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Innovation and practice of the industry- education- integrated talent cultivation model for integrated circuits oriented to industrial demand: A case study of the School of Integrated Circuits, Shenzhen Polytechnic University

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Abstract: The integrated circuits (IC) industry serves as a foundational pillar for the development of the digital economy and new quality productive forces. The rapid expansion of the industry has led to a continuously widening shortage of high-level technical and skilled talent. Vocational undergraduate education bears the responsibility of cultivating talent for IC manufacturing, processing, and application development. Traditional talent cultivation models suffer from problems such as curriculum content lagging behind industrial technology, training projects divorced from real engineering scenarios, and shallow school-enterprise cooperation. Using a case study method and taking the School of Integrated Circuits of Shenzhen Polytechnic University as the research object, this paper reviews the current status of IC industry talent supply in China and the common dilemmas of industry-education integration in IC programs of vocational undergraduate institutions, and systematically analyzes the multi-party collaborative cultivation system that the school has built to meet industrial demand: establishing a government-school collaborative innovation platform, an industry-chain collaborative innovation platform, and a cross-regional collaborative education network; implementing enterprise order-based cultivation; building the featured curriculum brand of "National Chips for National Use, One Student One Product"; bringing together national-level experts to form a "teaching-research-production" integrated faculty; and promoting intra-university interdisciplinary integration and innovation. This model effectively breaks down the barriers between talent cultivation and the job demands of the industry chain, shortens students' school- to- enterprise adaptation period, and achieves a seamless transition from campus learning to enterprise posts. Based on the case practice, this paper proposes optimization suggestions from the dimensions of improving the multi-party collaborative governance mechanism, promoting the curriculum transformation of industrial projects, improving the incubation support system for scientific and technological achievements, and strengthening the guarantee for interdisciplinary talent cultivation, providing a replicable practical sample for the deep integration of industry and education in IC programs at domestic vocational undergraduate institutions.

Keywords: integrated circuits; vocational undergraduate education; industry-education integration; collaborative cultivation; industrial demand; new quality productive forces

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1 Introduction

China's integrated circuit industry has entered a stage of rapid development, and the demand for high-level and interdisciplinary technical and skilled talent across all segments of the industry chain continues to rise. The IC industry is characterized by high technology intensity, high capital intensity, and rapid iteration, which places higher demands on talents' engineering practical capability and domestic chip application ability. Traditional university talent cultivation generally suffers from problems such as an excessive proportion of theoretical teaching, students' lack of experience in real process, chip development, and system integration projects, long job adaptation periods for graduates entering enterprises, and structural mismatch between talent supply and actual industrial demand.

Vocational undergraduate education is positioned to cultivate high-level technical and skilled talent oriented to the industrial front line [1]. Industry-education integration and school-enterprise collaborative cultivation serve as the core levers of vocational undergraduate education [2-3]. As a highland of domestic IC industry agglomeration, Shenzhen has a complete industry chain and abundant enterprise resources, providing unique external conditions for vocational undergraduate institutions to carry out deep industry-education integration. Based on Shenzhen's locational and industrial advantages and oriented to the job requirements of the IC industrial chain, the School of Integrated Circuits of Shenzhen Polytechnic University (hereinafter referred to as "the School") has explored and constructed a new industry-education-integrated talent cultivation model with multi-party linkage among government, schools, enterprises, and cross-institutional partners, forming a series of distinctive practices. These provide practical references for IC programs in other domestic vocational undergraduate and higher vocational institutions to carry out industry-education integration reform, helping to alleviate the shortage of high-level technical and skilled talents in the IC industry.

2 Current status of talent demand in the IC industry and common problems of industry-education integration in vocational undergraduate institutions

2.1 Supply-demand issues of talents in the IC industry

China's IC industry chain covers multiple segments including design, manufacturing, packaging and testing, equipment, materials, and power semiconductor applications, with widely varying requirements for competency structures across positions. The industry no longer requires talents merely to master theoretical knowledge; it places greater emphasis on hands-on engineering capability, the ability to use domestic chips and EDA tools, project collaboration capability, and problem-diagnosis capability.

At the regional level, Shenzhen agglomerates a large number of IC design, power device, and chip application enterprises, with many positions requiring high-level technical and skilled talents who can quickly get up to speed in chip application, module integration, product development, and test verification. Such talent is precisely the cultivation target of vocational undergraduate education. However, the current talent supply shows obvious shortcomings: first, the curriculum systems of most institutions update more slowly than industrial technology iterates; second, campus training equipment is costly, making it difficult to build pilot-scale real industrial environments; third, students lack complete engineering project experience and have insufficient hands-on experience with domestic chips and domestic tools.

2.2 Common pain points of industry-education integration for IC programs of vocational undergraduate institutions

First, school-enterprise cooperation is superficial and single-faceted. In many institutions, the cooperation remains at the level of short-term lectures, visits, and internships; enterprises rarely participate deeply in the entire process of talent cultivation plan revision, textbook development, course teaching and assessment, and talent cultivation plans become disconnected from job competency requirements of enterprises. Meanwhile, enterprises lack sufficient motivation to participate in industry-education integration, and there is no stable, long-term incentive mechanism [4].

Second, real industrial projects are difficult to transform into teaching resources. IC projects have long cycles, high technical thresholds, and sensitive intellectual property, making it difficult to convert real enterprise projects directly into teaching projects; on-campus training mostly consists of simplified verification experiments and lacks pilot-scale practice scenarios oriented to industrialization, so students find it difficult to access the complete industry-chain development process.

Third, there is an insufficient supply of interdisciplinary faculty. IC technology updates rapidly, and many full-time teachers lack long-term R&D experience on the industrial front line; when industrial engineers enter campus teaching, they in turn lack teaching methods and curriculum design capabilities, creating a bottleneck in the construction of "dual-qualified" faculty.

Fourth, cultivation resources are geographically limited, and cross-regional industrial resources are difficult to share. A single institution has limited resources. If it relies only on local enterprise resources, students have limited access to upstream and downstream resources of the industrial chain, making it difficult to form a holistic understanding of the industrial chain.

Fifth, disciplinary barriers are prominent, and IC application innovation is confined within the specialty itself. The final landing of chips into products requires integration with multiple fields such as product design, healthcare and industrial design. Traditional cultivation models are confined within microelectronics and chip circuits, lacking cross-disciplinary product innovation training.

3 Innovative practice of industry-education-integrated talent cultivation at the School of Integrated Circuits, Shenzhen Polytechnic University

Relying on the advantages of Shenzhen's IC industry cluster and oriented to industrial job demands, the School of Integrated Circuits of SZPU has built a multi-party collaborative system among government, schools, enterprises, and cross-institutional partners, established multi-level innovation platforms, innovated talent cultivation mechanisms, created featured cultivation brands, and promoted intra-university interdisciplinary integration, forming a complete industry-education-integrated talent cultivation model.

3.1 Building a government-school collaborative innovation platform to create pilot-scale industrial practice scenarios

The School actively promotes government-school linkage and has established deep cooperative relationships with both the Bao'an District and Nanshan District governments, including a plan to co-build an IC industry innovation center with the Nanshan District government. The Nanshan District government coordinates and provides off-campus site resources, while the School takes the lead in jointly building laboratories with IC enterprises to jointly carry out research project incubation. Different from traditional campus teaching laboratories, this platform aims to build a pilot-scale industrial practice platform that can support the participation of vocational undergraduate students.

Traditional university training platforms are dominated by teaching verification experiments and lack industrialization-oriented pilot-scale practice scenarios. Through the government-school co-built platform, students are no longer limited to basic experiments and can participate in technology verification and prototype trial-production stages close to industrialization. The government provides site support, enterprises invest technology, equipment, and engineering cases, and the school contributes research strength and student manpower, forming a collaborative platform of "government setting the stage, schools taking the lead, and enterprises providing technology", which forms a complete chain spanning on-campus experiments and pilot-scale trial production to project incubation, solving the problem of vocational undergraduate students lacking industrialized practice scenarios.

3.2 Building an industrial-chain collaborative innovation platform and leading the establishment of the SiC-embedded industry consortium

Relying on the team of national specially-appointed experts, the School is preparing to establish the SiC-embedded industry consortium, uniting more than ten upstream and downstream enterprises in the domestic industry chain to jointly develop the complete industrial-chain solution for domestic SiC-embedded power modules [5].

SiC power semiconductors belong to the third-generation semiconductors and represent a key track in the domestic IC industry, with a huge talent gap. The consortium covers upstream materials, device design, module packaging, testing, and downstream applications, breaking the limitations of a single enterprise or a single segment. Under the consortium's operating mechanism, vocational undergraduate students can deeply participate in real industrial technology research projects, follow enterprise engineers and expert teams, and fully participate in scheme demonstration, prototype development, test, and debugging, honing their engineering capabilities in real projects and achieving "learning by doing". Centered on domestic semiconductor technology research, the platform guides students to become familiar with domestic third-generation semiconductor technology, aligning with the strategic needs of China's IC industry self-development.

3.3 Implementing targeted cultivation based on enterprise orders and deepening all-around school-enterprise cooperation

The School has established in- depth cooperation mechanisms for targeted cultivation with leading listed enterprises in the industry and built an order-based class cultivation model. For example, it has established an order-based undergraduate class with LUSTER LightTech, selecting outstanding students in their junior year to join this targeted cultivation programme. Students conduct on-the-job internships at the enterprise and are given priority for employment at LUSTER LightTech upon graduation, realizing the integration of talent cultivation, internship, and employment.

At the same time, the School has signed all-around strategic cooperation agreements with listed IC enterprises such as Empyrean Technology and Beijing Golden Times Media Technology. The cooperation is not limited to internship and employment but extends to the entire process, including talent cultivation plan revision, joint development of courses and textbooks, co-construction of on-and off-campus training bases, on-campus teaching by enterprise engineers, and joint assessment. Enterprises are deeply involved in the whole talent cultivation process and integrate job competency standards into course objectives. School and enterprises jointly develop courses and school-based textbooks tailored to domestic EDA and chip application positions, solving the pain point of course content being disconnected from industrial positions.

3.4 Forming a cross-regional collaborative education community to enrich industrial practice resources across regions

As a member institution, the School joined the "Xinhuo Zhumeng" (Chip Spark, Dream Building) collaborative education community initiated by Nanjing University of Science and Technology, building a cross-regional collaborative education network. The IC industry chain is distributed nationwide, and resources of a single region such as Shenzhen cannot cover all segments of the industry chain. Through the community platform, the School hopes to realize cross-regional sharing of institutional and enterprise resources. Students can share the community's online courses, industry lectures, competition resources, and off-site enterprise practice opportunities, breaking through geographical limitations, gaining access to semiconductor industrial-chain resources in different regions of the country, broadening their industrial horizons, and compensating for the resource shortcomings of a single institution.

3.5 Creating the distinctive training brand of "National Chips for National Use, One Student One Product" and establishing a task-driven curriculum system

The School has developed a domestic chip innovation curriculum system themed "National Chips for National Use, One Student One Product" as a distinctive industry-education integration talent training brand. The system requires each

student to finish one production-oriented or application-oriented deliverable based on indigenous chips every semester, driving learning through project works and replacing the traditional teaching model centered on theoretical knowledge.

At the end of the semester, the School sets up review panels composed of front-line technical experts from enterprises to evaluate student deliverables through project defense. The evaluation criteria draw on industrial product development requirements and cover assessment dimensions such as functional realization, reliability, cost and application value, rather than merely testing theoretical knowledge. Outstanding student deliverables are displayed and promoted on the School's official WeChat public account. The School facilitates connections between these projects, enterprises and venture capital to obtain follow-up incubation support. This model guides students to innovate based on domestic chips, fosters their awareness of indigenous chip application and develops a product-oriented development mindset and strengthens engineering innovation capability.

3.6 Assembling national renowned experts to form a faculty team for teaching-research-industry integration

The School has introduced multiple national specially-appointed experts to lead industry-education integration projects and curriculum system construction. The core teaching team combines front-line industrial R&D experience with vocational undergraduate teaching capability: national-level experts grasp frontier technology directions of the industry, lead the industrial-chain consortium and research projects, and guide faculty teams in transforming frontier industrial technologies into teaching content. At the same time, the School encourages two-way flow of school and enterprise personnel: campus teachers enter enterprises for secondment and training, while enterprise engineers come to campus to undertake training teaching and project guidance. The interdisciplinary faculty ensures that course content keeps pace with industrial technology iteration, brings real industrial cases and engineering challenges into the classroom, and supports project-based and work-based teaching reforms.

3.7 Promoting intra-university interdisciplinary integration to foster innovation in IC application scenarios

The School breaks down intra-university disciplinary barriers and conducts deep interdisciplinary cooperation with colleges such as the College of Creative Design and Innovation and the College of Medicine and Nursing, integrating IC technology with healthcare and industrial design to develop market-demand-oriented healthcare electronic products.

Traditional IC talent cultivation mostly focuses on chip circuits, neglecting the needs of industrial design and application scenarios for product commercialization. Under the interdisciplinary cooperation model, the School encourages students to team up with medical, nursing, and industrial design students, starting from health application needs, completing chip hardware development, circuit debugging, product appearance, and interaction design, and developing intelligent hardware products for healthcare scenarios. This fosters students' scenario-based product development mindset, cultivates interdisciplinary talents who can translate chip technology into livelihood-oriented applications, and broadens career pathways for IC talents.

4 Suggestions for optimizing industry-education-integrated talent cultivation in vocational undergraduate IC programs

4.1 Improving the multi-party government-school-enterprise collaboration mechanism

On the one hand, the advanced laboratories built by the School should be transformed into pilot-scale platforms for enterprises, where the university and enterprises jointly develop and fabricate related products and submit applications for research projects; at the same time, some of the School's mature research projects are supported to obtain backing from venture capital firms and industrial partners for incubation and conversion into marketable products. On the other hand, cooperation with the local government should be strengthened to build the industrial innovation center as soon as possible, turning it into a research achievement transformation center and an enterprise incubation platform [6].

4.2 Promoting the curriculum transformation based on industrial projects and constructing a modular project-based teaching system

Industrial project-based teaching should be implemented, distinguishing research tasks from teaching tasks. On the premise of protecting enterprise intellectual property rights, enterprise project requirements should be transformed into horizontal projects, and the university organizes on-campus students to undertake and develop these projects, forming joint research teams of campus experts, full-time teachers, enterprise engineers, and students. The projects should be broken down according to the competency gradient of vocational undergraduates and converted into modular teaching tasks for students' courses. During project development, relevant knowledge points should be explained to students to strengthen their understanding of knowledge points through "learning by doing" and "doing to learn", and enable them to master the corresponding product development process. Relevant practices should subsequently be summarized and used as course cases to form a project case library, continuously updating course resources.

4.3 Improving the incubation support system for innovation achievements under the initiative of "National Chips for National Use, One Student One Product"

A full-chain support system for the incubation of student innovation achievements should be built. Upon completion of work evaluation, the School should cooperate with the College of Innovation and Entrepreneurship to support students seeking to commercialize their works through guided activities such as market research. Externally, normalized channels with venture capital institutions should be established, and a seed-stage support mechanism for student innovation projects should be set up: for works with industrialization potential, teams shall be offered technical guidance and prototyping support, so as to open the incubation pathway from student creations and prototype samples to commercialization projects. Archives of student innovation achievements should be established to continuously track the subsequent development of outstanding works.

4.4 Improving the institutional guarantee for intra-university interdisciplinary collaborative talent cultivation

Supporting measures for credit recognition of interdisciplinary projects, cross-faculty supervisor incentives, and joint project funding management should be issued. Special topics on interdisciplinary innovation in integrated circuit applications should be set up, encouraging teachers and students from multiple majors such as integrated circuits, healthcare and creative design to establish long-term collaborative teams. Interdisciplinary joint workshops should be launched with fixed project cycles aligned with the semester schedule, and cross-disciplinary joint evaluation criteria should be established, incorporating interdisciplinary project outcomes into students' comprehensive evaluation and teachers' performance assessment, promoting interdisciplinary cultivation from spontaneous pilot to institutional operation.

4.5 Deepening two-way faculty exchange between school and enterprise and improving the enterprise mentor incentive system

The leading role of the national expert teams should be leveraged, and the two-way mobility system for university and enterprise personnel should be improved. An enterprise mentor appointment system should be established, giving reasonable incentives to enterprise engineers who participate in course teaching, work evaluation, and order-based class cultivation. Campus teachers should be encouraged to regularly take secondments in industry-chain enterprises for research and study, continuously feeding new industrial technologies and processes back into the classroom. A three-tier faculty team of "specially-appointed experts + dual-qualified campus teachers + enterprise industry mentors" should be built.

4.6 Continuing to leverage the resources of the cross-regional "Xinhuo Zhumeng" collaborative education community

Cooperation within the "Xinhuo Zhumeng" community should be deepened to promote cross-regional course co-construction, joint projects, and co-hosted competitions. Online lectures on the industrial chain, remote experiments, and

joint student research projects should be carried out through the community. A cross-regional student practice exchange mechanism should be established to compensate for the shortcomings of single-region industrial-chain resources and help students develop a holistic understanding of the national IC industry chain.

5 Conclusion

Relying on Shenzhen's IC industrial cluster and oriented to industrial employment demands, the School of Integrated Circuits of Shenzhen Polytechnic University has explored and formed a multi-party collaborative industry-education-integrated talent cultivation model. Through a series of measures—co-development of an industrial innovation center with the government, establishment of a consortium for the SiC industrial chain, order- based customized talent cultivation for enterprises, the cross-regional collaborative education community, the "National Chips for National Use, One Student One Product" work-based teaching, the recruitment and cultivation of high-end expert faculty, and intra-university interdisciplinary integration and innovation—the model breaks through the limitations of shallow traditional industry-education-integrated cooperation, introduces authentic industrial research projects into undergraduate talent cultivation, and cultivates high-level technical and skilled talent oriented to the self-reliant development of domestic integrated circuits.

The case study shows that industry-education integration in vocational undergraduate IC programs oriented to industrial demand must, externally, build a multi-party collaborative system among government, universities, industrial-chain enterprises, and cross-institutional partners to consolidate collaborative ties among all stakeholders; internally, it should take authentic engineering projects as the carrier, supported by interdisciplinary faculty, while encouraging students to develop products and engage in interdisciplinary applied innovation. The practical experience of this case can serve as a reference for the industry-education-integrated reform of IC, third-generation semiconductor, and other hard-technology programs in domestic vocational undergraduate institutions, helping to cultivate high-level technical and skilled talent that supports the self-reliant development of China's IC industry.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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