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# Exploration of Teaching Reform in Computer Network Course based on "Four Integrations and Dual Enhancements"

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**Abstract:** With the rapid development of information technology, traditional computer network courses have gradually revealed issues of obsolescence and singularity in teaching content, methods, and practical aspects, making it difficult to meet the demands for cultivating high-quality innovative talents under the background of emerging engineering education. This research, centered on the core concept of "Four Integrations and Dual Enhancements," systematically promotes the teaching reform of computer network courses by focusing on the deep integration of four aspects: disciplinary competitions and course teaching, teaching and scientific research, the "Two Leaders and Three Learnings" mechanism, and basic knowledge with frontier trends. Through restructuring course content, innovating teaching methods, strengthening practical components, and improving the evaluation system, the aim is to achieve the "dual enhancements" of students' innovative thinking and practical abilities. Practice has shown that this model effectively stimulates students' learning initiative and enhances their comprehensive abilities and engineering literacy, offering positive reference significance for reforms in similar science and engineering courses.

**Keywords:** Computer Network, Four Integrations and Dual Enhancements, Teaching Reform, Innovative Practice.

## 1. Introduction

With the rapid development and deep integration of new-generation information technologies such as cloud computing, the Internet of Things, and artificial intelligence, there is an increasingly urgent societal demand for innovative talents with solid theoretical foundations in networking and outstanding engineering practical abilities. As a core and foundational course in the field of information technology, the teaching quality of Computer Networks is directly related to the cultivation quality of professionals in related disciplines. However, the teaching of computer network courses in many universities still generally follows the traditional "teacher lectures, students listen" indoctrination-style teaching model, characterized by slow updates in teaching content that lag behind industrial technological frontiers; monotonous teaching methods that fail to stimulate students' deep thinking and learning interest; weak practical teaching components where experiments are mostly verification-based, lacking comprehensiveness and design, leading to a disconnect between students' knowledge and practice; and a course evaluation system that emphasizes knowledge over ability, making it difficult to fully reflect students' comprehensive literacy. These issues severely constrain the cultivation of students' innovative spirit and practical abilities. Therefore, introducing the systematic and integrated teaching reform model of "Four Integrations and Dual Enhancements" holds significant practical necessity and urgency for addressing current teaching dilemmas and meeting the requirements of emerging engineering education construction.

This study aims to systematically apply the "Four Integrations and Dual Enhancements" concept to the teaching reform practice of computer network courses. Its core purpose is, by promoting the deep integration of disciplinary competitions and course teaching, teaching and scientific research, "Two Leaders and Three Learnings," and basic knowledge with frontier trends, to reconstruct the course system, innovate teaching methods, strengthen practical components, and improve evaluation mechanisms, ultimately achieving the synergistic enhancement of students' "innovative thinking" and "practical ability." The theoretical significance of this study lies in enriching the theoretical connotation of engineering course teaching reform and providing specific practical cases and theoretical support for the "integrated" teaching model. Its practical significance lies in the fact that the formed replicable and operable reform paths and implementation strategies can not only effectively improve the teaching effectiveness of computer network courses but also provide valuable reference and insights for the reform and innovation of related science and engineering courses such as those in electronic information and computer science.

Domestic and international research on teaching reform has accumulated rich results. For example, Project-Based Learning (PBL) has been proven effective in enhancing students' problem-solving abilities; blended online and offline teaching demonstrates advantages in expanding learning space and time and enabling personalized learning; introducing competition mechanisms into teaching has also been shown to stimulate students' learning motivation. However, existing research mostly focuses on a single dimension or partial aspect of teaching reform, lacking comprehensive studies that systematically integrate and collaboratively design course content, teaching methods, practical paths, evaluation mechanisms, and educational objectives. In particular, there remains a research gap regarding systematic models that organically "integrate" multiple elements such as research frontiers, disciplinary competitions, and the reconstruction of teacher-student roles, and based on this, achieve the "dual enhancement" of students' higher-order cognitive abilities and comprehensive practical literacy. This study is an active exploration aimed at addressing this gap.

This study first analyzes the mechanism of the "Four

Integrations and Dual Enhancements" model, then examine the current teaching situation and problems in computer network courses, and focus on elaborating specific practical measures based on this model, including course content restructuring, teaching method reform, practical component strengthening, and evaluation system improvement. Research methods mainly include case study, conducting in-depth analysis of the teaching practice process; questionnaire surveys and interviews, collecting feedback on student learning experiences and outcomes; and comparative analysis, comparing student learning outcome data before and after the teaching reform to assess the reform's effectiveness.

# 2. Analysis of the "Four Integrations and Dual Enhancements" Talent Cultivation Model

## 2.1. The Connotation of the "Four Integrations" Concept

"Four Integrations" refers to the organic integration of four aspects: disciplinary competitions and course teaching, teaching and scientific research, the "Two Leaders and Three Learnings" mechanism, and basic knowledge with frontier trends. Its core concept is to break the fragmented state of various links in traditional teaching and construct a student-centered, ability-oriented, integration-as-path teaching ecosystem. By integrating competition mechanisms, research elements, teacher-student interaction mechanisms, and frontier dynamics into the entire process of course teaching, it achieves the organic unity of knowledge impartation, ability cultivation, and value guidance, thereby stimulating students' learning initiative and creativity and enhancing their comprehensive quality.

(1) Integration of Disciplinary Competition Content and Course Teaching

Disciplinary competitions serve as an important platform for testing students' comprehensive abilities, and their content is often cutting-edge, comprehensive, and challenging. Integrating competition content into course teaching can not only enrich teaching resources but also effectively stimulate students' learning motivation [1]. In specific practice, project tasks related to competitions, such as network protocol analysis, network attack and defense simulation, and intelligent network architecture design, can be embedded into the course design, enabling students to accumulate competition experience while completing course learning and enhancing their comprehensive application abilities. Furthermore, by forming competition guidance teams and organically combining competition training with course experiments and course design, a virtuous cycle of "promoting learning through competition and promoting competition through learning" is formed, enhancing students' teamwork and engineering practical abilities.

(2) Integration of Teaching and Scientific Research

The integration of teaching and scientific research is an important way to promote course content updates and improve teaching quality. On one hand, teachers can transform their own scientific research project outcomes into teaching cases, such as introducing frontier topics like SDN-based network management and IoT security mechanisms into the classroom, allowing students to encounter real research problems and cultivating their research thinking and innovation awareness. On the other hand, students are encouraged to participate in teachers' research projects, or small research tasks are integrated into course design [2], such as network performance simulation and protocol optimization design, enabling students to master research methods through practice and enhance their ability to solve complex engineering problems. Through the interaction between teaching and research, synergistic development of knowledge dissemination and knowledge innovation is achieved.

(3) Integration of "Two Leaders and Three Learnings"

"Two Leaders and Three Learnings" is a teaching mechanism based on "teachers as leaders, students as main body," integrating three learning methods: "independent learning, collaborative learning, and inquiry learning." Under this mechanism, teachers are no longer one-way transmitters of knowledge but organizers, guides, and facilitators of the learning process; students shift from passive acceptance to active construction, mastering basic knowledge through independent learning, improving communication skills through collaborative learning, and cultivating innovative thinking through inquiry learning [3]. For example, when explaining the TCP/IP protocol stack, teachers can design layered tasks, guiding students to work in groups to investigate the working principles and evolution of protocols at each layer, and communicate through classroom presentations, debates, etc., thereby deepening their understanding of the network architecture.

(4) Integration of Basic Knowledge Points from Textbooks and Frontier Development Trends

Computer network technology develops rapidly, and textbook content often lags behind technological evolution. To bridge this gap, the integration of basic knowledge and frontier trends should be emphasized in teaching. On one hand, core fundamentals such as network architecture, protocol principles, and data communication should be solidified; on the other hand, emerging technological content such as 5G/6G networks, the Internet of Things, edge computing, and network intelligence should be introduced, expanding students' technical horizons through special lectures, literature reading, and technical reviews. Furthermore, by combining the latest industry standards and open-source projects, students can understand the dynamics and direction of technological development, enhancing their ability to adapt to future technological changes.

## 2.2. Elaboration of the "Dual Enhancements" Goal

"Dual Enhancements" refers to the systematic enhancement of students' "innovative thinking" and "practical ability" through the "Four Integrations" mechanism. This goal reflects the shift from a "knowledge-based" to a "ability-based" orientation, emphasizing the cultivation of students' engineering awareness, critical thinking, and comprehensive practical abilities while mastering a solid theoretical foundation, enabling them to become high-quality innovative talents adapted to future technological development.

(1) Enhancement of Students' Innovative Thinking

The cultivation of innovative thinking relies on a problem-oriented and open-exploration teaching environment. Through project-based learning, case analysis, and research training, students are guided to analyze network problems from multiple perspectives and propose novel solutions. For example, when explaining network security, open topics such as "zero-trust architecture design" can be set, encouraging students to consult literature, conduct simulation experiments,

and propose their own architectural ideas, thereby cultivating their systematic thinking and innovation capabilities.

(2) Enhancement of Students' Practical Ability

The enhancement of practical ability relies on a multi-level, progressive practical teaching system. From basic verification experiments to comprehensive design projects, and then to competitions and innovation-entrepreneurship training, students' hands-on abilities and engineering literacy are gradually improved. Through industry-university cooperation, training base construction, and competition platform establishment, students are provided with real or highly simulated network environments, allowing them to gain sufficient training in network configuration, fault troubleshooting, system deployment, etc., achieving an effective transformation from "knowing" to "doing."

# 3. Analysis of the Current Teaching Situation of Computer Network Courses

With the rapid development of information technology and the continuous advancement of the new engineering education concept, the computer network course, as a core fundamental course for related majors such as Computer Science and Technology and Network Engineering, has a teaching quality directly related to students' professional literacy and employment competitiveness. However, in the current teaching practices of most universities, this course still faces many problems that need urgent resolution, severely constraining the cultivation of high-quality innovative talents.

## 3.1. Problems Existing in the Traditional Teaching Mode

Currently, many universities still predominantly use the traditional teaching mode in the computer network course, revealing the following prominent issues:

(1) Teaching content is outdated. Computer network technology develops rapidly, with new technologies such as 5G/6G, IoT, edge computing, and network intelligence continuously emerging. However, the content of existing textbooks updates slowly, mostly still focusing on the OSI seven-layer model and TCP/IP protocol stack, failing to timely integrate current mainstream technologies and frontier development trends. This leads to a disconnect between what students learn and actual industry needs, making it difficult for them to adapt to future technological requirements.

(2) Teaching methods are singular. Most classrooms still remain teacher-centered, employing the "teacher lectures, students listen" indoctrination-style teaching. This one-way knowledge transfer mode lacks interactivity and inspiration, making it difficult to mobilize students' learning enthusiasm and not good for cultivating students' abilities to analyze and solve problems and their critical thinking.

(3) The practical teaching component is weak. Experimental content is mostly verification-based, such as using network commands and analyzing protocol data packets, lacking comprehensive, design-oriented, and innovative experimental projects. Students often follow steps mechanically during experiments, lacking a deep understanding of the overall network system architecture and actual engineering problems, resulting in a disconnect between theoretical knowledge and practical ability.

(4) The course evaluation system is imperfect. The current evaluation method still relies mainly on closed-book final exams, focusing on the memorization and understanding of basic concepts and theoretical knowledge, while neglecting the comprehensive assessment of students' practical abilities, innovative thinking, and teamwork skills. This "emphasizing knowledge, neglecting ability" evaluation orientation is not conducive to guiding students' all-round development.

## 3.2. Analysis of Student Learning Situation

Regarding students' learning conditions under the current teaching mode, the following phenomena have been identified through classroom observation, student interviews, and questionnaire surveys:

(1) Insufficient learning interest and initiative. Due to outdated teaching content and monotonous teaching methods, some students find the course boring and lack learning motivation. Especially during theoretical lectures, students are prone to distraction and low classroom participation, affecting the overall learning effect.

(2) Difficulties in understanding theoretical knowledge. Computer networks involve a large number of abstract concepts and complex protocol mechanisms. Students generally find it difficult to understand content such as network layering, routing algorithms, and congestion control. The traditional lecture method struggles to visually demonstrate network dynamic behavior, leading to students' weak grasp of key principles.

(3) Weak practical application ability. Although students can memorize some network principles, they are often at a loss when faced with practical tasks such as network planning, configuration, debugging, and optimization. Some students report that the experimental content differs significantly from real network environments, lacking effective training in transforming theoretical knowledge into the ability to solve practical problems.

In summary, the current computer network course has obvious deficiencies in the timeliness of teaching content, the diversity of teaching methods, the comprehensiveness of practical components, and the scientific nature of the evaluation system. These problems not only affect students' learning experience and outcomes but also restrict the cultivation of their innovative thinking and practical abilities. Therefore, promoting teaching reform centered on "Four Integrations and Dual Enhancements," systematically optimizing course content, teaching methods, practical systems, and evaluation mechanisms, has become an inevitable choice for improving the teaching quality of computer network courses and adapting to the talent cultivation needs of new engineering education.

# 4. Teaching Reform Practice of Computer Network Course based on "Four Integrations and Dual Enhancements"

To effectively enhance the teaching quality of the computer network course and implement the "Four Integrations and Dual Enhancements" talent cultivation concept, this study systematically promotes teaching reform from four dimensions: course content restructuring, teaching method reform, practical teaching strengthening, and evaluation system improvement, forming a set of operable and promotable practical paths for teaching reform.

## 4.1. Course Content Restructuring

In course content design, the traditional static knowledge structure primarily based on the OSI/TCP/IP protocol stack is broken, and a three-level course system of "Foundation + Frontier + Integration" is constructed. The Foundation level focuses on explaining core knowledge such as network architecture, data communication principles, routing and switching, ensuring students master the basic theories of networking; the Frontier level introduces emerging technologies such as 5G/6G, IoT, edge computing, Network Function Virtualization, and Software-Defined Networking, expanding students' horizons through thematic modules, technical reviews, and literature study; the Integration level emphasizes integrating disciplinary competition content, research cases, and engineering practice problems into the course. For example, competition topics from the "National College Student Network Technology Competition," such as network planning and design, network security attack and defense, are transformed into course projects, achieving "promoting learning through competition and promoting application through learning." Additionally, teachers' research directions and research content are transformed into teaching cases, enhancing the advancement and practicality of the course content.

## 4.2. Teaching Method Reform

In teaching methods, a shift from "teacher-centered" to "student-centered" is promoted, constructing a teaching model with the "Two Leaders and Three Learnings" mechanism as the core and the collaboration of various teaching methods.

(1) Application of Case-Based Teaching. For difficult content such as network protocols and network security, real enterprise cases (e.g., DDoS attack protection, data center network architecture design) are selected for analysis, guiding students to analyze the problem background, technical paths, and solutions, cultivating their systematic thinking and engineering judgment.

(2) Implementation of Project-Driven Teaching. The course content is divided into several project modules, such as "Campus Network Planning and Deployment," "Smart Home Network Simulation," etc. Students complete the entire process from requirements analysis, scheme design to simulation implementation in group forms. During project implementation, students not only consolidate skills like network configuration and protocol analysis but also exercise teamwork and project management abilities.

(3) Construction of Blended Online and Offline Teaching Mode. Online resource libraries are built using platforms like SPOC and MOOC, including micro-lecture videos, protocol simulation animations, online experiment platforms, etc., supporting students' independent learning; offline classrooms focus on difficult point analysis, project discussion, and interactive presentation, achieving the organic combination of "learning knowledge online, practicing ability offline." Teachers analyze student learning behaviors through learning platform data to implement precise guidance and dynamic teaching adjustments.

## 4.3. Strengthening of Practical Teaching Components

Practical teaching is the key link to enhancing students' engineering literacy and innovation ability. This study systematically strengthens the practical system from three aspects: the construction of on-campus training bases, the development of off-campus practices, and the guidance of competition projects.

(1) Construction of On-Campus Computer Network Training Base. Relying on central financial support and industry-university cooperation projects, a comprehensive network training platform covering routing and switching, network security, wireless networks, SDN, and other functions has been established. The platform supports experiments such as virtualized networking, protocol analysis, and attack-defense drills. Students can complete multi-level experimental tasks from basic verification to comprehensive design here, achieving "learning by doing and doing by learning."

(2) Development of Off-Campus Practical Teaching. Off-campus internship bases have been established in cooperation with multiple enterprises, organizing students to participate in actual enterprise network engineering projects, such as campus network upgrades and cloud computing platform deployment. Guided by enterprise engineers and through real-environment drills, students can gain an in-depth understanding of industry technology trends and enhance their job adaptability.

(3) Encouraging Student Participation in Disciplinary Competitions and Innovation-Entrepreneurship Projects. Competitions such as the "Internet+" Innovation and Entrepreneurship Competition, the "Challenge Cup" Technological Competition, and the National Network Technology Competition are incorporated into the course extension components, establishing mechanisms for competition credit recognition and rewards. The teacher team conducts specialized training and project guidance based on competition content, helping students transform course learning into competition achievements and innovation projects, forming a virtuous interactive ecosystem of "course --- competition --- innovation---entrepreneurship."

## 4.4. Improvement of the Course Evaluation System

To comprehensively reflect students' knowledge, abilities, and literacy, a diversified learning evaluation system is constructed. The previous evaluation method dominated by final written exams is changed to form a three-dimensional structure of "process evaluation + summative evaluation + practical ability evaluation." Process evaluation includes classroom participation, online learning progress, project reports and presentations, etc., accounting for 40%; summative evaluation assesses core theories through closed-book exams, accounting for 30%; practical ability evaluation is comprehensively assessed based on experiment completion quality, competition performance, innovation project outcomes, etc., accounting for 30% [4]. Simultaneously, a teacher teaching quality feedback mechanism is established, collecting teaching feedback through multiple channels such as student evaluations, peer observations, and teaching supervision, continuously optimizing teaching content and methods, achieving "promoting teaching through evaluation and promoting learning through evaluation."

Through the above systematic teaching reform practices, the computer network course has gradually achieved full-chain innovation from content, methods, practice to evaluation, effectively promoting the implementation of the "Four Integrations and Dual Enhancements" concept, laying

a solid foundation for cultivating high-quality network engineering talents with innovative thinking and practical abilities [5].

# 5. Analysis of Teaching Reform Implementation Effects

To scientifically evaluate the implementation effectiveness of the "Four Integrations and Dual Enhancements" teaching reform model in the computer network course, this study systematically analyzes and summarizes from three dimensions: student learning outcomes, teacher teaching effects, and course construction achievements.

## 5.1. Evaluation of Student Learning Outcomes

Through the implementation of the "Four Integrations and Dual Enhancements" teaching model, students have achieved significant improvements in the mastery of network theoretical knowledge, the application of practical skills, and the cultivation of innovation and entrepreneurship abilities. In theoretical assessment, the average score of students' final exam results in the recent two semesters increased by approximately 12% compared to before the reform, especially the score rates on comprehensive questions such as protocol mechanism analysis and network architecture design improved greatly, reflecting students' deeper understanding of core knowledge points. In terms of practical ability, students actively participated in various disciplinary competitions and achieved excellent results.

## 5.2. Evaluation of Teacher Teaching Effectiveness

During the teaching reform practice, the teacher team actively promoted the innovation of teaching methods and the improvement of teaching abilities, achieving remarkable results. In terms of teaching methods, teachers widely applied case-based teaching, project-driven teaching, and blended teaching models, significantly enhancing classroom teaching interaction frequency and depth, and markedly improving student classroom participation and satisfaction. By guiding students to participate in scientific research projects and disciplinary competitions, teachers' practical guidance abilities were also strengthened, forming a virtuous cycle of "teaching benefits teachers as well as students." In the past two years, the course teaching team cumulatively guided students to win 4 provincial-level competition awards, and published 2 teaching research papers, demonstrating the continuous improvement of teachers' comprehensive abilities in teaching content design, practical teaching organization, and competition guidance.

## 5.3. Summary of Course Construction Achievements

Guided by the "Four Integrations and Dual Enhancements" concept, the computer network course has achieved systematic results in resource construction and practical conditions. In terms of teaching resources, a digital resource system including micro-lecture videos, protocol simulation animations, online experiment platforms, and project case libraries has been established, initially forming a blended online and offline teaching environment supporting student independent learning and collaborative inquiry. Practical teaching conditions have significantly improved. The network training base built relying on industry-university cooperation already covers mainstream technological directions such as routing and switching, network security, and SDN, supporting multi-level experimental teaching and innovation training. Furthermore, the teaching reform experience of this course has been promoted and used for reference in multiple science and engineering courses within the university, and has been shared and exchanged multiple times in regional teaching seminars, gradually forming a certain demonstration and radiation effect, providing a replicable practical paradigm for similar course reforms [6].

# 6. Conclusion

Relaying on the "Four Integrations and Dual Enhancements" concept, this study systematically carried out exploration and practice of teaching reform in the computer network course. By promoting the deep integration of four aspects: disciplinary competitions and course teaching, teaching and scientific research, the "Two Leaders and Three Learnings" mechanism, and basic knowledge with frontier trends, the course content system was reconstructed, teaching methods were innovated, practical components were strengthened, and the evaluation mechanism was improved, effectively enhancing students' innovative thinking and practical abilities. The practical results show that this model significantly enhances students' learning initiative and comprehensive literacy, promotes the overall improvement of teachers' teaching abilities, promotes the systematic construction of course resources and the substantial improvement of teaching conditions, and initially forms a replicable and promotable course reform paradigm.

However, this study still has several limitations. For example, interdisciplinary integration has not been deeply expanded, and the connection between some frontier technological content and basic theory remains somewhat abrupt; the collaborative mechanism of the teacher team in project-based teaching and competition guidance needs further optimization; additionally, the stability and coverage of off-campus practical resources still need strengthening to better adapt to the development requirements of different students.

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