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Promoting the Construction of the "Computer Organization" Course through the "Four Threes" Model

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Abstract

To implement the concept of "Emerging Engineering Education" and achieve the goal of deeply integrating its development with innovation and entrepreneurship education, enabling students to acquire a solid foundation of professional knowledge, advanced engineering application skills, and strong innovation and entrepreneurship qualities and capabilities, this study addresses long-standing issues in the school's "Computer Organization" course, such as difficulties in understanding and mastering theoretical knowledge, poor practical hands-on abilities, and weakened innovation capabilities. Accordingly, a specialized innovation-entrepreneurship integrated teaching model, termed the "Four Threes" model—guided by three objectives, integrated through three content areas, advanced in three steps, and evaluated via three outcomes—has been proposed and constructed. This model is based on three overarching goals: knowledge, ability, and literacy. It revolves around three types of teaching content: hardware innovation cases, entrepreneurial practice, and project design. The learning process is carried out step by step through a three-phase approach: pre-class guided learning, in-class research-based learning, and post-class extended learning. Additionally, based on the teaching characteristics of each phase, a comprehensive multi-evaluation mechanism encompassing knowledge and ability, process and results, and individual and team performance has been established. Practical results show that the "Four Threes" specialized innovation-entrepreneurship integrated teaching model can fully engage students, effectively stimulate their learning motivation, enhance their interest in learning, help them master systematic design, and foster their collaborative awareness and innovative thinking. The application of this model in professional courses of Computer Science and Technology has led to a 10.01% increase in students' final comprehensive scores, an excellent rate of 85% in project design, and a course satisfaction survey rate of 92.5%, demonstrating the strong operability of this model.

Keywords

Specialized Innovation-Entrepreneurship Integration; Computer Organization; Teaching Reform.

1. Introduction

1.1. Background

The world is currently in the midst of a wave of technological innovation, led by new-generation information technologies such as artificial intelligence, quantum information, and integrated circuits. These technologies are bringing about a great revolution in science, technology, and industry, presenting opportunities for cultivating a new generation of scientific research talents.

China's 14th Five-Year Plan proposes new requirements to improve the modernization level of industrial and supply chains and accelerate the development of strategic emerging industries.

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These requirements place higher demands on university talent cultivation, as well as on the positioning and quality structure of engineering talent training. Therefore, appropriate adjustments must be made.

The construction of "New Engineering Disciplines" (Emerging Engineering Education) is being continuously improved. Its main tasks are to lay the foundation for future industries and sectors, and to guide the direction of future industrial development. It emphasizes interdisciplinary studies, industry-education integration, joint talent cultivation, and the development of students' innovation and entrepreneurship abilities.

Computer Organization* is an important foundational course for disciplines such as computer science and technology, software engineering, and the Internet of Things. It serves as a bridge within the university curriculum, connecting earlier courses to later advanced courses, and acts as a bridge for students transitioning from digital logic to operating systems and other subsequent advanced courses. The goal of this course is to help students grasp the working principles and design methods of computer hardware systems. However, due to the abstract and difficult nature of the course content, it has long been a problem that teachers struggle to teach effectively and students find it difficult to understand and connect to practical applications. When students learn this course, they often only remember fragmentary abstract concepts such as binary, timing control, and micro-operations from the textbook, lacking a complete, systematic view of hardware and engineering thinking. Consequently, they cannot apply the relevant theoretical knowledge to the latest developments in computer hardware research and development.

As the concept of "mass entrepreneurship and mass innovation" has taken root in people's minds, innovation and entrepreneurship education is no longer just a supplementary part of talent cultivation; it has increasingly become a key indicator of educational effectiveness. However, how to truly integrate innovation and entrepreneurship education into the professional teaching system — especially achieving a natural integration in a theory-intensive and foundational course like *Computer Organization*, while avoiding the "two separate skins" phenomenon where professional teaching and innovation training are disconnected from each other — has become an important issue that must be addressed in the deepening reform of engineering education. Therefore, exploring and establishing a practical specialty-innovation integration teaching model tailored to the characteristics of this course is of great theoretical significance and practical urgency. Such a model can effectively stimulate students' learning initiative, systematically cultivate their innovative thinking, entrepreneurial literacy, and engineering practice abilities, and thus improve the overall quality of talent cultivation in the computer hardware field.

1.2. Research Objectives and Significance

This study aims to address the teaching pain points of the Computer organization course by constructing and implementing a systematic and operable specialty-innovation integration teaching model structured along the main line of "objectives → content → process → evaluation". The specific objectives are as follows:

(1) Establish a new system of teaching objectives guided by the three goals of "knowledge, ability, and literacy", achieving a shift from knowledge transmission to comprehensive talent cultivation.

(2) Design a new course content system integrating the three components of "hardware innovation cases, entrepreneurship practice, and project design", organically combining industry frontiers, entrepreneurial ecosystems, and classic theories.

(3) Design a new teaching process paradigm advancing through three stages — "pre-class, in-class, and post-class" — ensuring deep and full integration of specialty and innovation elements throughout the entire process.

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(4) On this basis, construct a three-dimensional comprehensive evaluation index system that balances "process and outcome, individual and team, knowledge and ability" so as to better assess student development.

The effectiveness of this model will be tested through practical teaching, and the replicable experience as well as referable implementation paths will be summarized.

This study has the following significance:

(1) Theoretically, it expands the application scope of specialty-innovation integration education in fundamental engineering courses, forming a concrete, highly operable micro-level instructional design paradigm with specific course characteristics.

(2) Practically, it provides a feasible implementation path and specific methods for the teaching reform of Computer Organization and similar fundamental hardware courses, thereby helping to cultivate more reserve hardware talents with innovative qualities and entrepreneurial potential.

2. Current Status of Domestic and International Research

2.1. Integration Models of Innovation-Entrepreneurship Education and Engineering Education in Foreign Countries

Developed countries started early in integrating innovation-entrepreneurship education with professional education and have developed distinctive models. Top engineering institutions in the United States, such as Stanford University and the Massachusetts Institute of Technology (MIT), embrace the concept of "the university as an entrepreneurial ecosystem," infusing the spirit of innovation and entrepreneurship into various engineering courses. MIT's "Engineering Leadership" program and Stanford's "Design Thinking" workshops emphasize cultivating students' innovative thinking, teamwork, and business insight while solving real, complex engineering problems. In terms of teaching methods, project-based learning (PBL), problem-based learning (PBL), and the CDIO (Conceive-Design-Implement-Operate) engineering education model are widely adopted. Their core idea is to enable students to actively construct knowledge and develop abilities throughout a complete engineering cycle using projects as the vehicle [1,2,3].

At German Universities of Applied Sciences (Fachhochschulen), thanks to a well-established "dual system," the latest cutting-edge technologies and actual R&D needs from enterprises are brought into daily teaching and graduation projects. Throughout their learning process, students engage in technology R&D closely aligned with industry practice. In Japan, universities also adopt a "dual" education approach, where teaching proceeds step by step in a certain sequence. At the elementary school level, the focus is on inspiring students' innovative thinking; in the upper grades of secondary school, professional directions are integrated, and entrepreneurial simulation and practical training are carried out [4]. These models share several common characteristics: always starting from the students' perspective, making progress through active learning and hands-on experience; being project-driven to bridge theoretical knowledge and the application of skills; emphasizing competency outcomes and using diversified evaluation criteria; and focusing on the collaboration of school-enterprise-society in talent cultivation. The above foreign advanced experiences can serve as references for the instructional design ideas of "three-content integration" and "three-stage progression."

2.2. Research Progress of Specialty-Innovation Integration Teaching Reform in China

In recent years, domestic universities have actively responded to national policies and conducted extensive explorations in the teaching reform of specialty-innovation integration. Related research can be summarized into the following aspects:

Research on teaching model innovation: Various distinctive integration models have been proposed. Zhang Xiaolei [5] proposed a blended teaching model of "six preparations before class, six lectures during class, six assistances after class" for online teaching environments, emphasizing the refined design of teaching links and whole-process management, which provides process design references for the "three-stage progression" in this study. Ren Jingjing [6], within the context of "New Engineering Disciplines," combined the "flipped classroom" with the "BOPPPS" effective teaching model to construct a student-centered interactive classroom teaching paradigm. The closed-loop structure of "bridge-in, objective, pre-assessment, participatory learning, post-assessment, summary" offers great insights for optimizing the "in-class" stage.

Research on course content and resource integration: Scholars believe that the core of specialty-innovation integration lies in systematic reconstruction from the perspective of course content. Li Peng [7] advocates project-driven, interdisciplinary knowledge integration and students' active inquiry learning, which echoes the "project design integration" discussed in this paper. Wang Zhifeng [8], based on the supply chain management course, explored how to integrate industry standards, enterprise processes, and entrepreneurial cases into the classroom. Regarding teaching methods and tools, how to truly bring integrated education into the classroom and realize its value has always been a persistent challenge. Dong Mingran [9] proposed a five-step teaching method of "construction-shaping-experience-review-transfer," emphasizing experiential and reflective teaching. Similarly, the well-known "3s+ teaching method" — familiar to teachers through online demonstrations — includes specific operable strategies such as "stand-up check-in," "model construction," "As-if questioning," and "graphical review." These strategies are greatly beneficial for enhancing classroom interaction and promoting deep learning during the "in-class" stage of this study.

Research on teaching evaluation system reform: Scientific evaluation serves as a guiding baton. Song Lihua [10], in her study of the secondary vocational course Network Marketing, adopted a "three-party evaluation form" combining student self-assessment, peer assessment, and teacher assessment, focusing on multi-dimensional performance such as information retrieval, task implementation, and participation status. This provides an empirical reference for constructing the "three-outcome evaluation" system in this study.

Although domestic research has achieved fruitful results, studies on specialty-innovation integration focusing on theory-intensive, fundamental hardware courses such as *Computer Organization* remain relatively scarce [11,12]. Existing research mostly concentrates on management and economics courses, electronic information courses (with a more applied orientation), or practical courses in secondary and vocational schools. How to combine abstract computer hardware principles with vivid innovation and entrepreneurship education still lacks systematic teaching model design and in-depth practical verification. The "Four Threes" model proposed in this study aims to address this research gap by attempting to construct a comprehensive specialty-innovation integration teaching solution that covers objectives, content, process, and evaluation, and is specifically tailored to the Computer Organization course.

3. In-depth Analysis of Existing Problems in the Teaching of Computer Organization Course

The traditional teaching of the *Computer Organization* course mainly suffers from the following four-dimensional problems regarding specialty-innovation integration:

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3.1. Single Teaching Objective, Out of Step with the Talent Demands of the Era

Traditional syllabi often restrict objectives to the knowledge level, such as "mastering the functions and working principles of computer components" and "understanding the instruction execution process." This single knowledge-oriented goal leads to teaching that stops at "what" and "why," severely neglecting the crucial aspects of "how to do" and "how to innovate" in engineering education. After learning the course, students may memorize pipeline stages and cache mapping methods, but they do not know how to evaluate the pros and cons of a processor architecture, let alone understand the technical frontiers, innovation pain points, and entrepreneurial opportunities in the current hardware field. This is far from the requirements of "New Engineering Disciplines," which aim to cultivate students' ability to solve complex engineering problems, innovative thinking, and professional literacy.

3.2. Closed Teaching Content, Isolated from Industrial Innovation Practice

The textbook content has remained unchanged for many years, centered around the classic von Neumann architecture. Revolutionary innovations over the past two decades that have profoundly changed the industrial landscape — such as multi-core/many-core processors, general-purpose computing on GPUs, heterogeneous computing, compute-in-memory, and the RISC-V open-source instruction set — are rarely or never covered. Teaching cases are outdated, and lab content mostly involves verification-based, isolated functional tests (e.g., arithmetic unit and memory experiments) using fixed lab kits, lacking a complete project training cycle that includes requirement analysis, design selection, module integration, and system debugging. The course has become a "closed system" running parallel to the vibrant industrial innovation practice, making it difficult for students to establish connections between the knowledge they learn and real-world hardware innovation, thus failing to inspire their enthusiasm for exploration and creation.

3.3. Indoctrinating Teaching Process, Suppressing Student Agency and Creativity

The mainstream classroom format remains "teacher lectures, students listen, memorize before exams." Even when multimedia is used, it is merely "moving the blackboard content online," resulting in a lack of deep interaction between teacher and students and among students themselves. The lab process is rigid; students follow the lab manual step-by-step ("cooking by recipe"). When results do not match expectations, they tend to blame the equipment rather than deeply analyze the principles or attempt debugging and resolution. In this passive indoctrination and mechanical operation teaching process, students' agency is absent, and their critical thinking, system design ability, debugging skills, and capacity for innovation in the face of uncertain problems are not effectively developed.

3.4. One-Sided Teaching Evaluation, Unable to Drive Comprehensive Ability Developmen

Course assessment is typically dominated by a closed-book final exam (accounting for 70%-80%), supplemented by lab report scores. The exam focuses on rote reproduction of concepts, principles, and simple calculations, while lab reports are mostly formatted descriptions of operational steps and results. This evaluation approach — "one exam determines everything," "emphasizing outcome over process," "emphasizing individual over team," "emphasizing knowledge over ability" — cannot scientifically measure students' growth and effort in system design, innovative thinking, teamwork, and engineering communication. It objectively guides students toward exam-oriented learning, running counter to the inquiry-based, collaborative, and creative learning advocated by specialty-innovation integration.

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The above four major problems are intertwined, collectively leading to students' perception of the course as "inefficient, boring, and useless," severely restricting the improvement of talent cultivation quality. Therefore, a systematic teaching reform is imperative.

4. Overall Implementation Plan of the "Four Threes" Specialty-Innovation Integration Teaching Model

To address the above problems, this study constructs a specialty-innovation integration teaching model featuring "three objectives, three content components, three teaching stages, and three evaluation outcomes." The overall framework and implementation plan are as follows.

4.1. Three Objectives: Reconstructing a Three-Dimensional Teaching Goal System

First, the course teaching objectives are expanded from a single knowledge dimension to a three-dimensional goal system integrating "knowledge, ability, and literacy." This system guides the entire teaching design and implementation. The specific content of the three objectives and their roles are shown in Table 1.

Table 1. Content and value of the three objectives

Goals	Content	Value
Knowledge objectives	Master core concepts and basic principles of computer system architecture, CPU (arithmetic logic unit, controller) working principles, memory system organisation, buses and I/O systems	basic
Ability objectives	Use hardware description languages (such as Verilog) or simulation tools to model and carry out simple designs of key components; possess the ability to analyse and preliminarily optimise computer hardware system performance; be capable of completing the design, debugging, and report writing of a simplified CPU or subsystem as part of a team; have basic skills in hardware technology research and innovative solution design	core
Literacy objectives	Foster rigorous and pragmatic engineering ethics and the 'craftsman spirit'; stimulate interest in and enthusiasm for exploring computer hardware technology; establish a systematic and historical perspective on hardware innovation; cultivate awareness of intellectual property based on hardware technology and entrepreneurial potential	sublimation

In the course of Computer Organisation Principles, the three major objectives of knowledge, ability, and literacy are not separated from each other, but form a progressively layered and organically unified whole: a solid foundation of knowledge supports excellent engineering ability, and outstanding practical ability is internalised and elevated into profound professional literacy and innovative spirit. Together, the three constitute a complete objective system for cultivating outstanding computer hardware talents who can meet the future industrial demands.

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4.2. Content Integration: Restructuring the Open Course Content System

Focusing on the new teaching objectives, the course content is reorganised and expanded to form a new system of 'Classic Principles and Three Types of Integrated Content'.

(1) Hardware Innovation Case Integration: While teaching the classic principles, relevant breakthrough innovation cases in related fields are simultaneously introduced, with specific hardware cases and their corresponding chapters as shown in Table 2.

Table 2. Integration of hardware innovation cases and their corresponding chapters

Chapter	Content
CPU	Comparative explanation of the evolution from single-core to multi-core, the competition between ARM and x86 ecosystems, the RISC-V open-source revolution, and case studies of start-ups such as SiFive.
Memory	Introducing the leap from DRAM to HBM (High Bandwidth Memory), from NAND Flash to 3D NAND technology, as well as Intel Optane persistent memory innovations.
Bus and I/O	Expanded discussion on the iterations of the PCIe protocol and the prospects of the CXL (Compute ExpressLink) interconnect protocol

These cases serve as "live teaching materials," helping students understand how principles drive innovation and how innovation transforms industries.

(2) Integration of entrepreneurial practice: explore entrepreneurial stories and business models in the hardware field and incorporate them into teaching. Introduce domestic and international companies that have successfully started businesses relying on FPGA cloud services, chip design IP cores, open-source hardware (such as the Raspberry Pi ecosystem), low-power IoT chips and other directions. Analyse their technological entry points, market positioning, and the challenges they face (such as chip fabrication costs, ecosystem development), guiding students to consider how technological value can be converted into commercial value.

(3) Integration of project design: design a series of open-ended projects from simple to complex to replace some verification experiments. Project design runs throughout the course and serves as the core medium for integrating knowledge, developing abilities, and cultivating qualities.

4.3. Three-Step Advancement: Designing an Integrated Teaching Process Model

Integrate professional and innovative learning throughout the entire teaching process, forming a progressive closed loop of "pre-class guidance - in-class research - post-class extension." Pre-class guidance (mainly online) includes goal orientation, resource dissemination, and pre-test feedback. In-class research (mainly offline, with blended interaction) adopts the BOPPPS structure to deepen the process. In the process of deepening the BOPPPS structure, each module of the course is organically embedded in the classroom and endowed with professional and innovative integration characteristics: the introduction uses innovative events as entry points to trigger cognitive conflict; learning objectives clearly present the three dimensions of knowledge, skills, and literacy; pre-tests use Rain Classroom quick quizzes or virtual simulation operations to accurately diagnose prior knowledge; participatory learning serves as the core, integrating case studies (analysing the rise of the RISC-V ecosystem), model construction (group collaboration to draw dynamic data path diagrams), and "what if" questions (such as

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"How to optimise the memory hierarchy when designing an AI edge computing chip?") for diverse interactions; post-tests are conducted through simulation result presentations or immediate peer evaluation of group design schemes to assess effectiveness; the summary guides students to map knowledge networks and industry connections in the form of an "innovation insight diagram," achieving a cognitive closed loop. In the post-class extension phase, students are required to continue applying classroom learning, investigate real hardware problems, keep up with the latest research developments in the field, and are encouraged to transform optimisation results into competition entries or prototype entrepreneurial plans. Through structured reflection logs, they continuously consolidate engineering thinking and innovative methodologies in hardware design.

4.4. Three Result Evaluation: Building a Diversified Teaching Evaluation System

Establish a comprehensive evaluation system that matches the new model to fully assess students' learning outcomes.

Table 3. Evaluation Forms and Content of the Diversified Teaching Evaluation System

Evaluation form	Evaluation content
Combining process evaluation with outcome evaluation	Process (40%): Includes completion of pre-class tasks, participation in class interactions (data from Rain Classroom), weekly progress reports on experiments/projects, and quality of reflective journals. Results (60%): Includes the final closed-book exam (focusing on analysis and design, 30%) and the final project outcome (physical/simulation, report, defence, 30%).
Combining individual evaluation with team evaluation	Individual performance: personal assignments, exam results, contribution to group projects (determined through peer evaluation and teacher observation). Team performance: overall project quality, innovation, report and defence level. Team grades form part of individual grades, encouraging students to focus on collective outcomes.
Combining knowledge evaluation with competence/quality evaluation	Knowledge Mastery: Assessed through final exams and regular quizzes.Abilities and Qualities: Design, debugging, and innovation abilities are assessed through project results; communication and collaboration skills are assessed through reports and presentations; innovative thinking and engineering ethics are assessed through case discussions and reflection logs.

This evaluation system collects data through various channels such as 'Rain Classroom', 'Xuexitong', online collaborative documents, and project defence assessments, aiming to be objective, fair, and clearly guided.

5. Analysis of the Practical Effects of Teaching Reform

To verify the effectiveness of the "Four Threes" teaching model, this study conducted a one-semester teaching practice in the 2023 cohort of the Computer Science and Technology programme.

5.1. Practice Design

Six parallel classes with no significant differences in admission scores and previous course averages were selected as the research subjects. Classes 1 to 3 served as the experimental

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classes (number of students n=95) using the "Four Threes" integrated specialised entrepreneurship teaching model; Classes 4 to 6 were the control classes (number of students n=98) using the traditional lecture-based teaching mode supplemented with confirmatory experiments. The same teaching materials were used, taught by the same teacher, ensuring equal teaching hours. Data were collected through questionnaires, performance analysis, project evaluations, and teacher-student interviews.

5.2. Quantitative Analysis of Learning Outcomes

Academic Performance Comparison: A unified examination and marking system were applied at the end of the semester, with the students' overall results as shown in Figure 1.

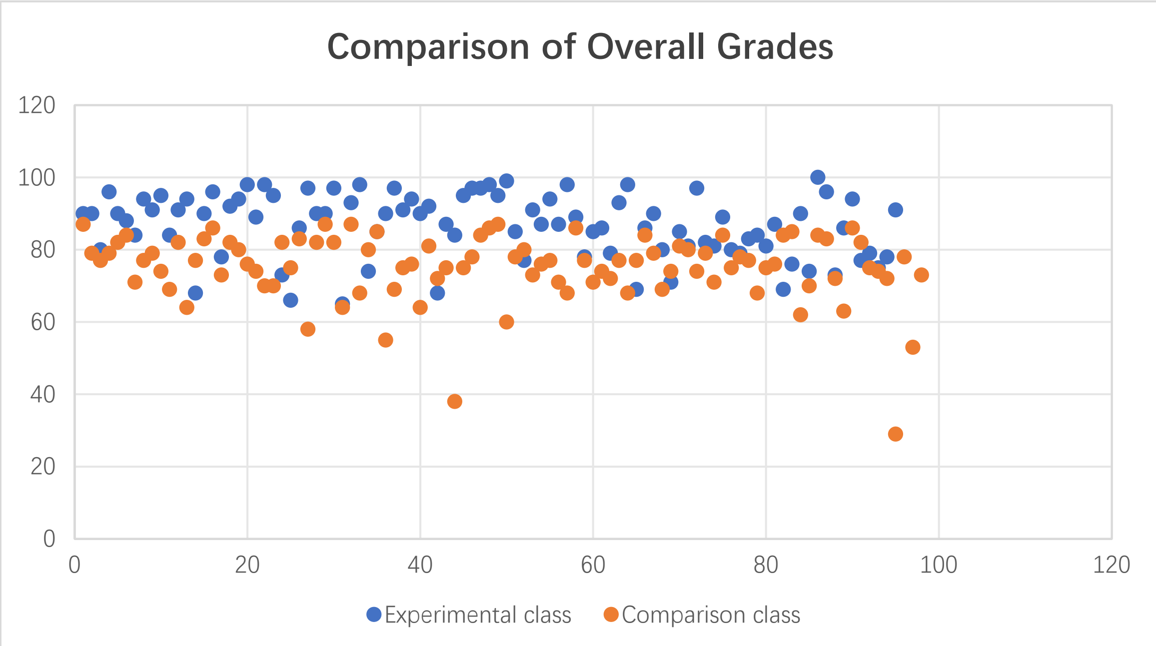

Figure 1. Comparison of Overall Grades

The average score of the experimental class was 85.08, while the control class scored 75.07; an independent sample t-test indicated a significant difference ($p<0.01$). Particularly in comprehensive design and analysis questions, the experimental class achieved a score rate of 85.2%, significantly higher than the control class at 75.7%. Project Completion Quality: The experimental class completed the comprehensive project "Simple Pipeline CPU Design Based on FPGA" in groups. Evaluation results showed that the excellent rate of projects (A, B) reached 85%, and three groups included innovative elements such as custom instruction extensions or simple branch prediction optimisations. The verification reports of the control class were generally more homogeneous. Learning Engagement and Attitude Survey can be seen in Figure 2: a questionnaire conducted after the course indicated that the experimental class scored significantly higher than the control class across all indicators ($p<0.001$).

5.3. Qualitative Analysis of Competence and Literacy Development

Through interviews with the experimental class students, analysis of reflective journals, and observation of project presentations, it was found that students showed significant improvement in the following aspects, as detailed in Table 4:

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Table 4. Qualitative Analysis of Competence and Literacy Development

Abilities and Literacy	Student Feedback
System design ability and engineering thinking	Through deep involvement in complete project practice, students generally indicated that they have developed an understanding of core engineering concepts such as 'top-down design', 'modular construction', 'interface protocol standards' and 'timing constraint optimisation'. During repeated debugging and troubleshooting, their logical thinking ability and practical problem-solving skills have been significantly enhanced.
Innovation awareness and sensitivity to frontiers	Case analyses and open-ended question sessions significantly broaden industry perspectives. Many students remarked, "We used to think chip design was only for a few major companies, but now we understand that the open-source RISC-V architecture provides more people with a channel to participate in innovation." Inspired by this, some students have voluntarily begun to follow trends in cutting-edge technologies such as artificial intelligence chips and compute-storage integrated architectures.
Teamwork and communication skills	The group collaboration project model requires students to master collaborative skills such as task breakdown, schedule management, technical communication, and conflict resolution. During the project defence stage, their technical presentation and on-the-spot response abilities are also thoroughly exercised.
Entrepreneurial cognition germination	In classroom discussions centred around hardware entrepreneurship, entrepreneurs' understanding of tech startups is no longer limited to writing code, gradually recognising more complex aspects including intellectual property, supply chains, and ecosystems. Although these discussions cannot immediately lead all entrepreneurs to engage in real entrepreneurial practice, they begin to plant a question in their minds that must be considered: what to truly do after some time, leading to a deeper understanding and insight into entrepreneurship.

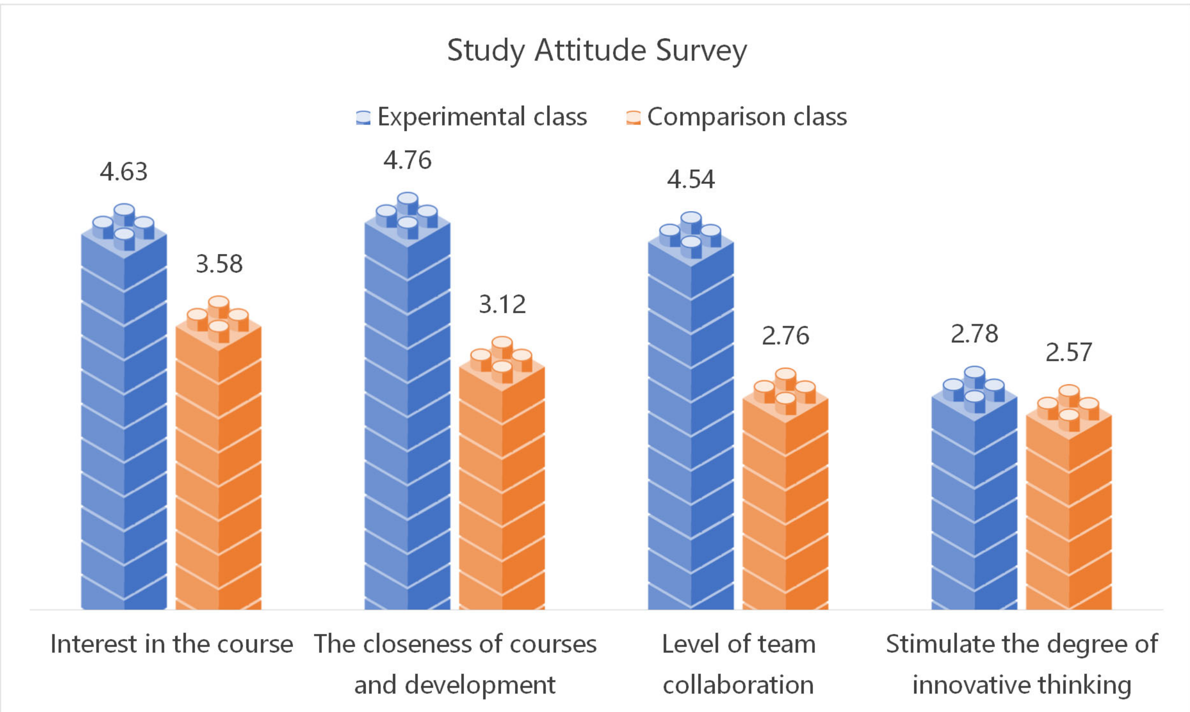

Figure 2. Survey on Learning Engagement and Attitude

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5.4. Teaching Reflection and Continuous Improvement

Meanwhile, in the course of our practice, we also encountered some practical problems: for example, students found it difficult to accept open-ended projects and group learning at the beginning, and some students still stubbornly adhered to the traditional learning methods. In addition to the original teaching methods, the new teaching model also places higher demands on teachers: besides keeping up with industry trends at all times, they must learn to provide more precise guidance for students on complex projects; moreover, it is essential to improve teaching resources such as the FPGA experimental platform and industry mentors. In response to the current situation, the course team plans to make improvements in the following areas: first, continue to refine the project management model, considering the adoption of an agile development board to make collaboration between groups clearer and more efficient; second, further strengthen the stable teaching team to enhance mutual teaching benefits; third, accelerate cooperation with local integrated circuit companies, expand more school-enterprise practice platforms, and improve the talent cultivation system.

6. Conclusion and Outlook

6.1. Research Conclusions

Based on the persistent teaching difficulties in the Computer Organisation Principles course, this paper proposes and implements a specialised-innovation integrated teaching model characterised by 'three objectives guidance, three content integration, three-step advancement, and three-result evaluation'. Practice has shown that this model effectively addresses the issues of the course being overly theoretical, content being biased, excessively conceptual and detached from real-world applications; it achieves innovation in the teaching system by transforming the sole focus on 'knowledge' into an integrated goal of 'knowledge, ability, and character', meeting the intrinsic development requirements of talent under the New Engineering background; it incorporates fixed, relatively isolated knowledge points of the course with elements such as Internet thinking, ensuring the course content is up-to-date through innovative frontier cases, exemplary entrepreneurial practices, and open-ended projects, keeping pace with industry development; it changes the previously entirely teacher-centred teaching model into a student-oriented inquiry-based approach, using the 'three-step advancement' model to ensure students achieve both depth and full engagement in learning; it breaks away from the past exam-oriented evaluation method by establishing a diversified comprehensive evaluation combining process and results, individual and group assessments, as well as knowledge and ability assessments, with the 'three-result evaluation' effectively guiding and documenting the entire process of students' holistic development. Theory meets practice, and facts speak louder than words. During teaching practice, it was found that after adopting the new teaching model, students showed high enthusiasm for learning, and their assignments, exams and grades were commendable, their engineering practice abilities improved, and notably, their teamwork awareness and innovation abilities were significantly enhanced, indicating substantial progress in teaching quality.

6.2. Research Limitations and Prospects

This study has certain limitations: the practical period lasted only one semester, so the long-term impact on students' innovation abilities and entrepreneurial behaviours remains to be tracked; the practical sample was limited to one university, so the generalisability of the model needs to be further verified in universities of different levels and types; the teaching effectiveness partly depends on the current laboratory conditions and faculty level of the university.

Looking forward, this research can be further developed in the following directions:

Vertical integration: Extend this model upwards to courses such as "Computer System Architecture" and "SoC Design," and link it downwards to "Digital Logic," establishing an integrated hardware systems capability training chain throughout the undergraduate stage.

Horizontal expansion: Explore the joint development of cross-course comprehensive projects with software courses such as "Operating Systems" and "Compiler Principles," cultivating students' system innovation abilities in both software and hardware collaboration.

Technology empowerment: Utilise technologies such as digital twins and virtual simulation to build a more powerful and widely accessible online hardware lab cloud platform, overcoming the limitations of physical laboratory resources.

Ecological co-construction: Deepen industry-education integration, co-establish internship bases, joint laboratories, and innovation workshops with more integrated circuit companies and open-source hardware communities, more closely linking classroom learning with the industry ecosystem.

The "Four Threes" specialised-innovation integrated teaching model is a systematic attempt in the teaching reform of the Computer Organisation course. It responds to the call for innovation in engineering education, providing a practical and feasible path to cultivate outstanding computer hardware talents who are industry-minded, capable, and innovative. Its concepts and methods also offer valuable references for the teaching reform of other foundational engineering courses.

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