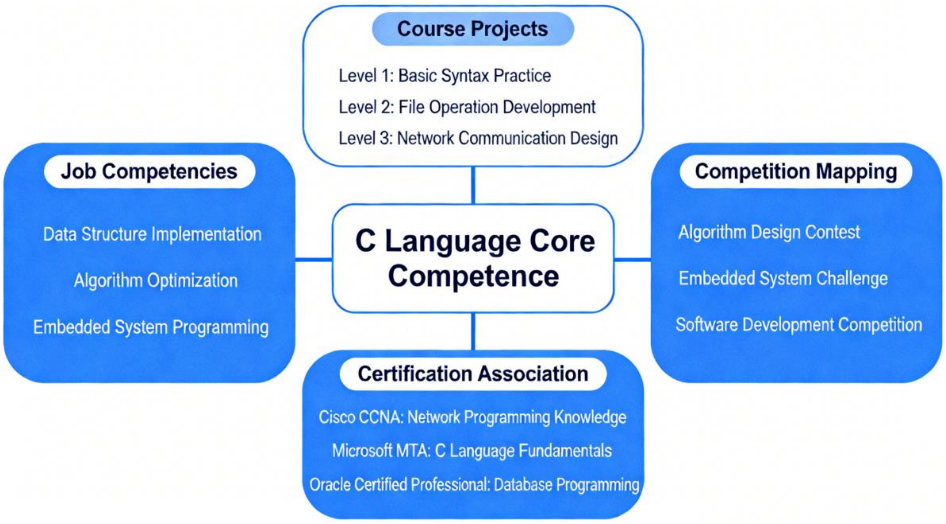

Figure 3. Integrated Content System of "Post, Course, Competition and Certification".

2.2.1. Project-based content reconstruction.

A comprehensive "step-by-step" practical project library has been collaboratively developed with engineers from Tencent Cloud and Chinasoft International [3]. This library encompasses a range of projects, starting from basic tasks such as "intelligent car control," advancing to more comprehensive systems like the "IoT data acquisition system," and culminating in advanced projects such as the "simple cloud background service interface." These projects are meticulously designed to integrate core knowledge points of the C programming language, including pointers, structures, and file operations, into the complete project development process. This approach ensures that learners can apply theoretical concepts in practical scenarios, thereby enhancing their understanding and skills in software development (As shown in Table 2).

Table 2. Cases of Project-Based Teaching.

Project Name	Main Technical Training Points	Ideological and Political Integration and Educational Objectives
Intelligent Car Control (Basic Practice)	Pointer operation, structure definition, hardware interface programming, sensor data processing	Cultivate the awareness of engineering practice and craftsman spirit, help students understand the practical value of technology, and establish a scientific thinking of "from theory to practice".
IoT Data Acquisition System	Structure arrays, file storage, multi-thread	Strengthen systematic thinking and collaboration ability, make

(Comprehensive Practice)	communication, conditional judgment, random trigger simulation	students experience the technical responsibility in the era of interconnection of all things, and establish the mission of serving society with science and technology.
Simple Cloud Background Service Interface (Advanced Practice)	Linked lists/structure arrays, network protocol simulation, file operations, simple transaction logic, interface encapsulation	Improve the awareness of architecture design and engineering specifications, help students understand the trends of cloud computing and industrial digitalization, and enhance professional competence in the digital age.

2.2.2. Integrated design of "post, course, competition and certification".

The integration of courses with job roles involves aligning educational materials such as project task books, code specifications, and development documents with the practical requirements of entry-level development positions in the industry. This approach ensures that students are not only learning theoretical concepts but are also gaining practical skills that are directly applicable to their future careers. By mirroring the expectations and tasks found in real-world junior development roles, the curriculum becomes more relevant and beneficial for students, preparing them effectively for the workforce. This alignment also facilitates a smoother transition from academic learning to professional employment, as students are already familiar with the types of tasks and standards they will encounter in their jobs [4].

The integration of courses with competitive programming involves transforming classic algorithm questions from well-known competitions, such as the Blue Bridge Cup and ACM-ICPC, into course experiments and after-class challenges. This method not only enhances the learning experience by providing practical applications of theoretical knowledge but also prepares students for participation in these prestigious competitions [7]. By incorporating competition elements into the curriculum, students are encouraged to develop problem-solving skills and innovative thinking. Additionally, the course term project is strategically combined with competition selection processes, allowing students to apply their learning in a competitive context, thereby enhancing their analytical and coding skills.

The integration of courses with professional certifications involves a detailed mapping of the assessment criteria from certifications such as the National Computer Rank Examination (Level 2 C) and Tencent Cloud Engineer to relevant teaching modules. This strategic alignment ensures that the course content not only covers the necessary academic knowledge but also prepares students for certification exams. By decomposing the key points of these certifications and integrating them into the curriculum, students can simultaneously work towards their academic goals and certification preparation. This dual focus enhances the value of the educational program, as students are equipped with both theoretical knowledge and practical skills that are recognized by industry standards [5].

2.2.3.". Dual-teacher" collaborative teaching.

Enterprise engineers play a significant role in the educational process by actively engaging in teaching through various methods such as online workshops and offline project reviews. Their involvement is crucial as they introduce the latest technical trends and provide real-world engineering cases, which enrich the learning experience [2, 9]. Additionally, they offer a rigorous perspective on code review, which is essential for students to understand the importance of quality and precision in software development. This collaborative approach not only enhances the practical skills of students but also bridges the gap between academic learning and industry requirements, preparing students for future challenges in the engineering field.

2.3. Implementing Diversified Value-Added Evaluation and Examining Learning Effects with Certified Achievements.

A comprehensive and diversified evaluation system has been established to cover the entire educational process. This system emphasizes the development of value-added skills and aligns closely with professional certifications. By integrating these elements, the evaluation framework not only assesses the current competencies of learners but also tracks their progress over time. This approach ensures that learners are not only meeting academic standards but are also gaining skills that are recognized and valued in professional settings. The system is designed to provide a holistic view of a learner's achievements, thereby facilitating a more nuanced understanding of their educational journey.

2.3.1. Intellectualization of process evaluation.

The "Zhiyun" platform is designed to automatically record and evaluate various aspects of students' learning processes. This includes tracking the number of code submissions, which provides insight into the students' engagement and persistence in coding tasks. Additionally, the platform assesses debugging efficiency, offering a measure of students' problem-solving skills and their ability to refine and optimize code. Contributions to online discussions are also evaluated, reflecting students' collaborative skills and their ability to engage in academic discourse. Furthermore, the duration of video learning is monitored, indicating the time students dedicate to absorbing instructional content. Collectively, these metrics contribute to 40% of the total score, providing a comprehensive evaluation of students' learning activities and engagement.

2.3.2. Projectization of outcome evaluation.

The evaluation of individual and team projects is a comprehensive process that involves both school teachers and enterprise tutors. This collaborative assessment focuses on several key aspects, including the quality of project completion, the level of innovation demonstrated, and the effectiveness of the defense performance. These elements are crucial in determining the overall success of the projects [10]. The evaluation process is designed to ensure a balanced and fair assessment, accounting for 40% of the total score. This approach not only encourages students to strive for excellence but also fosters a strong partnership between educational institutions and industry professionals, ultimately enhancing the learning experience and preparing students for future challenges.

2.3.3. Certification of value-added evaluation.

Obtaining authoritative industry certifications, such as achieving excellence in recognized examinations like the National Computer Rank Examination Level 2, or receiving awards in prestigious competitions, is considered a significant "value-added" component in course evaluations. This approach allows for an additional incentive of up to 20 points, which can be directly converted into the course score. By integrating social and industrial evaluations into the academic framework, this measure substantially enhances the quality and credibility of learning achievements. This system not only motivates students to excel in their studies but also aligns academic success with industry standards, thereby increasing the practical relevance of their educational accomplishments, as illustrated in Figure 4.

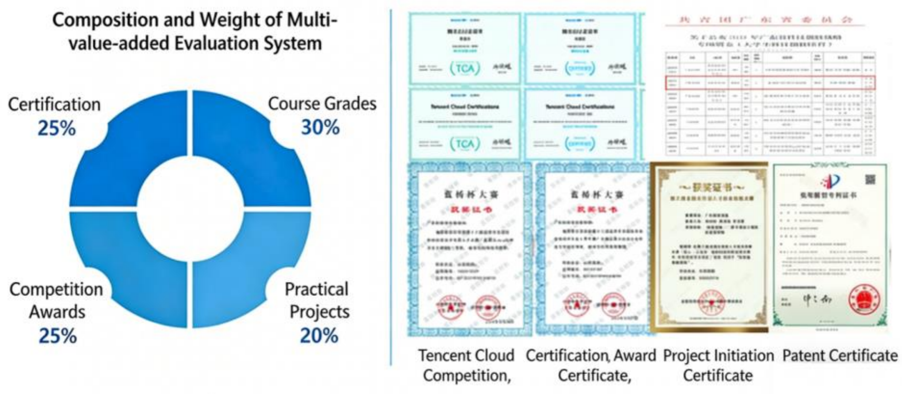

Figure 4. Composition and Weight of the Diversified Value-Added Evaluation System.

3. Practical Effects of the Reform

Following three comprehensive rounds of teaching practice, the reform initiative has demonstrated significant success, achieving its predetermined objectives across various dimensions. This success is evident in the enhanced engagement and performance of students, as well as the improved teaching methodologies adopted by educators. The reform has also fostered a more interactive and dynamic learning environment, which has contributed to a deeper understanding of the subject matter among students. Furthermore, the initiative has encouraged the integration of innovative teaching tools and techniques, thereby enriching the overall educational experience.

3.1. Significant Improvement in Students' Learning Effects and Ability Development.

3.1.1. Improvement in academic performance and core abilities.

Following the educational reform, there has been a notable enhancement in students' academic performance, as evidenced by an average increase of approximately 8.5 points in course scores. Additionally, the failure rate has significantly decreased by 60%, indicating a substantial improvement in students' understanding and mastery of the course material. Beyond these quantitative measures, there has been a marked improvement in achieving course objectives, particularly in areas such as solving complex engineering problems and system design and implementation. These objectives have seen an increase of more than 15% in achievement levels compared to the period before the reform, highlighting the effectiveness of the new educational strategies in fostering essential skills and competencies among students [11].

3.1.2. Leap in the quantity and quality of competition awards.

During the 2025-2026 academic year, a significant achievement was recorded as 58 students enrolled in this course received awards at or above the provincial level in the prestigious Blue Bridge Cup National Software and Information Technology Professional Talent Competition [12]. Notably, 12 of these students achieved the third prize or higher at the national level, marking a historical peak in both the quantity and quality of awards received. This accomplishment reflects a substantial improvement in the students' skills and competencies. Furthermore, notable advancements were also observed in other competitive arenas, such as the ACM International Collegiate Programming Contest (ACM-ICPC) and RoboMaster, where students demonstrated exceptional technical prowess and innovative problem-solving abilities. These achievements underscore the effectiveness of the curriculum and the dedication of both students and faculty in fostering a competitive and innovative academic environment.

3.1.3. Substantial increase in the pass rate of industry certifications.

The percentage of students who actively apply for and successfully pass the National Computer Rank Examination at Level 2 in C Language has significantly increased from 35% to 82%. Among these students, 25% achieved an "Excellent" grade, demonstrating a high level of proficiency and understanding of the subject matter. Additionally, some exceptional students have gone beyond this achievement by successfully obtaining Tencent's Junior Engineer Certification [13]. This notable improvement in certification pass rates reflects the effectiveness of the educational strategies implemented, as well as the dedication and hard work of both students and educators in enhancing technical skills and knowledge (As shown in Table 3).

Table 3. Comparison of Key Effect Data of Teaching Reform.

Evaluation Index	Before Reform	After Reform	Improvement Range
Average Course Score	76.5	85.0	+8.5
Failure Rate	10.2%	4.1%	-60%
Number of Student Award Winners in Competitions above Provincial Level	22 person-times	58 person-times	+164%
Pass Rate of NCRE Level 2, Tencent Cloud Skill Certification or Computer Software Examination	35%	82%	+134%
Class Satisfaction Survey (Excellent Rate)	75%	95%	+20%

3.2. Abundant Achievements in Teachers' Teaching Development and Research.

Among the 12 core members of the project, half of them, specifically 6 individuals, have achieved senior professional titles such as professor, associate professor, or senior engineer [14]. This represents 50% of the total full-time teaching staff. Additionally, 4 members hold intermediate professional titles, making up 34% of the team, while 2 members possess junior professional titles, accounting for 17%. Furthermore, 3 teachers have attained doctoral degrees, which constitutes 25% of the full-time teaching personnel. This diverse range of qualifications among the team members highlights the depth of expertise and the commitment to academic excellence within the project.

A new teaching material, titled C Language Programming Practical Tutorial, has been developed, integrating project-based and intelligent characteristics. This innovative course has been recognized as part of the first batch of Smart Curriculum Construction Projects by the China Higher Education Computer Education Research Association. The reform model's achievements have been acknowledged with prestigious awards, including the first prize for Teaching Achievements from the Guangdong Computer Society. Additionally, it received the second prize for Excellent Cases of Teaching Quality Management and Evaluation Reform from the Guangdong Higher Education Teaching Management Association. These accolades underscore the significant impact and success of the reform initiatives in enhancing educational quality and innovation.

3.3. Enhanced Radiating Effect on Curriculum and Major Construction.

The educational model has been effectively expanded beyond the initial course of C Language Programming to encompass four core courses within the School of Computer Science. These courses include Data Structures, Algorithms, and Python Programming, collectively forming an "Intelligence + Practice" course group. This innovative approach has been instrumental in fostering a collaborative learning environment. The experience gained from this model has been disseminated across all course groups within the Industry College. This dissemination has significantly contributed to the advancement of industry-education integration, facilitating a deeper and more comprehensive development within the Industry College. By integrating practical intelligence with academic learning, the model enhances the educational framework, preparing students for real-world challenges in the technology sector (As shown in Figure 5).

Figure 5. Students' Learning Effects and Achievements.

4. Innovations

The core characteristics and innovations of this research are encapsulated in the systematic framework known as "ternary collaboration, dual-drive, and one-platform support." This approach signifies a comprehensive integration of three collaborative elements, which are designed to work in harmony to drive progress. The dual-drive mechanism refers to the simultaneous propulsion of two key factors that enhance the research's effectiveness [15]. Additionally, the one-platform support provides a unified base that facilitates seamless interaction and coordination among various components, ensuring that the research objectives are met with precision and efficiency.

4.1. Proposing and Practicing a New Paradigm of Ternary Collaborative Education of "AI + Practice + Certification".

Artificial intelligence technology has evolved from being merely a supplementary tool in education to becoming a central engine that fundamentally reshapes the teaching process. This transformation allows AI to play a pivotal role in enhancing educational methodologies and outcomes. Concurrently, enterprise practice has shifted from being isolated instances to becoming the primary framework for reconstructing the educational content system. This shift ensures that practical, real-world applications are integrated into the learning experience, providing students with relevant and applicable skills [11]. Furthermore, industry certification has transitioned from being an external examination to serving as a benchmark that guides learning evaluation. This new role of certification ensures that educational assessments are aligned with industry standards, thereby enhancing the relevance and applicability of the education provided. The integration of technology, industry, and education is thus achieved in a comprehensive and structural manner, rather than through a mere aggregation of components. This paradigm shift represents a significant advancement in educational practices, fostering a more holistic and interconnected approach to learning.

4.2. Constructing a Teaching Quality Continuous Improvement Model Driven by the PDCA-OBE Dual Cycle.

The integration of the macroscopic Outcome-Based Education (OBE) concept with the microscopic Plan-Do-Check-Act (PDCA) management tool provides a structured and data-driven approach to the core concept of "continuous improvement" in engineering education. This approach transforms the enhancement of teaching quality from a mere summary of experiences into a scientific decision-making process that is driven by data. By employing this model, educational institutions can systematically track and analyze teaching outcomes, allowing for precise adjustments and improvements. This method ensures that educational practices are not only reflective but also proactive, enabling educators to anticipate and respond to the evolving needs of students and industry demands.

The research introduces an innovative model that deeply integrates the PDCA cycle, a well-established quality management tool, with the OBE concept, which is central to engineering education certification. This integration forms a "dual cycle" driving model, which is depicted in Figure 6. The dual cycle model leverages the strengths of both frameworks, creating a robust mechanism for continuous improvement [16]. By aligning the PDCA cycle's iterative process with the outcome-focused approach of OBE, the model facilitates a comprehensive evaluation and enhancement of educational practices. This synergy ensures that educational objectives are consistently met and that the quality of education is perpetually refined.

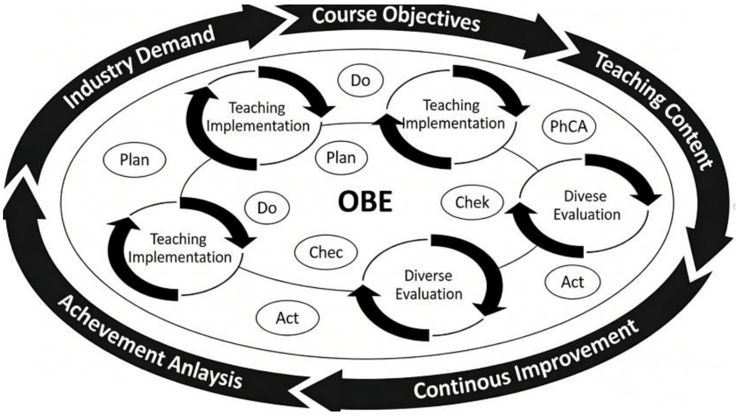

Figure 6. PDCA-OBE Dual Cycle Driving Model.

The external cycle, which is oriented towards OBE, begins with the identification of industrial needs and graduation requirements. These needs serve as the foundation for designing course objectives, teaching content, and evaluation methods. By starting with the end goals in mind, educators can ensure that the curriculum is directly aligned with the skills and knowledge required by the industry. This reverse engineering approach allows for a more targeted and effective educational experience, ensuring that students are well-prepared to meet the demands of their future careers.

The internal cycle, empowered by the PDCA methodology, incorporates a micro-cycle within each teaching unit and throughout the entire course. The "Zhiyun" teaching platform plays a crucial role in this process by collecting data on students' learning status during the Check phase. This data-driven approach enables educators to dynamically adjust teaching strategies during the Act phase, ensuring that teaching methods remain aligned with desired learning outcomes. The Plan and Do phases involve setting clear objectives and implementing teaching strategies that are informed by the collected data. This continuous feedback loop ensures that teaching practices are consistently refined and optimized to enhance student learning experiences.

4.3. Developing a Characteristic Implementation Path of "Independent R&D of Platform and Deep Cultivation of Industry-Education Integration".

Faced with the challenge that general teaching platforms often struggle to fully meet the specific needs of professional education, we adhere to a self-directed approach by independently developing the "Zhiyun" platform. This initiative allows us to maintain control over teaching data and drive educational reform. Concurrently, by collaborating with leading enterprises to establish the Industry College, we implement industry-education integration at a granular level. This integration permeates every aspect of the curriculum, projects, teaching staff, and evaluation processes. Such a comprehensive approach ensures that both practical applications and certification processes remain authentic and cutting-edge. By embedding industry standards and practices into the educational framework, we aim to bridge the gap between theoretical knowledge and real-world application, thereby enhancing the overall quality and relevance of the educational experience [17].

5. Conclusions

Taking solving the deep-seated contradictions in the teaching of basic engineering courses in application-oriented undergraduate universities as the starting point, taking industry-education integration as the fundamental path and taking intelligent technology as the innovation engine, this teaching reform project has successfully constructed and verified the ternary collaborative teaching model of "AI + Practice + Certification". Practice has proved that this model effectively stimulates students' internal learning motivation and creativity, significantly improves the quality of talent training and its alignment with industrial needs, and provides a forward-looking, effective and operable "Excellent Engineer Training Program" for the reform of basic engineering courses in the new era, contributing to cultivating more high-quality engineering talents adapted to the development of the digital economy. This model not only addresses the existing challenges in engineering education but also sets a precedent for future educational reforms. By integrating artificial intelligence with practical applications and certification processes, the model ensures that students are not only theoretically proficient but also practically skilled, making them more adaptable to the rapidly evolving technological landscape. The emphasis on industry-education integration ensures that the curriculum remains relevant and responsive to the needs of the industry, thereby enhancing the employability of graduates. Furthermore, the model's adaptability allows it to be tailored to various engineering disciplines, making it a versatile tool for educational institutions aiming to modernize their teaching methodologies.

The teaching model has been promoted in the university. The core experience of the "AI + Practice + Certification" model has been extended from the C Language Programming course to core courses such as Data Structures and Algorithms and Python Programming, forming a "Intelligence + Practice" course group covering the core basic computer courses. At the same time, the model is deeply integrated into the entire talent training process of the Excellent Engineer Class of the "Tencent Cloud Industry College". The teaching syllabi, project cases and resources of relevant courses have been systematically upgraded by setting up the "University-Enterprise Joint Course Group". This expansion signifies a strategic enhancement of the curriculum, ensuring that students receive a comprehensive education that is both broad and deep. By incorporating a wide range of programming languages and methodologies, the model prepares students for diverse challenges in the tech industry. The collaboration with industry leaders like Tencent Cloud ensures that the curriculum is continuously updated to reflect the latest technological advancements and industry standards. This proactive approach not only benefits the students but also strengthens the university's position as a leader in engineering education. The systematic upgrade of teaching materials and resources further ensures that the quality of education remains high, providing students with the tools they need to succeed in their careers.

The model has been highly recognized by the industry and formed a good university-enterprise collaborative education ecology. Two core cooperative enterprises, Tencent Cloud and Chinasoft International, have given substantive recognition to the achievements and fully affirmed the comprehensive quality of the teaching team. This recognition from leading industry players underscores the effectiveness and relevance of the teaching model. It highlights the successful bridging of the gap between academic learning and practical industry requirements. The collaborative education ecology that has been established serves as a benchmark for other institutions aiming to foster similar partnerships. By aligning educational outcomes with industry expectations, the model not only enhances the employability of graduates but also contributes to the overall development of the engineering sector. The positive feedback from industry partners also reflects the high standards maintained by the teaching team, which is crucial for sustaining the model's success and ensuring its continued evolution in response to changing industry needs.

In the future, we will further explore the "micro-certification" system. In cooperation with enterprises, the modular skill points in the course (such as "pointer safe programming" and "modular design") will be packaged into more refined "micro-certifications" to realize the digitalization, credit-based accumulation and exchange of learning achievements. This initiative aims to provide students with a more granular and flexible approach to skill acquisition, allowing them to tailor their learning experiences to their individual career goals. By breaking down complex skills into smaller, manageable units, the micro-certification system facilitates continuous learning and skill development. This approach not only benefits students by providing them with tangible proof of their competencies but also aids employers in identifying candidates with specific skill sets. The digitalization of learning achievements ensures that students can easily track and showcase their progress, enhancing their professional profiles. As the demand for specialized skills continues to grow, the micro-certification system represents a forward-thinking solution that aligns educational outcomes with the dynamic needs of the digital economy.

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