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Exploring and Implementing a Teaching Model for Computer Network Principles Based on "One Core, Two Unifications, Three Co-constructions, and Four Integrations."

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Abstract

The continuous development of information technology and the ongoing advancement of educational informatization present new challenges and opportunities for talent cultivation models in universities. As a foundational course for computer science and related disciplines, the quality of teaching and the effectiveness of talent development in the Computer Network Principles course directly impact students' professional competence and future prospects. To address issues such as resource imbalance and monotonous teaching methods in the course, we collaborated with the Computer Network Teaching Team at Bohai University to jointly propose and implement a "One Core, Two Unifications, Three Co-constructions, Four Integrations" teaching model featuring cross-institutional course enrollment and credit recognition. Centered on the principle of "fostering virtue through education," this model establishes fundamental norms through the harmonious unity of "student-centeredness and teacher guidance" and the harmonious unity of "pre-planned teaching and classroom generation." It aggregates superior resources) through the "co-construction of course resources," "co-construction of teaching teams," and "co-construction of evaluation criteria," ultimately achieving the integration of "employability, craftsmanship spirit, professional ethics, and innovation awareness." This paper elaborates on the conceptual framework, implementation process, outcomes, challenges, and

reflections of this model.

Keywords

principles of computer Networks, cross-campus course enrollment, credit recognition, teaching model；one core, two unifications, three collaborations, four integrations, educational informatization

1. Introduction

Computer network technology is the foundation of the information society, and its applications have extended to various fields of the economy, culture, and social life. The principles of computer networks involve fundamental concepts, protocols, and architectural structures, making it a crucial course for cultivating students' basic abilities in network planning, design, management, and maintenance. For a long time, this course has faced issues such as an imbalance in high-quality teaching resources, significant disparities in teaching levels and experimental conditions between different universities and even between different departments within the same university, which has prevented students from accessing quality education. The teaching model has been relatively rigid, primarily relying on teacher-led lectures, resulting in low student engagement and a common disconnect between theory and practice. The evaluation methods have been one-dimensional, focusing mainly on theoretical knowledge while paying insufficient attention to the development of students' practical skills and innovative thinking. Furthermore, inter-university cooperation has been limited, with inadequate credit recognition systems, hindering the sharing of high-quality educational resources and preventing students from benefiting from cross-university learning opportunities.

In the era of Education Informatization 2.0, technologies such as the Internet, big data, and artificial intelligence have demonstrated their remarkable capabilities. They have broken down barriers of time and space, making the optimal allocation and sharing of educational resources possible, which is driving higher education reform into a new phase (Liaoning Provincial Three-Year Action Plan for Educational Informatization, 2013-2015). Cross-institutional course enrollment and credit recognition, as important means of educational resource sharing and innovation in talent cultivation models, can effectively address the aforementioned issues, providing students with broader learning opportunities and more abundant learning resources. Against this background, we have partnered with Bohai University to jointly explore and implement a cross-institutional course enrollment and credit recognition teaching model for the Principles of Computer Networks course, based on the principle of "one core, two unifications, three joint constructions, and four integrations." This initiative aims to enhance the quality of course teaching and cultivate network technology talents who can meet the demands of the new era.

2. Analysis of the Connotation of the "One Core, Two Unifications, Three Joint Constructions, and Four Integrations" Model

The "One Core, Two Unifications, Three Joint Constructions, and Four Integrations" model is a

systematic framework for educational reform, where each component is interconnected and builds upon the previous one, collectively supporting the practice of cross-university course enrollment and credit recognition. Since March 2020, the "Principles of Computer Networks" course has adopted a blended teaching model combining online and offline methods for research and practice. In accordance with the regulations and requirements of the Liaoning Provincial Department of Education regarding cross-university course enrollment credits (Liaoning Provincial Department of Education, 2014), and in consideration of the actual conditions of the construction of the high-quality shared resource course "Computer Networks" at Bohai University, as well as the teaching plan of the Computer Science and Technology major in our department, the practice of cross-university course enrollment credits for the "Principles of Computer Networks" course has been carried out on the Liaoning Cross-University Credit Platform (known as "Cool Study Liaoning"). During the implementation of cross-university course enrollment credits, an exploration and practice of the "One Core, Two Unifications, Three Joint Constructions, and Four Integrations" model in the cross-university course enrollment and credit recognition of the "Principles of Computer Networks" course was conducted. Specifically, "One Core" refers to the fundamental task of fostering virtue through education, which is the core of the reform; "Two Unifications" involve the harmonious integration of student-centered learning and teacher-led guidance, as well as the harmonious integration of pre-planned teaching and dynamic classroom generation; "Three Joint Constructions" include the collaborative building of teaching teams, teaching resources, and assessment and evaluation systems between course providers and users; and "Four Integrations" encompass the integration of employability skills, craftsmanship spirit, professional ethics, and innovative awareness, as illustrated in Figure 1.

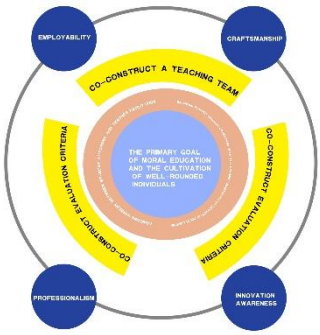

Figure 1. The "One Core, Two Unifications, Three Collaborative Constructions, and Four Integrations" Teaching Model

2.1 One Core: Upholding the Cultivation of Virtue and Nurturing of Talents as the Core of the Reform

"Laying a solid moral foundation and nurturing well-rounded individuals" is the fundamental mission of education and the core of this reform model (Deng, 2024). We integrate this principle throughout the entire teaching process, not only focusing on cultivating students' professional knowledge and skills but also emphasizing the development of their ideological and moral qualities, scientific and cultural

literacy, and physical and mental well-being. In the teaching of the "Principles of Computer Networks" course, we incorporate elements such as patriotic education, cybersecurity awareness, the cultivation of craftsmanship spirit, and the development of teamwork skills into the teaching activities. This approach guides students to establish correct worldviews, outlooks on life, and values, fostering them to become morally upright, well-rounded socialist builders and successors.

2.2 Two Unifications: Building a Harmonious and Unified Educational Environment

Adhering to the "Two Unifications," namely the harmonious unity between student-centered learning and teacher guidance, and the harmonious unity between planned teaching and emergent classroom dynamics. These two unifications serve as concrete pathways to implement the core mission of "cultivating virtue and nurturing talents," aiming to create a harmonious educational environment that respects students' individual development, stimulates their learning potential, while also ensuring the correct direction and clear objectives of teaching (Hu, Shi, & Zhu, 2017).

2.2.1 Achieving Harmony between Student Autonomy and Teacher Facilitation

The harmonious unity between student-centered learning and teacher guidance is a core embodiment of modern educational philosophy. In this model, students are no longer passive recipients of knowledge but active participants and leaders in the learning process. They are encouraged to explore proactively, ask questions, and collaborate, fostering self-directed learning skills and innovative thinking [5]. Meanwhile, teachers transform into guides and facilitators of learning. Through carefully designed teaching activities, timely feedback, and personalized guidance, they stimulate students' interest in learning, help them overcome difficulties, and deepen their understanding of complex knowledge such as the principles of computer networks. This unity respects students' agency while leveraging the professional leadership of teachers, jointly promoting mutual growth in teaching and learning.

2.2.2 Balancing Planned Teaching Objectives with the Dynamic Generation of Learning in the Classroom

The harmonious unity between planned teaching and emergent classroom dynamics is key to enhancing teaching quality. Planned teaching refers to the "blueprint" meticulously designed by teachers based on curriculum standards, student characteristics, and learning objectives, providing direction and structure for instructional activities. However, the classroom is a vibrant and dynamic space where student responses, sparks of thought, and unexpected questions can all lead to "emergent" moments. Skilled teachers can keenly capture these generative resources, flexibly adjust the pre-planned teaching sequence, and integrate students' immediate feedback into the lesson. This unity ensures both the systematic nature and effectiveness of teaching while infusing the classroom with vitality and energy. As a result, the teaching of courses like Principles of Computer Networks is no longer a rigid, one-way instillation, but rather a process of joint exploration and co-creation of knowledge between teachers and students.

2.3 Three Collaborative Constructions: Joint Development of Course Resources, Collaborative Building of Course Teams, and Shared Construction of Assessment and Evaluation Systems

2.3.1 Joint Development of Course Resources

By dismantling resource barriers, teaching teams collaborate to create or curate materials such as online courses, instructional videos, case libraries, and lab manuals. These resources are made accessible to educators and students across all participating institutions. This collaborative approach to resource development not only encourages exchange among multiple parties but also enhances the efficiency of resource use, helping to overcome resource limitations in some schools.

2.3.2 Collaborative Building of Course Teams

Establishing cross-institutional mechanisms for teacher communication, collaboration, and resource sharing is a crucial step. Firstly, these mechanisms facilitate the invitation of distinguished teaching faculty and industry experts from various institutions to deliver online or offline lectures and workshops. Secondly, they enable the organization of cross-institutional teaching and research activities, allowing for collaborative curriculum development, discussions on pedagogical challenges, and the exchange of instructional strategies. For core knowledge points or practical components, an "lead instructor-assistant" model can be implemented, wherein a more experienced instructor serves as the lead, while other faculty members act as assistants, providing supplementary instruction, addressing student inquiries, and evaluating assignments. This collaborative approach to faculty development enhances the overall quality of instruction, promotes the professional growth of educators, and provides students with exposure to diverse pedagogical styles and expert insights.

2.3.3 Shared Construction of Assessment and Evaluation Systems

The collaborative development of assessment and evaluation protocols for the Computer Network Principles course supersedes the conventional paradigm wherein a single institution and an individual instructor solely determine student assessment. This methodology embraces multi-stakeholder engagement and pluralistic integration. Academics from both the home institution and affiliated institutions deliberate and co-establish assessment benchmarks. Moreover, mentorship from industry professionals and sector specialists is incorporated into the evaluation of practical exercises. Consequently, the assessment framework more accurately reflects authentic professional demands. The evaluative strategy is characterized by its heterogeneity, integrating not merely traditional theoretical examinations but also encompassing process-based evaluations such as web-based laboratory exercises, project conception, and collaborative learning reports. Assessment grades are aggregated through the collective judgment of all participating instructors, thereby yielding a more comprehensive and objective depiction of students' scholastic achievements, with particular emphasis on their practical competencies in network configuration and diagnostic troubleshooting.

2.3.4 Four integrations: Integration of Employability, Craftsmanship, Professionalism, and Innovation Awareness

For the cross-institutional course enrollment and credit recognition model in Principles of Computer

Networking, based on the “One Core, Two Unifications, Three Collaborative Constructions, Four Integrations” framework, the “Four Integrations” are the practical means and ultimate expression of fostering students’ comprehensive skills and future competitiveness. By deeply integrating employability, craftsmanship, professionalism, and innovation awareness, this approach aims to move beyond the traditional teaching focus on theory alone, shaping high-quality network technology professionals ready for future societal needs.

Employability constitutes a foundational objective of the course. The Principles of Computer Networking course functions as a prerequisite subject within the Computer Science and Technology major. It is imperative that this course be closely integrated with professional roles within the industry. In the pedagogical design, there is a deliberate emphasis on employing authentic corporate work tasks and project-based case studies for instructional purposes. For example, when elucidating the TCP/IP protocol stack, the pedagogy extends beyond the theoretical framework to incorporate tasks that simulate enterprise network environments, encompassing activities such as configuration, optimization, and troubleshooting. This pedagogical approach enables students to acquire a mastery of network principles through the completion of relevant practical tasks, thereby developing core vocational competencies including network planning, device configuration, fault diagnosis, and resolution. Moreover, the assessment and evaluation methodologies incorporate industry-standard skill certification criteria or evaluation protocols commonly utilized by enterprises. This practice facilitates students' early comprehension of industry requirements and enhances their immediate operational proficiency upon entering the job market.

The spirit of craftsmanship is an embodiment of professional attitude. The field of computer network technology necessitates that practitioners possess a meticulous and perfectionist approach to their work. The course incorporates standardized practical activities designed to cultivate this spirit of craftsmanship. For instance, when setting up network experimental environments, students are required to adhere strictly to established protocols, ensuring organized cabling, accurate device configurations, and comprehensive documentation. When tasked with troubleshooting network faults, students are expected to exhibit patience and meticulousness, leaving no stone unturned until the issue is resolved. Furthermore, the experiences of distinguished engineers are shared, illustrating their relentless pursuit of excellence in network construction and maintenance, and their continuous drive to refine their technical skills. Through these narratives, the rigorous, focused, and innovative ethos of craftsmanship is subtly instilled in the students.

Professional competence is the core of comprehensive ability. Network engineers not only need technical skills but also require strong professional conduct. Within the course, we also integrate elements such as professional ethics, teamwork, communication, and information security awareness into the teaching process. For example, in group projects, task allocation requires members to communicate and collaborate to jointly complete the design and implementation of network solutions. When covering network security topics, the focus should extend beyond technical defenses to also

address network ethics and legal regulations, guiding students to establish a correct perspective on cybersecurity and recognize the importance of protecting user privacy and maintaining network order. Simulated corporate project presentations and technical documentation exercises are used to hone students' written and oral communication skills.

An innovative mindset is the driving force for future development. Computer network technology is constantly evolving. Students must continuously learn and innovate. Within the course, students should not be content with merely acquiring knowledge; they should strive to explore new technologies and novel applications. For instance, after completing basic experiments, students can undertake extension tasks where they attempt to use emerging network technologies (such as SDN, IPv6, etc.) to solve problems or innovate upon existing network solutions. Activities like technical seminars and innovation competitions can be organized. In the evaluation process, greater recognition can also be given to innovative ideas and unique solutions. This approach aims to cultivate students' critical thinking, problem-solving abilities, and innovative practical skills, enabling them to adapt to technological changes in the future and potentially even lead technological advancements.

These four elements are not isolated; rather, they form an organic whole, interpenetrating and mutually reinforcing each other. Employability serves as the goal orientation, the spirit of craftsmanship represents the pursuit of quality, professional competence acts as the behavioral standard, and the innovative mindset functions as the engine for development. Through the in-depth practice of these "Four Integrations" in the teaching of the Principles of Computer Networking course, we aim to cultivate students who are not only technicians with a solid understanding of network principles but also highly qualified interdisciplinary talents possessing strong skills, good character, a commitment to continuous learning, and innovative capabilities. Such individuals will be better equipped to meet the demands of the rapidly changing IT industry and contribute to the construction of a strong network nation in our country.

3. Process of Mode Practice

The practice process of cross-campus course enrollment and credit recognition for the Principles of Computer Networks course can be roughly divided into the following stages.

3.1 The Stage of Preliminary Preparation and Consensus Building

3.1.1 Establishing a Collaborative Group

The collaborative group is formed by the course responsible person and backbone teachers, with clear division of labor and a regular communication mechanism established.

3.1.2 Needs Survey and Analysis

Through methods such as questionnaires and symposiums, understand the current state of courses in various schools, teachers' needs, and students' expectations, and analyze existing problems.

3.1.3 Consensus Discussion and Standard Development

Multiple seminars were held to conduct in-depth discussions on the connotation and implementation

pathways of the "One Core, Two Unifications, Three Collaborative Constructions, Four Integrations" model. Focusing on the "Two Unifications," key faculty members were organized to jointly revise the syllabus, clarifying core knowledge points and competency requirements, and preliminarily developing

3.1.4 Initial Resource Integration

Each institution inventoried their existing high-quality course resources and preliminarily identified a list of shareable resources, such as some teaching videos, laboratory manuals, and question banks.

3.2 Phase of Model Construction and Resource Development

3.2.1 Refining the "Two Unifications"

Building upon the preliminary work, further refine the teaching standards, clearly defining the desired depth of instruction and recommended time allocation for each knowledge point. Develop detailed assessment and evaluation guidelines, including specific requirements and weightings for formative assessments (such as homework, discussions, lab reports) and summative assessments (like mid-term and final exams). Also, standardize the requirements for question types and quantities related to core knowledge points.

3.2.2 Advancing the "Three Collaborative Constructions"

Collaborative Construction of Course Resources: A series of network experiment simulation software were jointly developed. High-quality teaching videos recorded by faculty members from various institutions were integrated, and a shared course resource platform was established. Several high-quality online courses were also uniformly selected as supplementary materials.

Collaborative Construction of Course Teams: Cross-institutional teacher communication groups were established to facilitate the regular sharing of pedagogical insights. Industry experts were invited to deliver online lectures. The lead instructors and teaching assistant arrangements for certain core chapters were determined.

Collaborative Construction of Assessment and Evaluation: Cross-institutional discussions were held to jointly formulate assessment standards and methods. This evaluation system incorporates both theoretical knowledge assessments conducted by university faculty and practical skills and professional competency assessments conducted by industry mentors. The evaluation content extends beyond final exam scores to emphasize the assessment of formative achievements during the cross-institutional learning process, including projects, experiments, and communication skills. Through collaborative evaluation involving universities, industries, and inter-institutional partners, a more objective reflection of students' comprehensive abilities is achieved. This synergistic approach enhances teaching effectiveness and ensures the quality of graduates meets industry needs, thereby encouraging students' holistic development.

Designing the "Four Integration" Teaching Plan: Develop teaching plans based on actual practice that integrate online and offline learning, theory and practice, and on-campus with off-campus experiences. For instance, schedule fixed times each week for online learning, while offline classroom sessions

primarily focus on discussions, Q&A, and experimental guidance. Practical projects require students to work in groups, culminating in project reports and presentations.

3.3 Pilot Operation and Adjustment Optimization Phase

3.3.1 Small-Scale Pilot

Select a portion of classes to participate in the pilot program for cross-institutional course credit transfer. Teaching and assessment in the pilot will be conducted according to the "Two Unifications" standards.

3.3.2 Process Monitoring and Data Collection

Collect data and information during the pilot phase through methods such as learning platform backend data, classroom observations, student interviews, and teacher feedback. The focus is primarily on examining student engagement, learning effectiveness, platform usage, and teacher collaboration.

3.3.3 Problem Diagnosis and Adjustment Optimization

Based on the collected data and feedback, promptly diagnose existing issues. For example, if it is observed that some students lack self-discipline in online learning, enhanced process supervision is required; if some practical platforms are unstable, technical upgrades need to be strengthened; and the assessment methods still need to be diversified, etc. The collaborative group discusses solutions and adjusts and optimizes the teaching standards, resources, platforms, and teaching plans accordingly.

3.4 The Implementation and Continuous Refinement Phase

3.4.1 Comprehensive Promotion

Following the pilot's success, the new model will be progressively implemented in the "Principles of Computer Networks" curriculum at all partner institutions. Credit transfer procedures will be finalized to ensure students can seamlessly acquire credits for courses taken elsewhere.

2.4.2 Continuous Improvement

A normalized assessment framework is implemented to conduct regular evaluations of the teaching model's efficacy. In response to technological developments, evolving industry demands, and student input, continuous enhancements are made to teaching resources, instructional strategies are refined, the "Three Co-constructions" are furthered, and the "Four Integrations" are solidified. This process ensures the model maintains its vitality and cutting-edge status.

4. Practice Effectiveness

Through exploration and practice, the "One Core, Two Unifications, Three Collaborative Constructions, and Four Integrations" model has achieved remarkable results in improving the teaching quality of the Computer Network Principles course and promoting student development.

4.1 High-quality Educational Resources Are Shared, and the Overall Teaching Level Is Improved

Through curriculum co-construction, students from all participating institutions gain access to a wider range of higher-quality online teaching resources, thereby addressing the shortage of such resources in some schools. Faculty co-construction enhances teachers' communication and learning abilities. A

unified curriculum standard ensures teaching quality, eliminating variations in quality that might otherwise arise from individual teacher differences. Students participating in cross-institutional course enrollment have shown increased satisfaction with the course resources and greater recognition of the instructors.

4.2 Students Show Greater Initiative in Learning, and Their Comprehensive Skills Are Being Honed

The blended learning model provides a more flexible way of learning, stimulating students' interest. Online self-directed learning helps cultivate students' information literacy and self-study skills, while offline interactive communication helps develop their expressive abilities. The high integration of theory and practice, particularly through project-based learning and practical platforms, enhances students' hands-on skills and problem-solving abilities. Students generally agree that cross-institutional courses have enabled them to acquire knowledge, develop their skills, and broaden their horizons.

4.3 Strengthening the Practical Component Has Resulted in an Enhanced Ability to Compete for Employment

The collaborative construction of practical platforms has addressed the issue of insufficient experimental conditions in some schools, ensuring that all students have adequate opportunities for hands-on practice. By incorporating corporate resources and vocational literacy education, the course content has become more aligned with industry needs, allowing students' practical skills and professional qualities to improve simultaneously. Some students who participated in the project received recognition from potential employers during internships or job searches, acknowledging their solid practical skills and good professional conduct.

4.4 The Inter-university Cooperation Mechanism Has been Initially Established, and the Credit Recognition System is Being Carried out in an Orderly Manner

"The 'Two Unifications' have laid a solid foundation for credit recognition. Reaching a consensus among teachers from various institutions on curriculum standards and assessment requirements has made the recognition of grades and conversion of credits for students studying across institutions much smoother. Currently, this primarily takes place between partner institutions. The concept and mechanism for inter-university cooperation have been initially established, paving the way for broader credit recognition in the future."

5. Challenges and Considerations

While positive results have been achieved in some aspects, we have also encountered certain challenges during the implementation process, which require in-depth reflection and the search for solutions.

5.1 Balancing Standardization and Distinctive Development

A unified curriculum standard helps ensure the quality of basic teaching but may also constrain reforms tailored to the specific characteristics of individual schools and their students. Under the unified standard, promoting the development of teaching feature at each school to meet the needs of students

with different levels and interests requires continuous exploration. In the future, it could be considered to offer elective modules or feature practical projects based on unified core requirements.

5.2 Fairness and Effectiveness of Assessment and Evaluation

Ensuring consistent assessment and evaluation also practically involves the challenge of guaranteeing uniform evaluation standards across different schools and teachers. Additionally, the recording and verification of formative assessment records can be quite complex. Utilizing technology (such as learning analytics) for a more objective and comprehensive evaluation of students' learning processes and outcomes is a necessary condition for improving the effectiveness of assessment. Furthermore, designing assessment methods that better evaluate students' comprehensive abilities and innovative thinking is also a key direction for future efforts.

5.3 Sustainability of Resource Co-construction and Sharing

Resource co-construction requires a significant investment of human, material, and financial resources. Establishing long-term investment and incentive mechanisms is key to encouraging teachers to continuously participate in resource development and updates, which is crucial for the sustainable development of resource co-construction. Mechanisms such as intellectual property rights sharing and rewards for teaching achievements can be considered, along with seeking support from the school or higher-level departments.

5.4 The cost and Maintenance of Practical Platform Construction

The cost of building high-quality practical platforms is relatively high, and they require continuous technical maintenance and updates. This places a heavier burden on schools with relatively limited resources. In the future, it's possible to explore more diverse models for platform construction, such as partnering with enterprises, utilizing open-source technologies, or sharing resources from large cloud platforms, to reduce both construction and maintenance costs.

5.5 Complexity of Cross-school Management and Coordination

Cross-school cooperation involves multiple aspects such as academic administration, student record management, and credit recognition, making coordination challenging. It is necessary to establish more efficient and standardized management and coordination mechanisms, clarify the rights and responsibilities of all parties, and simplify operational procedures. The development of an information management platform is crucial for improving administrative efficiency.

6. Conclusion and Outlook

The cross-institutional enrollment and credit recognition teaching model for the "Computer Network Principles" course, based on the framework of "one core, two unifications, three joint constructions, and four integrations," represents a systematic reform initiative targeting the pain points of traditional course instruction within the context of educational informatization. Practice has demonstrated that this model can effectively integrate high-quality educational resources, enhance teaching quality, and promote students' all-round development, providing a valuable practical pathway for deepening

university teaching reforms and cultivating high-quality applied talents.

Although this model still faces numerous challenges, with the advancement of educational informatization and increased awareness of university collaboration, these issues will gradually be overcome. In the future, there is a need to further refine the standards of the "two unifications," expand the scope of the "three joint constructions," and innovate the forms of the "four integrations." For instance, we can further explore more evaluation methods, develop more intelligent personalized learning systems, deepen and broaden collaborations with enterprises, extend cross-institutional enrollment to more courses, and explore cross-regional and cross-institutional types of credit recognition. Through continuous exploration and effort, the "one core, two unifications, three joint constructions, and four integrations" model can better promote educational equity, improve talent cultivation quality, and serve the high-quality development of higher education in China.

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