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Teaching Reform and Practice with Computer Network Courses in the Context of New Engineering Education

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Abstract: The initiative of Emerging Engineering Education (EEE) is designed to address the new technological revolution and industrial transformation. This paper aims to explore the reform and practice of both the content and teaching methods of Computer Network courses under the context of EEE. To meet the demands for engineering practicality and interdisciplinary learning emphasized by EEE, the course content has been restructured. Furthermore, in order to effectively deliver the multi-level curriculum, innovations and reforms in classroom teaching based on the BOPPPS model are also discussed.

1. Introduction

The latest technological revolution and industrial transformation present a new challenge on engineering education. In 2017, the Ministry of Education, in collaboration with various universities, released the "Fudan Consensus", "Tianjin Action" and "Beijing Guidelines", introducing the concept of Emerging Engineering Education (EEE) [1]. EEE emphasizes interdisciplinary integration, focusing on areas such as artificial intelligence, big data, and cloud computing within the computer field. It promotes an interdisciplinary training model characterized by "Computer + X" (e.g., smart healthcare, bioinformatics). Simultaneously, EEE requires that course content keeps pace with cutting-edge technology and promotes practical and innovative abilities

The Computer Network course is a core curriculum in computer science, communications, control, and other related areas. From a pedagogical perspective, EEE needs a shift in this course from a knowledge-transmission-centered approach to a competency-development-centered one. Computer Network course with competency-oriented requires comprehensive improvements in reconstructing course objectives, reshaping course content, innovating teaching methods, and enhancing practical and evaluation components.

2. Analysis of the Current State of Computer Network Courses

2.1 Current Architecture of Computer Networks

Computer network technology demonstrates network topology and architecture to students, based on the TCP/IP protocol stack for communication and centered around switching/routing devices for data forwarding[3]. This supports ubiquitous data exchange from the Internet of Things (IoT) to supercomputing. Current computer network teaching primarily focuses on the principles and protocols of the foundational parts, along with basic networking configuration learning. As shown in Table 1, the course content is structured around the five-layer model, explaining principles and some protocols layer by layer. Experiments mainly involve networking configuration of switches and routers. The theoretical part of computer networks is extensive and abstract, often requiring basic configuration experiments to observe network behavior or verify the correctness of protocols and principles. While these experiments aid in understanding the theory, they are insufficient to form a system that meets industry demands.

Table 1 Architecture of Computer Network Content

OSI Seven-Layer Model	TCP/IP Four-Layer Conceptual Model	Five-Layer Model	Network Protocols	Devices
Application	Application	Application	DHCP, DNS, FTP, HTTP, POP3, SMTP, SSH, TELNET	Gateway
Presentation				
Session				
Transport	Transport	Transport	TCP, UDP	Layer 4 Router
Network	Network	Network	IP, ARP, RARP, ICMP, ICMPv6, IGMP, RIP, OSPF, BGP	Router
Data Link	Data Link	Data Link	ARQ, SW, CSMA/CD, PPP, HDLC, ATM	Bridge, Switch
Physical		Physical	None	Repeater, Hub

2.2 Analysis of the Intersection of Computer Networks and IT Positions

EEE requires disciplines to undergo practical transformation and upgrading. The Computer Network course must lay a solid foundation for students' employment and future related work from an engineering practice perspective. To better analyze the direction and focus of computer network teaching reform, it is essential to examine the essential technical skills from a market demand viewpoint. As shown in Figure 1, for the Computer Network course, the core network layer primarily targets network engineer positions, forming the foundation. The second layer is development and application, involving application and transport layer protocols commonly used in software or product development. It is evident that application and transport layer protocols are essential for developers. The third layer is security and architecture, requiring mastery of protocol analysis, protocol development, and network security-related design. The final layer encompasses emerging fields, where new technologies such as edge computing and AI networks can be explored.

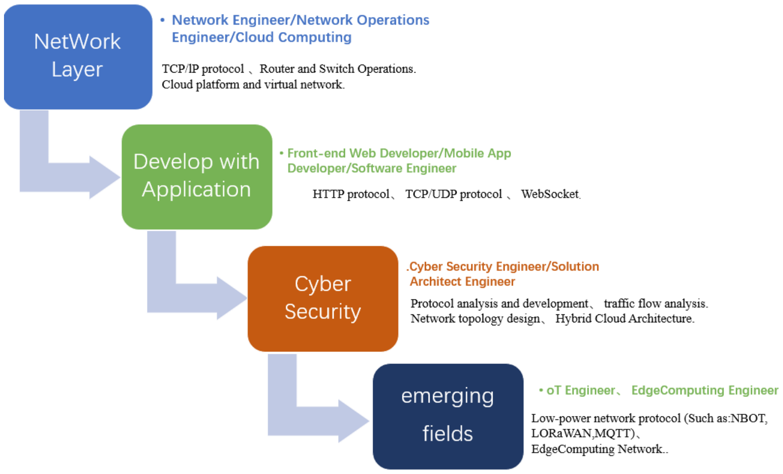

Figure 1 Intersection of Computer Networks and IT Positions

3. Ideas for Reform and Innovation in Computer Network Courses

Based on the analysis in the previous chapter, computer networks are widely applied in the ICT (Information and Communication Technology) field. To meet the EEE requirements for engineering practice, the practical component of the computer network course can be designed according to different roles. Therefore, the design principle for the practical part of the computer network course is: grounded in network engineering technology, introducing network programming cases, and guiding students to explore and engage in network security and emerging AI fields.

3.1 Grounded in Network Engineering Technology

The practical cases in the computer network course remain related to network engineering. Through industry-education integration, cases related to the Huawei HCIA network engineer certification can be introduced. During teaching, students can be encouraged to obtain Huawei HCIA certification. These cases primarily involve network topology design, configuration, and protocol observation experiments. Through network design and protocol packet capture analysis, students can observe data interactions in the network, thereby better understanding network concepts and principles.

3.2 Introduction of Network Programming Cases

These cases mainly focus on programming for application layer and transport layer protocols. Students can use their familiar programming languages along with Socket[4] programming to simulate and implement network-related functions.

3.3 Emerging AI Fields

For example, using AI algorithms to analyze traffic and identify potential network security issues. Students can also be guided to explore edge computing and implement related experiments.

3.4 Updating Classroom and Teaching Methods

In the context of EEE, computer networks need to consider interdisciplinary knowledge and practical applications in engineering. This poses challenges to current classroom teaching. Therefore, to effectively deliver computer network instruction, teaching methods must be improved and enhanced.

4. Content of Computer Network Course Reform

4.1 Hierarchical Restructuring of Practical Content

From the perspective of computer network teaching content, to adapt to the engineering practice requirements of EEE and enable students to master the interdisciplinary knowledge required by computer networks, the practical content is divided into three categories. In classroom teaching, to help students better understand network principles and protocols, network topologies are built in simulators during theoretical lectures to observe protocol interactions. Thus, network engineering experiments are foundational, mostly verification-based. Network programming experiments are primarily practiced outside of class during the teaching of transport and application layers. Exercises combining AI and networks are mainly conducted in graduation projects and course designs. The hierarchical structure of computer network practical content, as shown in Figure 2.

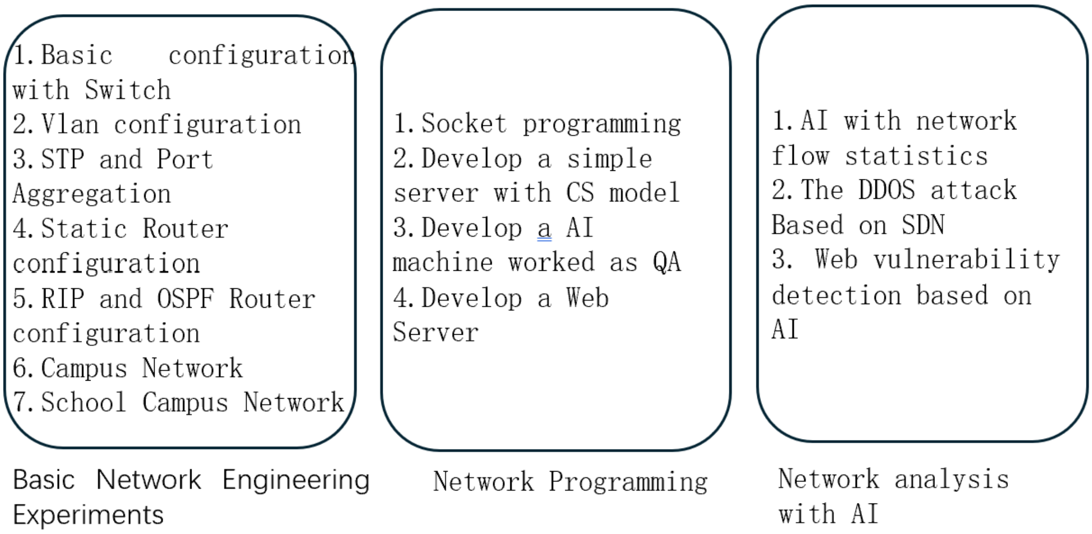

Figure 2 Hierarchical Structure of Computer Network Practical Content

4.2 Updating Classroom Teaching Methods

4.2.1 Project-Based Hybrid Teaching Model

In classroom organization, introduce network engineering practice cases, use projects as guides, and complete projects progressively through classroom tasks. The project-based teaching schedule, as shown in Table 2.

Table 2: Project-Based Teaching Schedule

Objective / Contents	1	2	3	4	5	6	7	Hours	Theory Hours	Practical Hours
Project 1: small-scale LAN	0.2	0.2	0.2	0.1	0.2	0.2	0.2	8	8	2
Project 2: Wireless LAN	0.1	0.2	0.1	0.1	0.1	0.1	0.1	4	2	2
Project 3: Campus Network	0.2	0.2	0.2	0.2	0.2	0.2	0.4	18	12	4
Project 4: Enterprise Network	0.3	0.2	0.3	0.4	0.3	0.2	0.2	16	8	6
Project 5: SDN Network Practice	0.2	0.2	0.2	0.2	0.2	0.2	0.1	4	2	2
Total	1.0	1.0	1.0	1.0	1.0	1.0	1	48	32	16

Each project includes progressively structured tasks. For example, in the Small LAN project, tasks are set as follows:

Task Number	Experiment Content
Task 1	Basic Switch Configuration
Task 2	Single Switch VLAN Network Planning and Implementation
Task 3	Cross-Switch VLAN Network Planning and Implementation
Task 4	Hybrid Port VLAN Configuration Experiment on Switches
Task5	Inter-VLAN Communication via Router-on-a-Stick: Planning and Implementation
Task 6	Link Aggregation in LACP Mode: Planning and Implementation
Task 7	Link Aggregation in Manual Mode: Planning and Implementation
Task 8	Spanning Tree Protocol (STP) Network Planning and Implementation
Task 9	MSTP Network Planning and Implementation
Task 10	VRRP Load Balancing Network Planning and Implementation
Task 11	VRRP Primary-Backup Network Planning and Implementation

4.2.2 BOPPPS-Based Online and Offline Hybrid Teaching

Due to the hierarchical nature of the practical content, computer network teaching must be conducted within the constraints of the allotted class hours .

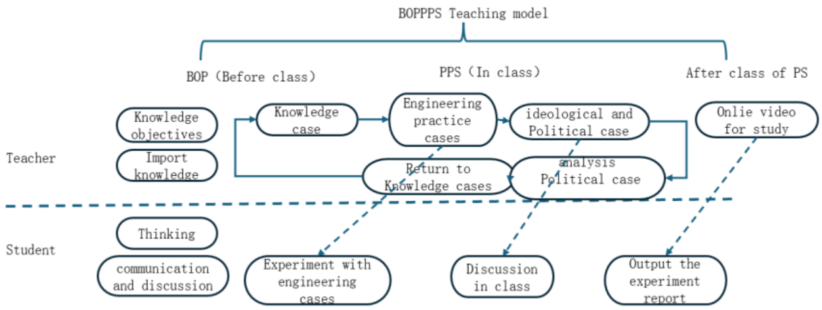

Figure 3 Teaching under the BOPPPS Online-Offline Hybrid Model

Lecture and Analysis: Based on the BOPPPS model[2], teachers should thoroughly explain knowledge points in class using methods such as case analysis and demonstration to ensure students fully understand. Case selections in class primarily stem from the task objectives decomposed from projects, and some tasks should extract ideological and political education cases for explanation. The teaching under the BOPPPS Online-Offline Hybrid Model,as shown in Figure 3.

Practice: Pre-class preview via Cloud Class (an online learning platform), in-class practice, and post-class report consolidation and extension. This part mainly involves network programming practice cases, which students can complete offline and submit online for teacher grading.

Extension: Conducted online through additional problems. Interested and capable students can complete related tasks, primarily through competitions, graduation projects, etc., to fulfill this part of the practical content. Introduction of New Tools like AI into Classroom Teaching.

With the advent of tools like DeepSeek, the integration of AI and education has yielded excellent results. Computer network theory is profound and broad, requiring vivid explanations of theories and protocols, supplemented by experiments allowing students to observe network protocols and principles. Networking configuration experiments require familiarity with Huawei or Cisco commands. Students can utilize AI assistance to complete these experiments.

5. Effectiveness and Evaluation

To comprehensively reflect students' interdisciplinary competence and engineering practical abilities under the Emerging Engineering Education framework, this course has established a diversified, process-oriented, and competency-based evaluation system. It moves beyond the traditional single-exam assessment model by emphasizing students' comprehensive performance in project practice, teamwork, and innovative application.

Table 3: Assessment Components and Weighting

Number	Assessment Dimension	Specific Content	Weight
1	Project Practice	Completion of tiered projects (Network Engineering, Network Programming, AI + Networking)	40%
2	Lab Reports & Documentation	Experiment analysis, protocol capture reports, project design documents, code commenting standards	20%
3	Class Participation & Collaboration	Interactive performance in the BOPPPS model, group collaboration, completion of online tasks	10%
4	Innovation Capability & Extension	Participation in competitions, graduation projects, outcomes of AI-assisted experiments, research reports on emerging technologies	10%
5	Certification & Examination	Huawei HCIA certification (or simulated certification exam), final theoretical + practical comprehensive exam	20%

Through continuous improvements, students' learning enthusiasm remains consistently high. In the 2024 Huawei HCIA certification training and examination, both participation and pass rates reached record levels, with the HCIA certification pass rate exceeding 90%. The classroom presentation, as shown in Figure 4.

Figure 4 Classroom Presentation

6. Conclusion

In the context of Emerging Engineering Education, the Computer Network course has undergone optimization of engineering practice projects and a structured arrangement of hierarchical practical cases. On one hand, this allows for better verification of computer network theoretical knowledge, enabling students to observe and learn network concepts intuitively. On the other hand, through projects of varying difficulty levels, students not only master basic network engineering configuration skills but also broaden their horizons, allowing them to engage in network technology-related learning and research using the latest AI and other new technologies.

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