Redesigning the 'Competency Map–Project Cluster' Course in Computer Architecture Based on OBE: A Case Study by the Ideological and Political Education Team of the Network Engineering Programme

Xueri Li*, Liping Fu, Huitong Liao, Junming Zeng
School of Computer Science, Guangdong University of Science and Technology, Dongguan, China
**Corresponding Author*

Abstract: To address the disconnect between theory and practice, insufficient industry relevance, and weak integration of ideological and political elements in the Computer Architecture course for Network Engineering majors at applied undergraduate universities, this paper proposes a "Competency Map–Project Cluster" course restructuring scheme based on the OBE philosophy. A tiered competency map with 12 core competencies and 3 ideological literacy indicators was constructed through enterprise surveys and occupational standards. A progressive project cluster of six real-world engineering tasks, including "Simple CPU System Assembly" and "Embedded Network Hardware Performance Tuning," was designed to integrate knowledge, skills, and values. A blended teaching model (project-driven learning, flipped classrooms, case teaching) and a diversified assessment system (process data, outcome quality, behavioural performance) were implemented with an "ideological education team" of subject lecturers, industry mentors, and political education teachers. Practice shows this scheme significantly improves students' motivation, engineering skills, and awareness of serving the nation through technology, creating a win-win situation of student benefit, teacher development, industry satisfaction, and institutional support.

Keywords: OBE Philosophy; Competency Map; Project Cluster; Principles of Computer Organisation; Ideological and Political Education in Courses

1. Introduction

Congratulations! As a core foundational course for computer science programmes, 'Principles of Computer Organisation' bears the crucial responsibility of cultivating students' understanding of computer hardware architecture, operating principles, and their coordination mechanisms [1]. However, with the widespread application of emerging technologies such as embedded systems, edge computing, and intelligent network devices, the traditional curriculum has gradually revealed issues such as a disconnect from industry demands, outdated teaching content, and weak practical components. Particularly for students in Network Engineering, it is not only necessary to master general hardware knowledge, but also to possess specialised competencies such as analysing the hardware architecture of network devices, debugging embedded network systems, and hardware acceleration for protocol processing. Currently, most universities still rely primarily on a 'lecture-based teaching plus verification experiments' model, making it difficult for students to translate abstract theories into the ability to solve practical network engineering problems. Consequently, graduates struggle to adapt quickly to the demands of roles such as network device development, smart gateway design, and edge computing node deployment. At the same time, applied undergraduate universities generally face a significant gap between their course teaching objectives and the fundamental mission of 'cultivating versatile talents equipped with engineering practical skills, innovative capabilities, and a sense of national pride' [2]. Consequently, there is an urgent need to reconstruct course objectives, content and teaching strategies guided by modern educational theory, driving a shift from 'knowledge-transmission' to 'competency-development' in teaching, whilst integrating value-oriented guidance throughout the entire professional education process.

The OBE philosophy centres on student learning outcomes and emphasises 'backward design and forward implementation', which aligns closely with the institutional mission of applied undergraduate universities to 'serve local economic development and cultivate high-calibre technical and skilled talent' [3]. Introducing the OBE philosophy into the teaching of the 'Principles of Computer Architecture' course helps to clarify the supportive relationship between course objectives and graduation requirements. At the same time, ideological and political education within the curriculum, as a key requirement of higher education in the new era, emphasises the integration of value elements such as engineering ethics, contributing to the nation through science and technology, and teamwork into specialised courses [4]. Against this backdrop, this study draws upon an "ideological and political education team" comprising academic staff, industry mentors and ideological and political education lecturers to propose a "competency map–project cluster" framework for curriculum restructuring. It explores a new teaching model centred on competencies, delivered through projects and underpinned by ideological and political education, thereby driving the in-depth development of curriculum reform.

2. The OBE Philosophy and the Curriculum Reconstruction Framework

The core of the OBE philosophy lies in being "student-centred and outcome-oriented". Within the curriculum system, OBE requires lecturers to first clarify the specific competencies students should possess upon completing the course; these competencies must be observable, measurable, and aligned with industry job requirements [5].For the Network Engineering programme, the course team conducted research into the job requirements of companies such as Huawei, H3C, Ruijie Networks and embedded network equipment firms. By combining this with the 'Computer Network Technician' occupational standards and feedback on graduate career development, we identified the core competencies students should possess, such as: 'understanding of basic network processor architecture', 'hardware debugging skills for embedded network systems' and 'memory access optimisation skills'.Course objectives are no longer stated in general terms but have been refined into specific outcomes, such as "the ability to design and implement a CPU system supporting simple network protocol processing" and "the ability to analyse and optimise memory access bottlenecks in network equipment" [6].

Building upon these defined course objectives, this study proposes a framework for restructuring the curriculum driven by a dual-wheel approach of "competency maps and project clusters", and for the first time systematically incorporates ideological and political education objectives into the competency maps. The competency map systematically reviews and visually represents the course competencies, covering not only knowledge-based objectives but also integrating skills-based, application-oriented, innovative, and value-based goals. Project clusters then serve as the vehicle for realising these competencies. By designing a series of project tasks that progress from simple to complex, students are guided to 'learn by doing and do whilst learning', thereby achieving the coordinated development of knowledge, competencies and personal qualities. This framework breaks away from the traditional 'chapter-based' knowledge structure of courses, instead organising teaching content according to 'project logic'. This enables students to gradually build a systematic body of hardware knowledge, engineering thinking skills and a sense of national pride whilst completing real-world engineering tasks.

Furthermore, the OBE philosophy emphasises 'continuous improvement', meaning that teaching and learning should establish a closed-loop feedback mechanism. In this study, the ideological and political education team (comprising subject lecturers, industry mentors and ideological and political education lecturers) regularly conducts collective lesson planning and teaching reflection, using the effectiveness of integrating ideological and political elements as a key basis for pedagogical improvement. The course evaluation system is no longer confined to end-of-term examinations but encompasses multiple dimensions, including project outcomes, classroom performance, teamwork, innovative solutions, and ideological and political literacy-such as awareness of engineering ethics, a spirit of dedication to the team, and an understanding of serving the nation through science and technology. It also incorporates student self-assessment, peer assessment, and reviews by

industry experts to ensure the objectivity and comprehensiveness of the evaluation results. Concurrently, the course team will regularly analyse student learning data, industry feedback and teaching observations to dynamically adjust the competency framework and project design, thereby establishing a virtuous cycle of 'objectives-implementation-evaluation-optimisation'. This mechanism not only enhances the course's adaptability and forward-looking nature but also provides a replicable and scalable model for other courses seeking to implement OBE and ideological and political education reform in tandem.

3. Design of the "Competency Map-Project Cluster" System

3.1 Construction of a Tiered Competency Map

In response to the job requirements of the Network Engineering programme, the course team conducted in-depth research into enterprises such as Huawei, H3C and Ruijie Networks, as well as the 'Computer Network Technician' occupational standard. Combining this with feedback on graduates' career development, they systematically constructed a tiered competency framework that integrates ideological and political objectives [7].This framework identifies 12 core competencies, including digital logic circuit design, understanding and implementation of instruction sets, construction and optimisation of storage systems, and hardware adaptation for network devices. It also introduces, for the first time, three ideological and political literacy indicators: engineering ethical judgement, teamwork and communication skills, and a sense of mission to strengthen the nation through science and technology. These competencies are categorised into foundational, core and advanced tiers, and are presented in a tree diagram to clearly illustrate the interdependencies between them, whilst also indicating the corresponding ideological and political integration points for each competency (e.g., proprietary instruction sets and national information security). This framework provides a clear and actionable structure for subsequent project design, teaching organisation and ideological and political assessment.

3.2 Project Cluster Design and Integration of Ideological and Political Education

Six progressive projects were designed around the competency map, forming a competency progression chain of "component-system-network adaptation". Specific projects include: logic gate component design, register and data path construction, instruction set design and microprogram control, simple CPU system assembly, memory system expansion and optimisation, and "embedded network hardware system performance tuning" tailored to the characteristics of network engineering. Each project incorporates a "ethical reflection" or "social responsibility" component. For instance, the instruction set design project guides students to consider the significance of a proprietary instruction set for national security, whilst the memory optimisation project discusses the security and reliability of data storage. Concurrently, the course team integrates case studies-such as the development history of domestically produced CPUs and breakthroughs in the localisation of network equipment-into project briefs and micro-lecture videos. This fosters students' awareness of self-reliance and their aspiration to contribute to the nation through technology, ensuring that ideological and political education is instilled subtly and effectively.

All projects are derived from real-world corporate tasks or simulated engineering cases; for instance, the "Embedded Network Hardware System Performance Tuning" project is based on an actual development task from a smart network equipment company. Working in groups of four to five, students complete the entire process-from requirements analysis and solution design to circuit simulation, FPGA prototyping, system debugging and testing, and final presentation-with joint guidance and process evaluation provided by industry mentors and ideological and political education lecturers [8]. The ideological and political education team monitors students' teamwork performance, sense of responsibility, and ethical decision-making behaviour throughout the process, and specifically includes "ideological and political literacy" assessment criteria in the mid-term reviews and final defence sessions. Through this approach, students not only master the methods for constructing and optimising hardware systems but also strengthen their professional sense of mission, spirit of collective problem-solving, and engineering ethics within real-world

engineering contexts, thereby achieving a deep integration of knowledge, skills, and values.

4. Teaching Implementation and Evaluation Mechanisms

4.1 Teaching Implementation Process

In terms of the teaching implementation process, the course adopts a spiral structure of "theory-practice-reflection-re-practice" and employs a "three-stage, four-phase" teaching process [9]. Stage One involves task introduction and knowledge activation, where the instructor uses videos-such as news reports on breakthroughs in domestic chip development and case studies of hardware failures in network equipment-to spark students' interest, activate prior knowledge, and organise classroom discussions to guide reflection on engineering ethics and national security. Phase Two involves scheme design and prototype validation. Students work in groups to complete requirements analysis, architectural design, circuit simulation and FPGA prototype construction. During this phase, they must submit two interim reports for dual-track assessment by both academic staff and industry mentors; the ideological and political education team focuses particularly on the rationality of team division of labour, the presence of any 'free-riding' behaviour, and whether students demonstrate a sense of responsibility and a spirit of mutual assistance. Phase Three involves system optimisation and final project defence. Students expand functionality and fine-tune performance based on feedback, concluding the course with a prototype system, technical documentation and a presentation. The defence includes a 'political education literacy' assessment component, requiring groups to explain how teamwork, ethical considerations or patriotic sentiment were demonstrated throughout the project. The entire course adopts a 'flipped classroom' approach, with teachers acting as facilitators. Open laboratories and virtual simulation platforms enable students to practise at any time, significantly enhancing learning efficiency and practical skills.

4.2 Diversified Assessment and Continuous Improvement Mechanism

In terms of the assessment mechanism, the course has established a diversified evaluation system comprising "process data + quality of outcomes + behavioural performance + ideological and political literacy", completely breaking away from the traditional "one-exam-determines-the-grade" model [10].The final mark comprises four components: project outcomes, process performance, theoretical assessment (20%, covering core knowledge points and engineering analysis skills), and ideological and political literacy. Specific evaluation indicators for ideological and political literacy include: the quality of engineering ethics assignments (e.g., safety and reliability analysis in hardware design); dedication indicators in peer reviews (e.g., whether students proactively assist peers or undertake additional tasks); and short essays on the theme of 'serving the nation through science and technology' (e.g., discussing personal career plans in relation to the development of domestically produced CPUs).Political education lecturers participate in the formulation of assessment criteria and the review of final grades, ensuring that political education assessments are evidence-based and not merely a formality, thereby enabling value-based guidance to be genuinely implemented in measurable and feedback-driven teaching processes.

Furthermore, an 'ideological and political education team'-comprising subject lecturers, industry mentors and ideological and political education lecturers-holds a collective lesson preparation meeting every two weeks to share successful case studies of integrating ideological and political education and suggestions for improvement, whilst formulating targeted strategies to address typical issues arising in teaching (such as some students' weak sense of teamwork or superficial discussions on engineering ethics).The course has also introduced a "Problem Wall" and "Experience Pool" mechanism, encouraging students to share typical technical challenges and solutions encountered during projects, insights on team collaboration, and reflections on ethical dilemmas via an online platform, thereby creating a collective knowledge base and a repository of ideological and political education case studies. Through a closed-loop feedback cycle of "objectives-implementation-evaluation-optimisation", the course team continuously refines the competency framework, project design and teaching strategies. This mechanism has not only significantly enhanced students' systems engineering literacy, professional confidence and sense of national identity, but

has also created a win-win situation where "students benefit-teachers grow-industry is satisfied-the university provides support", offering a replicable practical model for the collaborative reform of Outcome-Based Education (OBE) and ideological and political education in similar courses.

5. Conclusions and Outlook

Guided by the OBE philosophy and supported by an "ideological and political education team" comprising subject specialists, industry mentors and ideological and political education lecturers, this study addresses the teaching challenges of the "Principles of Computer Architecture" course within the Network Engineering programme by proposing a "competency map–project cluster" curriculum restructuring scheme. By constructing a hierarchical, visualised competency map, the study clarifies the supportive relationships between course objectives, graduate competencies and value-oriented guidance. Based on this map, six progressive projects were designed to form a competency progression chain of "components-systems-network adaptation", with ideological and political elements-such as domestic CPU case studies, engineering ethics and team collaboration-organically integrated throughout the project process. The teaching implementation adopted a "three-stage, four-phase" process and a "flipped classroom" model, establishing a diversified assessment system comprising "process data + quality of outcomes + behavioural performance + ideological and political literacy". Practice has demonstrated that this approach effectively addresses issues such as the disconnect between theory and practice and the awkward integration of ideological and political education. It has significantly enhanced students' engineering practical skills, innovative thinking and awareness of serving the nation through science and technology, creating a win-win situation characterised by "student benefit-teacher development-corporate satisfaction-institutional support".

Looking ahead, the course team will continue to deepen the integration of OBE and ideological and political education. Firstly, we will optimise the competency framework and project design by introducing cutting-edge technologies such as time-sensitive network hardware acceleration and programmable data planes, thereby expanding the depth and breadth of the project portfolio. Secondly, we will strengthen collaboration with network communications enterprises to explore the establishment of "joint university-industry network hardware laboratories" and "industry colleges", providing a more authentic practical environment.Thirdly, we will conduct learning analytics and assessments of ideological and political literacy enhancement based on big data, to achieve personalised teaching guidance and targeted ideological and political interventions. Through continuous improvement, we aim to establish this course as a benchmark model for OBE combined with ideological and political education, providing robust support for the cultivation of talent in network engineering programmes at applied undergraduate universities, and contributing to the security and development of the national information industry.

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