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Article

Designing Practice-Oriented Graduate Curricula to Meet Industrial and Societal Needs: A Policy-Informed Perspective

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Abstract: This article examines the challenges facing computer-related professional graduate programs amid rapid technological evolution and workforce demand shifts. By adopting a policy-informed and socially inclusive approach, the study develops a curriculum system that not only addresses industrial needs—such as algorithm design and systems development—but also fosters interdisciplinary innovation and employability. The proposed modular framework, shaped by enterprise engagement and dynamic adaptability, enhances students' readiness for the labor market while contributing to broader goals of social equity and higher education modernization. The findings offer a practical model for bridging the gap between academic training and real-world socio-industrial challenges.

Keywords: graduate education reform; innovation and employability; higher education policy; industry needs; social equity; interdisciplinary curriculum

1. Introduction

Driven by the global technological revolution and industrial transformation, computer technologies such as artificial intelligence and cloud computing are rapidly iterating, accelerating the digital transformation of various industries. China's "14th Five-Year Plan" also emphasizes the cultivation of high-level applied talents to break through core technology bottlenecks [1]. However, current computer science professional degree education faces numerous severe challenges, including mismatches between industry demands and educational supply, conflicts between enterprises' urgent needs for AI engineering and cloud-native development talents and outdated traditional curricula, weak innovation capacity development, lack of interdisciplinary collaboration and open-source practice opportunities, and superficial industry-academia collaboration [2]. To address these, this paper takes computer science as an entry point to construct an industry-demand-oriented curriculum system. Its significance lies in theoretically innovating a dynamic adaptation model for industry, competencies, and curricula, breaking the constraints of disciplinary silos. At the practical level, it narrows the talent supply gap through modular courses and a dual-mentor system. At the societal level, it provides talent support for overcoming technical challenges and serving the digital economy strategy. According to the Ministry of Industry and Information Technology, China's AI talent shortage is projected to reach 5 million by 2025, making curriculum reform an urgent priority.

Currently, professional degree education in developed countries emphasizes deep industry-academia

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integration and systematic cultivation of innovation capabilities. The United States, through the Cooperative Education (Co-op) model, such as at Carnegie Mellon University's School of Computer Science, embeds enterprise projects into the curriculum, forming a closed loop of learning, practice, and feedback [3]. Germany's "dual system" highlights enterprise-led skill certification, such as the IHK vocational qualification in the computer science field, which directly aligns with job standards [4]. At the research level, Wyne et al. [5] studied the Competency-Based Education (CBE) framework, outlining challenges academic institutions may face in implementing CBE and proposing future research directions in this area. MIT's New Engineering Education Transformation (NEET) program strengthens engineering innovation through interdisciplinary projects, such as autonomous driving system development [6]. Additionally, international accreditation standards promote the dynamic alignment of curriculum systems with industry technologies.

In recent years, professional degree education in China has developed rapidly, but significant shortcomings persist in the computer science field. At the policy level, the "Development Plan for Professional Degree Graduate Education (2020–2025)" explicitly calls for deepening industry-academia integration, yet in practice, university curricula suffer from severe homogenization [7]. For instance, most institutions still adopt academic-oriented curriculum frameworks, merely adding a few practical credits. Some universities have attempted reforms, such as Beihang University collaborating with Huawei to offer an "Intelligent Computing Systems" course and Zhejiang University's computer science professional master's program incorporating Alibaba Cloud's training platform. However, these efforts still face issues like low enterprise participation and delayed curriculum updates. In research, scholars often focus on macro-level strategies; for example, Zhang et al. [8] proposed a "four-chain integration" to empower new productivity. However, there is a lack of dynamic curriculum adjustment mechanisms tailored to the rapid iteration of computer technologies, as well as insufficient integration of emerging scenarios such as open-source ecosystems and AIGC.

This study focuses on computer science professional degree graduate students, targeting two main objectives: dynamic adaptation to industry demands and systematic cultivation of innovation capabilities. It constructs an integrated framework encompassing demand analysis, competency mapping, and curriculum iteration, with the specific graduate training framework detailed in Table 1. The research covers three aspects: first, based on the Gartner Hype Cycle, integrating cutting-edge fields like artificial intelligence and cloud computing to design tiered curriculum modules; second, developing practical courses through mechanisms such as university-enterprise joint laboratories and open-source community collaboration to ensure teaching content aligns with enterprise technology updates; third, establishing quantitative evaluation metrics, such as code contribution levels and project deployment outcomes, to replace the traditional exam-only model. Methodologically, a mixed-methods approach is adopted: qualitatively, theoretical models are built through literature analysis and expert interviews; quantitatively, competency demand priorities are clarified using survey data from multiple IT enterprises.

Table 1. Multi-dimensional System Framework for Postgraduate Training of Computing Degree Students Table.

Research Dimensions	Core Elements	Implementation Strategy	Methodological Support
Research Objectives	1. Dynamic adaptation to industry demands. 2. Systematic cultivation of innovation Capability.	Constructing an Integrated Framework for Demand Analysis, Capability Mapping, and Curriculum Iteration.	Mixed research paradigm
Research Content	1. Frontier layered curriculum system. 2. Dynamic synchronous teaching resources. 3. Quantitative capability evaluation system.	1. Design layered course modules based on the Gartner curve. 2. Develop practical courses through university-industry laboratories or open-source communities.3. Replace traditional exams with indicators such as code contribution levels.	1. Qualitative: literature analysis, expert interviews. 2. Quantitative: enterprise. questionnaire data modeling.

Table 1. Cont.

Research Dimensions	Core Elements	Implementation Strategy	Methodological Support
Implementation Path	1. Demand analysis. 2. Capability mapping. 3. Curriculum iteration.	1. Use the technology maturity curve to identify industry demands. 2. Match layered courses with innovation capability cultivation. 3. Achieve continuous updates through university-industry collaboration.	1. Technology maturity curve analysis. 2. Demand and capability matrix model.
Evaluation System	1. Process Evaluation (60%). 2. Outcome Evaluation (40%).	1. Code Contribution Level. 2. Project Deployment Success Rate. 3. Quality of Technical Documentation. 4. Feasibility of Innovative Solutions.	1. Machine learning algorithm assisted scoring. 2. A/B testing to validate indicator effectiveness.

2. Industry Demand Analysis and Model Construction

2.1. Computer Industry Demand Survey

This study systematically analyzes talent demands in the computer industry through questionnaire surveys, in-depth interviews with technology executives, and text mining of 100,000 job postings. The results, as shown in Figure 1, indicate that leading enterprises and unicorn companies prioritize algorithm design and optimization (76%), AI engineering capabilities such as model deployment and cloud-native development (68%), and emerging technology stacks such as AIGC toolchains and quantum computing (52%).

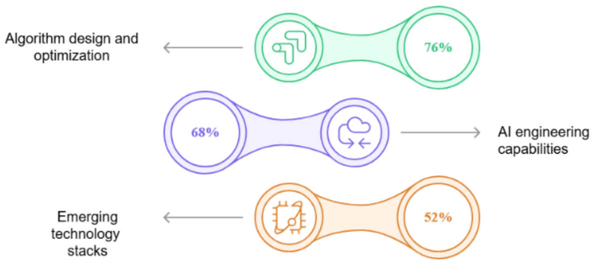

Figure 1. Talent skill requirements for headline and unicorn companies.

Currently, university curricula still focus on traditional technologies like MySQL, with only 32% of enterprises covering mainstream technologies such as K8s and TiDB. The supply-demand contradiction is evident, with 73% of enterprises noting that graduates lack real-world scenario experience, and only 12% of students have contributed to open-source projects, alongside weak interdisciplinary integration capabilities, as shown in Figure 2. Based on Gartner technology trends and job growth data, a dynamic curriculum update mechanism is proposed, prioritizing the inclusion of Prompt Engineering, edge intelligence, and privacy computing. Through university-enterprise joint laboratories and open-source collaboration, this approach addresses the triple contradictions of technological lag, practical disconnect, and innovation gaps, providing precise demand anchors for the curriculum system.

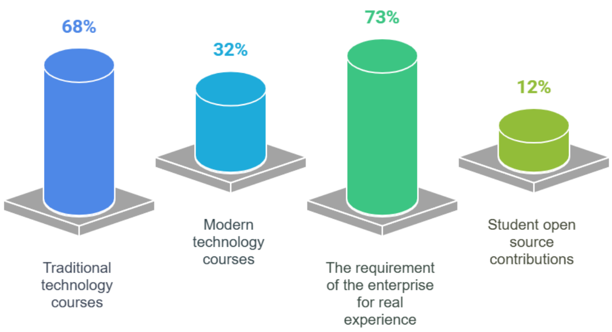

Figure 2. Gap between education and industry needs.

2.2. Existing Issues in Professional Degree Education

The current computer science professional degree education faces four core contradictions, as illustrated in Figure 3. First, there is a disconnect between curriculum content and technological iteration; while enterprises widely adopt cutting-edge technologies like cloud-native systems and AIGC toolchains, these are not included in university teaching, with curricula still centered on traditional databases and insufficient coverage. Second, practical teaching is superficial; enterprises report that graduates lack real-world scenario experience, and experiments often rely on simulation tools, severely detached from enterprise production environments such as Alibaba Cloud ACE and Huawei ModelArts platforms. Third, innovation capacity cultivation is one-dimensional, overly focused on coding skills while neglecting interdisciplinary integration, open-source collaboration, and ethical education. Fourth, industry-academia collaboration is superficial; university-enterprise partnerships are often limited to short-term internships, with enterprises rarely involved in curriculum design, rendering the dual-mentor system ineffective and feedback on technological updates delayed, with an average curriculum update cycle exceeding three years. These issues exacerbate the structural imbalance in talent supply, with graduates requiring an average of six months to adapt to enterprise needs, making reform an urgent necessity.

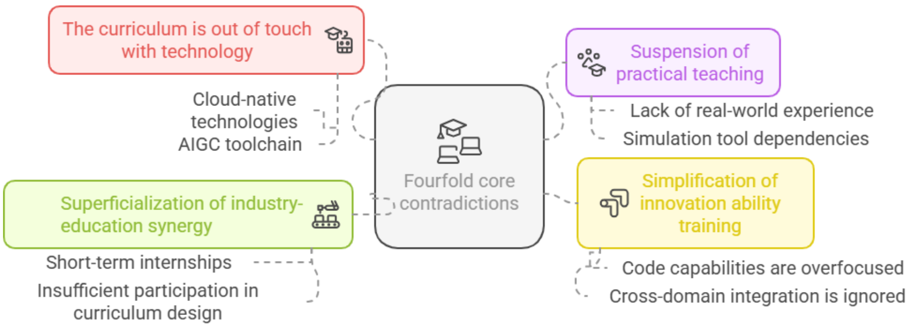

Figure 3. The fourfold core contradiction of computer degree education.

3. Framework for Professional Innovation Capacity Cultivation

Innovation capacity in the computer science field is a composite system integrating technological iteration, engineering practice, interdisciplinary fusion, and ethical responsibility. The technological dimension requires mastering core skills like algorithm optimization and distributed systems, rapidly assimilating cutting-edge technologies such as AIGC and quantum computing, and participating in open-source ecosystems. The engineering dimension emphasizes full-stack thinking, from requirements analysis to disaster recovery design, achieving industrial-grade system construction and extreme performance optimization. The interdisciplinary dimension transcends disciplinary boundaries, driving disruptive innovation through cross-domain modeling, such as AI in biomedicine, and understanding the technological foundations of the metaverse. The ethical dimension balances technical efficiency with humanistic values, using federated learning to ensure data privacy, correcting algorithmic biases, and anticipating risks of generative AI misuse. This model differs from the one-dimensional competency frameworks of traditional disciplines, providing support for addressing the complex challenges of the digital economy era.

This study constructs a three-stage progressive and four-dimensional interactive training path to systematically enhance the innovative abilities of graduate students in computer science, as shown in Figure 4. In the first stage, a solid technical foundation is built through core theoretical courses and toolchain practical training, with the integration of open-source ethics courses. The second stage leverages university-enterprise collaborative projects, requiring students to form teams to complete cross-disciplinary topics, with simultaneous guidance from industry mentors on technology selection and engineering standards. The third stage promotes the transformation of technology into products through competitions, contributions to open-source communities, and entrepreneurial incubation. During implementation, a dual-mentor system ensures industry-education collaboration, establishing a diverse evaluation system that includes GitHub contribution levels, project ROI, and ethics assessment reports. Each semester, 30% of the course content is dynamically updated based on industry technology stack research to ensure that the training path aligns in real time with industry demands.

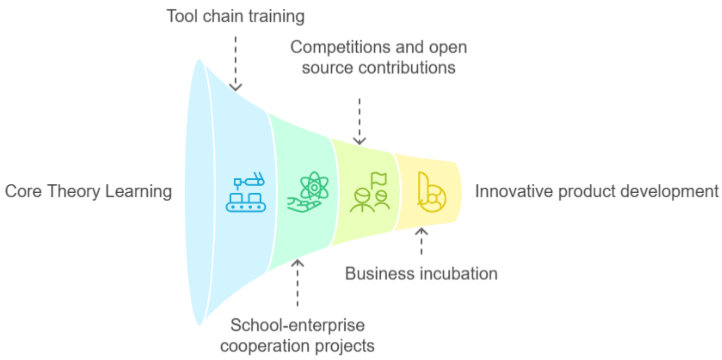

Figure 4. Pathway design.

4. Curriculum System Design for the Computer Industry

4.1. Curriculum Design Principles

In response to the fast technological iterations and deep cross-disciplinary integration in the computer field, the curriculum design will follow five key principles, as shown in Figure 5. The Dynamic Adaptation Principle will be based on Gartner's technology curve and industry research, such as the 200% growth in AIGC positions over three years, with 30% of the content updated annually, introducing cutting-edge areas like large language model engineering and privacy computing. The Layered Progression Principle will adopt a three-stage structure, progressing from basic skills to system design and then to industry solutions, gradually increasing complexity. The Industry-Education Deep Integration Principle will introduce real-world enterprise scenarios, implement a dual-mentor system, and conduct practical training through the Alibaba Cloud ACE platform. The Cross-disciplinary Integration Principle will involve creating "Computer + X" modules, with a requirement for students to complete at least one cross-disciplinary project. The Ethical Internalization Principle will include the mandatory course "Data Compliance and AI Governance," embed ethical evaluations within technical courses, and require a "Technology Social Impact Statement" for project submissions. These five principles will work together to ensure the curriculum system dynamically aligns with industry demands, fostering talents who possess both technical expertise and cross-disciplinary innovation.

Figure 5. Curriculum design principles.

4.2. Modular Curriculum Design

This paper constructs four main modules. The Core Theory Module is designed to solidify fundamental knowledge such as algorithms and system architecture, as shown in Table 2. The Industry Technology Module is divided into three major areas: Artificial Intelligence, Cloud Computing, and Cybersecurity, with content updated annually based on the Gartner Technology Curve. The Practical Innovation Module advances through three tracks: joint industry projects, open-source contributions, and competitions, with a requirement to complete at least one industrial-grade deployable project. The Comprehensive Literacy Module integrates AI ethics, agile development courses, and interdisciplinary projects. The courses are progressively structured from theory to ecosystem, establishing a dynamic mapping mechanism from enterprise demand lists to curriculum. In alignment with the industry technology stack, the graduation requirement is a GitHub annual activity of 50 or more contributions or a top 10% ranking on Kaggle, ensuring a balance between technical expertise and cross-disciplinary innovation.

Table 2. Modular course system.

Module Name	Module Content	Objectives and Requirements
Core theory module	Algorithms, System Architecture, and Other Basic Theoretical Knowledge	Strengthen the foundation to provide theoretical support for subsequent modules.
Industry technology module	Artificial Intelligence, Cloud Computing, Cybersecurity	Update content annually based on the Gartner Technology Curve, staying at the forefront of industry technologies.
Practical innovation module	Artificial Intelligence, Cloud Computing, Cybersecurity	Complete at least one industrial-grade deployable project to cultivate practical skills and innovative thinking.
Comprehensive literacy module	AI Ethics, Agile Development Courses, Interdisciplinary Projects.	Develop comprehensive literacy and enhance cross-disciplinary collaboration abilities.

5. Guarantee Mechanism and Resource Development

5.1. University-Industry Collaboration Mechanism

Focusing on the goal of deep integration of industry and education, a university-industry collaboration mechanism will be established that involves joint demand identification, shared resource development, and collaborative talent cultivation. Universities should sign long-term strategic agreements with multiple leading companies, jointly establishing a curriculum committee. Key technical personnel from companies will deeply participate in course development, transforming real industry scenarios into a teaching project repository, and dynamically tracking updates to the company's technology stack, adjusting 30% of the practical course content each quarter.

The dual-mentor system will be implemented, with industry mentors accounting for 40% of the evaluation weight. A three-month on-site R&D period at the company will be integrated into the semester, and contributions to open-source communities will be included in the credit system. Companies will concurrently donate computing resources, provide access to production-level development environments, and establish a technology transfer fund to support student entrepreneurship projects, forming a closed-loop from teaching to R&D and then to incubation, as shown in Figure 6.

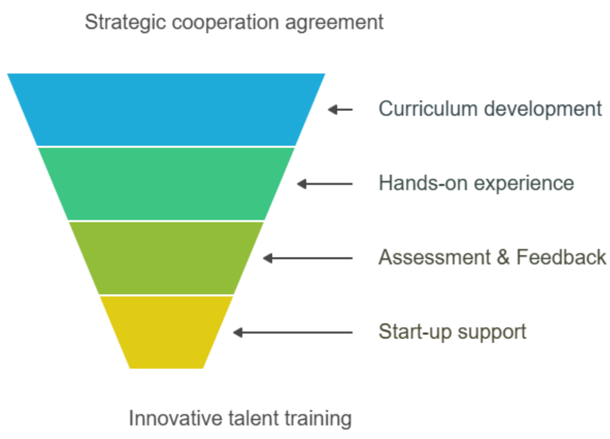

Figure 6. School-enterprise joint training of innovative talents.

5.2. Faculty Team Development

To address the challenge of insufficient industry experience among faculty in computer science degree education, a bi-directional empowerment and dynamic iteration path for faculty development needs to be established. At the teacher level, an industry rotation mechanism will be implemented, requiring teachers to obtain industry certifications and lead open-source projects, with the integration of technology transfer achievements into the title evaluation process. At the enterprise level, mentor admission standards will be set, requiring at least 5 years of experience in core positions. Companies will collaborate with universities to develop an industrial-grade case repository and participate in dual-mentor collaborative guidance. To ensure the smooth operation of this mechanism, the performance evaluation system needs to be reformed, with increased weight on enterprise project participation and student employment quality. Additionally, an industrial technology training center will be established, integrating enterprise-level development environments, technology trend analysis tools, and remote collaboration platforms.

6. Conclusions

This paper constructs a computer science degree curriculum system oriented towards industry demands and innovation capability cultivation. Through dynamic adaptation mechanisms, deep university-industry collaboration, and cross-disciplinary integration design, it effectively addresses issues such as outdated curricula, disconnect between theory and practice, and weak innovation. Furthermore, it provides a replicable practical solution to resolve the structural contradiction between educational supply and industry demand. In the future, continuous iteration will be driven by technological foresight, mechanism agility, and a holistic approach to talent development, advancing professional degree education from following industry trends to leading innovation, thus providing sustainable talent support for the development of the country's strategic emerging industries.

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Author Contributions

P.Q. and S.Z. conceived and designed the study. S.Z. collected the data, while B.Y. analyzed the data. P.Q. wrote the initial draft, and all three authors made contributions to the final manuscript. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data used in this study are not publicly available due to privacy concerns.

Conflicts of Interest

The authors declare no conflicts of interest.

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