



Exploration and Practice on the High-End Skilled Talent Cultivation Model of Integrated Circuits with the Characteristic of "One Achievement per Student for Domestic Chips Application"

Yongxue Wang*, Weiqiang Wu, Changbin Li

School of Integrated Circuits, Shenzhen Polytechnic University, Shenzhen, 518055, Guangdong Province, P.R. China

*Corresponding author. E-mail: wangyongxue@szpu.edu.cn

Abstract. Against the backdrop of the in-depth implementation of the national semiconductor independent innovation strategy and the high-quality development of the integrated circuit industry in the Guangdong-Hong Kong-Macao Greater Bay Area, technological bottlenecks in IC core technologies and the shortage of high-end skilled talents has become increasingly prominent. Positioned within vocational undergraduate education, the School of Integrated Circuits, Shenzhen Polytechnic University, closely focuses on industrial demands and innovatively adopts the talent cultivation model of "One Achievement per Student for Domestic Chips Application". Through constructing a whole-industry-chain cultivation system, optimizing the curriculum framework, deepening industry-education integration, strengthening practical and innovative training, and building characteristic industrial platforms, the School addresses the mismatch between conventional talent cultivation schemes and actual industrial talent demands, and explores a cultivation path for high-end skilled talent tailored to the development of the domestic chips industry. Based on the School's practical experience, this paper elaborates on the construction logic, implementation measures and practical effects of the model, and provides valuable references and inspiration for the cultivation of IC skilled talent in vocational education.

Keywords: Domestic Chips Application; One Achievement per Student; integrated circuits; high-end skilled talent; industry-education integration

1 Introduction

Integrated circuits are a strategic, fundamental and pioneering industry that underpins economic and social development and safeguards national security. The 15th Five-Year Plan ranks integrated circuits first among key emerging pillar industries, stressing the advancement of industrial innovation initiatives and intensified research on key core technologies. At present, China is comprehensively advancing chip independent innovation and domestic substitution. However, bottlenecks constraining the development of China's domestic chips industry remain prominent, including a

shortage of high-end skilled talents and a mismatch between talent training and industrial demands^[1-2].

Existing literature^[3-6] explores undergraduate talent training models for integrated circuits against the backdrop of emerging engineering education, while Reference^[7] investigates skilled talent training for integrated circuits at the vocational college level. As an important innovation in optimizing China's higher education structure, vocational undergraduate education has developed from pilot programs to large-scale rollout. It primarily fosters high-end skilled talent for strategic industries including high-end manufacturing, integrated circuits and the digital economy. This paper explores and practices the talent cultivation model for high-end integrated circuit talent at the vocational undergraduate level.

To break the bottleneck dilemma in the integrated circuit industry, coordinated efforts in both technology and market are imperative. From the technological perspective, priority should be given to key chip development technologies to overcome technical barriers in wafer manufacturing, advanced packaging, EDA tools and other critical areas, thereby achieving independent controllability of core technologies. From the market perspective, efforts should be targeted at the bottlenecks and difficulties in chip application. It is essential to address the reluctance and inability to fully adopt domestic chips, accelerate the deployment of domestic chips across diverse real-world application scenarios, and build an independently controllable industrial application ecosystem.

The dual driving force of technological innovation and ecosystem construction is fundamentally underpinned by the cultivation of high-quality skilled talent in integrated circuits^[8-12]. As a major platform for cultivating high-end skilled talent, vocational undergraduate universities undertake the important mission of supplying the integrated circuit industry with technical and skilled professionals equipped with engineering practical competence and innovative capabilities^[13].

The Integrated Circuits School of Shenzhen Polytechnic University, rooted in the Guangdong-Hong Kong-Macao Greater Bay Area, aligns with the talent demand across the entire industrial chain of domestic chips design, manufacturing, packaging, testing and application. The school has built an integrated circuit professional group covering three vocational undergraduate majors: Integrated Circuit Engineering Technology, Electronic Information Engineering Technology, and Modern Communication Engineering (see Figure 1). It has also innovatively proposed the talent cultivation model of "One Achievement per Student for Domestic Chips Application".

Guided by the principles of orienting toward industrial needs, focusing on practical competence, taking university-enterprise collaboration as the pathway, and regarding platform support as the guarantee, the school has constructed a full-chain, integrated training system for high-end skilled talent. Relying on industry-education integration platforms including the Huawei Industry Academy and the Huada Jiutian EDA Joint Laboratory, the school has developed and launched an innovative practical curriculum system oriented to domestic chips. It facilitates the closed-loop operation of teaching – practice – innovation – transformation and fosters a high-level professional cluster for integrated circuits.

At present, the school has achieved remarkable results in talent training quality, industry-education integration, and technical service capacity, providing a replicable

and promotable practical paradigm for cultivating high-end skilled talent in integrated circuits at the vocational undergraduate level^[13].

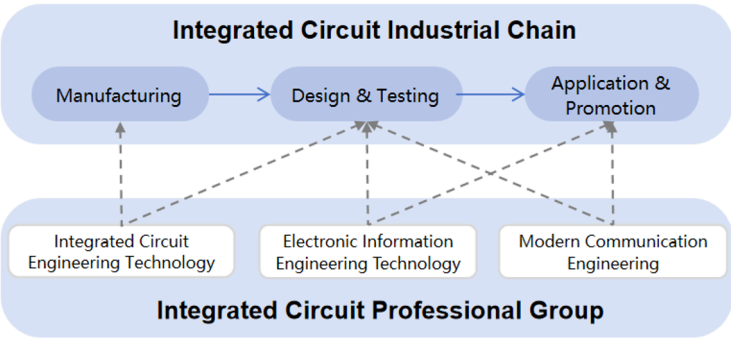


Fig. 1. Professional Group Established for the Integrated Circuit Industrial Chain

2 Curriculum of the "One Achievement per Student for Domestic Chips Application" Talent Cultivation Model

2.1 Construct a Professional Curriculum Featuring "Broad Scope, Solid Foundation, and Proficiency in Both Hardware and Software" to Consolidate Professional Fundamentals

The professional group is oriented to the talent demands of the entire integrated circuit industrial chain. Following the principle of "broad coverage and solid foundation", it consolidates students' professional fundamentals and industrial cognition.

Basic professional courses include Professional Cognition Seminar, Introduction to Integrated Circuits, Introduction to Artificial Intelligence, and other related courses, laying a solid foundation for students' technical, professional and career literacy. Meanwhile, fundamental electronic information courses such as Fundamentals of Circuits and Applications, Analog Electronic Technology, and Digital Circuits and Logic Design are offered to consolidate students' underlying knowledge framework in circuit design, signal processing and logical operation.

As shown in Table 1, the Integrated Circuit Engineering Technology program offers core professional courses such as Semiconductor Physics and Microelectronic Devices; the Electronic Information Engineering Technology program provides courses including Embedded Processor Application Development and FPGA Digital Logic and System Design; the Modern Communication Engineering program sets up core courses such as Computer Networks and Mobile Communication Technology. Focusing on post-oriented core competencies and technical application capabilities, these programs aim to cultivate students' professional ability to solve practical engineering problems in the fields of integrated circuits and artificial intelligence.

In addition, technical backbones from chip enterprises including Huawei, Xiaomi and Unigroup are regularly invited to deliver industry lectures. By interpreting technological trends and industrial ecological layouts with practical cases of

domestic- chips innovative applications, these lectures help students gain a clear understanding of the industry and build a strong sense of identity with the domestic chips ecosystem.

Table 1. Credit Hours and Course Distribution of the Professional Group

Course Category	Main Courses	Credits	Proportion of Class Hours
General Education Courses	Morality and the Rule of Law,College Foreign Language,College Physical Education and other courses.	50	29%
Disciplinary Basic Courses	Professional Cognition Seminar, Advanced Mathematics, Linear Algebra, Probability Theory and Mathematical Statistics, College Physics, C/C++ Programming, etc. Specialized Basic Courses: Introduction to Integrated Circuits, Introduction to Artificial Intelligence, Fundamentals and Application of Circuits, Analog Electronic Technology, Digital Circuits and Logic Design, Signals and Systems, Data Structures, Principles of Communication, Network Operating Systems, etc. Core Courses for the major of Integrated Circuit Engineering Technology: Physics and Devices of Semiconductors, Analysis of Semiconductor Materials, EDA Technology for Integrated Circuits, Integrated Circuit Manufacturing Technology, Chip Packaging Substrate Technology, Principles and Applications of Lithography Technology, Integrated Circuit Packaging Technology,Integrated Circuit Testing Technology, etc.	22 23 28	13%
Professional Courses (Take modern Communication Engineering major as an example)	Core Courses for the major of Electronic Information Engineering Technology: Embedded Processor Application Development,FPGA Digital Logic and System Design,Digital Signal Processing,Embedded Real-Time Operating System,Embedded Linux Application Development,AI Chip Technology and Applications, etc. Core Courses for the major of Modern Communication Engineering: Computer Networks,Cloud Service Technologies,Mobile Communication Technologies,Optical Communication Technologies,Digital Signal Processing,Communication Electronic Circuits,Digital Communication Design,Artificial Intelligence Application Development, etc. Specialized Elective Courses: Practice Series Courses on Domestic Chips Innovation(4 credits per semester from Semester 2 to Semester 7)The program offers tracks including Embedded Artificial Intelligence, Power Supply Design and Testing, Device Innovation and Application Practice, and Smart Healthcare System Development, which are selected by students. Comprehensive Project Training in Short Semester(4 credits per academic year for Grade 1 to Grade 3)	 24 12	42%
Intensive Practical Courses	On-the-job Internship and Graduation Design	16	16%
Total Credits		175	100%

Focusing on the fundamental competency of proficiency in both hardware and software as well as job suitability requirements, core courses are designed around two key dimensions: hardware design and software programming. Courses including Embedded Processor Application Development, C/C++ Programming, and Data Structures are offered to cultivate students’ interdisciplinary applied capabilities in hardware selection, driver development, and system debugging.

To meet the technical requirements of positions related to chip design, verification and application, practice-oriented theoretical courses such as Signals and Systems, Communication Principles, Integrated Circuit EDA Technology, and FPGA Digital Logic and System Design are delivered. Comprehensive Design and simulation experiments further strengthen students’ theoretical analysis and practical capabilities.

2.2 Explore the Intensive Practical Talent Cultivation Featuring the Short-Semester System to Strengthen Practical Abilities

The professional group aligns with the core job competencies in integrated circuits, electronic information, and communication engineering. It explores and implements a talent cultivation model characterized by intensive practical training under the short-semester system. The model arranges a one-month intensive practical teaching phase every academic year from the first to the third undergraduate year, constructing a step-by-step and progressive practical ability training system.

Practical training modules closely track cutting-edge industrial technologies and on-site job operational requirements,as is shown in Table 2.The Integrated Circuit Engineering Technology program provides three intensive practical courses: Transistor Process Implementation and Testing, Sensor Design and Process Implementation, and Power Chip Design, Implementation and Testing.The Electronic Information Engineering Technology program offers three intensive practical courses: Intelligent Warehouse Robot Design, Intelligent Vital Signs Monitor Design, and Intelligent Composite Robot Design.The Modern Communication Engineering program sets up three intensive practical courses: Campus Data Network Construction and Product Design, Metropolitan Mobile Network Construction and Product Development, and Cloud–Network Convergence Digital Application Development.

Table 2. Intensive Practical Courses for 3 majors

Major		Intensive Practical Courses		
		short-semester1	short-semester2	short-semester3
Integrated Circuit Engineering Technology	Circuit Information Engineering Technology Modern Communication Engineering	Transistor Process Implementation and Testing	Sensor Design and Process Implementation	Power Chip Design, Implementation and Testing
Electronic Information Engineering Technology		Intelligent Warehouse Robot Design	Intelligent Vital Signs Monitor Design	Intelligent Composite Robot Design
Modern Communication Engineering		Campus Data Network Construction and Product Design	Metropolitan Mobile Network Construction and Product Development	Cloud–Network Convergence Digital Application Development

Following the three-stage training logic of Basic Operation → Comprehensive Design → Innovative Application, the university jointly builds off-campus practice bases with enterprises including Huawei HiSilicon, UNISOC, and Loongson Technology. It introduces real industrial projects and domestic chips equipment, allowing students to deepen their theoretical understanding through full-process practical operation.

Via this three-stage progressive intensive practical training, the school effectively bridges theoretical knowledge and industrial practice, and gradually enhances students’ professional technical competence, job adaptability, and innovative capability. This approach cultivates high-quality, high-end skilled talent for the integrated circuit industry.

2.3 Construct a Series of Characteristic Practical Courses Titled "Domestic Chips Innovation Practice" to Cultivate Innovation Ability

The school has constructed a series of characteristic practical courses titled "Domestic Chips Innovation Practice", spanning from Semester 2 to Semester 7. Guided by the goal of domestic chips application, the courses align with national strategies and enterprise demands. Centering on the theme of domestic chips application and following the principles of "product orientation, performance assessment, and competition-education integration", the program allows students to independently choose product directions to enhance learning interest, adopts cross-grade student teams to realize product iteration and upgrading, and establishes school-enterprise joint teaching teams to ensure cultivation quality.

Adopting an interactive, open and inquiry-based teaching model, the courses integrate the cultivation of innovative thinking, improve students' innovation and entrepreneurship capabilities, and cultivate students into innovative applied talent.

Table 3. Training Methods and Objectives of the Domestic Chips Innovation Practice Series Courses

Student	Training Objectives	Training Methods
Freshmen	Complete basic tasks	Through basic skill training, students will master the operation of domestic EDA tools and basic process flows, participate in comparative experiments on domestic material properties, and lay a solid practical foundation.
Sophomores	Master practical skills	Further develop students' technical capabilities, and guide them to complete small-scale system development based on domestic chips platforms such as Loongson and PGRT, and prototype domestic applications for scenarios including industrial control and smart home.
Juniors	Conduct innovation	Driven by real enterprise needs, students are encouraged to innovate by undertaking projects such as Huawei HarmonyOS adaptation and SMIC process optimization, exploring the application of domestic chips in emerging fields including low-altitude technology and AI edge computing.
Seniors	Achieve cross-border integration	Emphasizing interdisciplinary and cross-border integration, students are guided to develop complex integrated solutions by combining communication, robotics and other majors, so as to promote the application of domestic chips in high-end scenarios such as automotive-grade applications and cloud computing.

Courses foster students' abilities hierarchically and progressively, with clear training objectives at each stage, as shown in Table 3. Through diversified training, the phased training goals are achieved: freshmen complete basic tasks, sophomores master practical skills, juniors carry out innovative practice, and seniors accomplish interdisciplinary integration.

The ultimate goal is to fulfill the cultivation objective of "One Achievement per Student", which requires each student to complete an original chip-related work, effectively responding to the orientation of "domestic chips application". The "One Achievement per Student" talent cultivation model for domestic chips applications is implemented as shown in Figure 2.

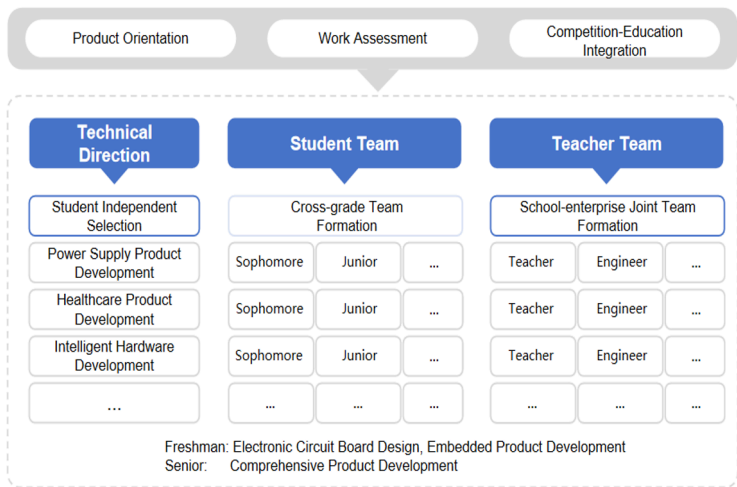


Fig. 2. Operation Mode of the Domestic Chips Innovation Practice Series Courses

3 Implementation Guarantees for the "One Achievement per Student for Domestic Chips Application" Talent Cultivation Model

3.1 Building a "Dual-Qualification, Dual-Competence, Full-time and Part-time Integrated" Teaching Team to Ensure Talent Support

Teachers are the key to the implementation of the education model. Aiming at improving professional competence and practical ability, and in response to the needs of industry-education integration, the school has built a high-quality dual-qualification teaching team consisting of full-time and part-time instructors. On-campus teachers have enhanced their industrial and technological capabilities through enterprise practice, key project research, and specialized training. Off-campus, technical backbones from enterprises such as Huawei and Emphyrean Technology are recruited as part-time teachers to make up for practical shortcomings, and industry leaders are employed to guide academic discipline development.

In addition, professional teaching and research teams have been established to promote curriculum reform and textbook development, thereby improving teaching resources. Faculty members of the school have participated in the compilation of featured textbooks, including Domestic Integrated Circuit EDA Technology and Ascend AI Processor Application Development. These textbooks have enriched teaching resources and further enhanced the competence of the teaching team.

3.2 Construction of a "Virtual-Real Integrated, School-Enterprise Co-constructed" Practice Platform to Strengthen Practical Competency Training

The school has established a four-in-one practical teaching system covering virtual simulation, on-campus training, enterprise internship and industrial platform practice. Relying on the industry-education integration platforms co-built with leading enterprises including Huawei, Emphyrean Technology and Xiaomi, the school has developed a practical teaching system that spans the entire industrial chain. It covers chip design, micro-nano manufacturing, device packaging and testing, as well as system integration and application, offering students real-world industrial practice scenarios.

In addition, the school has built joint laboratories with enterprises to carry out research on key technologies. For example, in collaboration with Shenzhen Longsight, it has set up a High-Frequency Signal Testing Center for Domestic Instruments and Meters, committed to formulating domestic testing standards and developing supporting courses, so as to strengthen students' ability to adapt to industrial development.

3.3 Improvement of a "Process-Oriented, Multivariate Evaluation" Mechanism to Ensure Training Quality

The school has established a four-dimensional evaluation system encompassing processes, projects, enterprises and achievements, which aligns with professional post standards and practical job requirements. Attendance, hands-on operation and project participation are all included in the process assessment. Centering on the initiative of "One Achievement per Student for Domestic Chips Application", the school evaluates students' comprehensive capabilities in design, development, innovation and teamwork throughout the entire learning process.

Enterprise supervisors are involved in the evaluation to ensure cultivated talent meet actual job demands. The system lays emphasis on the practical value and industrialization potential of students' works. Outstanding achievements are commended and promoted for industrial transformation and application.

For instance, the work Human Fall Detector Based on Stress Wave Detection developed by students addresses the pain points of an aging society. It overcomes the drawbacks of traditional fall detection solutions, such as privacy leakage, wearing discomfort and high false alarm rates. The project has won high recognition from review experts and industrial enterprises, and is currently under cooperation with elderly care enterprises for further application.

3.4 Deepening "Competition-Teaching Integration & Community Empowerment" to Ignite Students' Enthusiasm

The school ignites students' enthusiasm for innovative R&D through the integration of competition and teaching as well as the development of student societies. The content of national-level competitions in integrated circuits, robotics and other fields is integrated into practical teaching, so as to promote learning and innovation through

competitions and realize mutual empowerment between student projects and competitions.

Meanwhile, professional societies focused on chip application have been established to build a platform that integrates theoretical learning, skill training, and project R&D. Adopting a cross-grade mentoring model with joint guidance from the school and cooperating enterprises, the college organizes after-school innovative practices, further enhancing students' engineering competencies and teamwork skills.

4 Implementation Effects of the "One Achievement per Student for Domestic Chips Application" Talent Cultivation Model

4.1 Remarkable Improvement in Talent Cultivation Quality and Fruitful Competition Achievements

Through the implementation of the "One Achievement per Student for Domestic Chips Application" education model, students' engineering practical ability and innovative capability have been significantly improved. They have achieved outstanding results in various discipline competitions, delivered fruitful practical outcomes under the initiative, and greatly strengthened their career adaptability.

Students of the college have won the championship in the National University Students Robot Competition and the First Prize in the National Finals of the Vocational Skills Track of the National University Students Integrated Circuit Innovation and Entrepreneurship Competition. They also claimed the championship in the UAV event of the RoboCup China Open. In addition, students have been awarded the Global Grand Prize in the Huawei ICT Competition.

Meanwhile, students' professional literacy and vocational competence have been remarkably enhanced. A number of students have obtained Huawei HCIE certifications. Students have completed a series of projects under the "One Achievement per Student" initiative, including low-cost human fall detection devices and multifunctional intelligent obstacle avoidance devices. Some of these works have entered enterprise cooperation for industrial research and development.

4.2 In-Depth Promotion of Industry-Education Integration and Remarkable Results in Collaborative Talent Cultivation

The university has jointly built industrial colleges, training bases and technological innovation platforms together with leading enterprises including Huawei, Empyrean Technology and Xiaomi, forming a closed-loop industry-university-research transformation chain spanning demand identification, technological R&D and industrial commercialization.

Relying on these co-built platforms, the school has introduced more than 10 real enterprise projects and developed the course "Innovative Practice of Domestic Chips". It has carried out collaborative research with enterprises in bottleneck fields such as key integrated circuit materials, advanced packaging and microwave testing, promoted the domestic substitution of core technologies, and provided solid technical support for regional industrial development.

For instance, the advanced microwave testing platform has acquired testing capabilities ranging from above 60GHz to the terahertz band, supporting the industrial development of 6G, satellite internet and other fields. The school has taken the lead in establishing the Wide-Bandgap SiC Embedded PCB Consortium, which has received support from enterprises including BYD and CRRC. The Characteristic Semiconductor Engineering Research Center for AI Computing Power Applications has been approved as a provincial-level engineering research center, demonstrating the school's technical strength and talent cultivation level in the semiconductor sector.

4.3 Distinctive Education Model Formed with Prominent Demonstration Effect

The talent cultivation model "One Achievement per Student for Domestic Chips Application" has been widely recognized by the industry and universities, establishing an integrated-circuit talent-training paradigm with vocational-undergraduate characteristics. This experience has been shared with hundreds of institutions at various education and teaching seminars, including the Annual Conference of the National Steering Committee for Electronic Information Education and the Seminar on Double-High-Level Professional Group Construction, providing replicable experience for IC talent training in vocational-undergraduate universities.

The school has built a high-level five-in-one training base integrating teaching and training, skill competitions, scientific research and innovation, enterprise incubation, and social services. This base provides solid support for talent development and serves as a model for the construction of integrated circuit training bases in vocational-undergraduate universities.

Meanwhile, remarkable achievements have also been made in curriculum development and teaching resource construction. Circuit Fundamentals and Electronic Technology have been rated as national and provincial-level open online courses; more than 10 courses, including Cloud Service Technology, have been recognized as high-quality undergraduate-level courses. Textbooks such as Ascend AI Processor Application Development, 5G Mobile Network Deployment and Industrial Applications, and Loongson Embedded Processor Application Development have been adopted by many universities. The national-level professional resource databases for Communication Technology and Electronic Information Engineering Technology hosted by the school have been promoted nationwide, with more than 30 million online learning visits, forming a distinctive teaching resource system.

Furthermore, the school has developed international courses, including Ascend AI Processor Application Development, Cloud Service Technology, and 5G Mobile Network Deployment and Industrial Applications, training more than 2,000 students from over 30 countries. It has won the World Federation of Colleges and Polytechnics Award for Excellence in School-Enterprise Cooperation, and its talent training cases have been promoted and applied by UNESCO.

5 Conclusions

Facing the talent shortage bottleneck of China's domestic integrated-circuit industry, vocational-undergraduate education undertakes the key task of cultivating high-end skilled IC talents. This paper presents the "One Achievement per Student for Domestic Chips Application" talent-cultivation model practiced by the School of Integrated Circuits at Shenzhen Polytechnic University.

Centered on full-industrial-chain job requirements, the model optimizes curriculum systems, implements progressive short-semester practical training, and develops featured domestic-chip-oriented innovation practice courses. Supported by dual-qualification teaching staff, virtual-real integrated school-enterprise practice platforms and multi-dimensional process evaluation mechanisms, it realizes hierarchical ability cultivation for students and achieves the core target of one innovative chip-related output per student.

Practical verification shows that the model alleviates the mismatch between talent training and industrial demands. It enhances students' engineering practice and innovation competence, promotes in-depth industry-education collaboration, and produces promotable teaching cases and resources for vocational-undergraduate IC talent training.

Despite the achieved progress, further improvements are still needed in students' achievement transformation, high-level talent training and international-oriented vocational education construction. This model provides valuable practical references for peer institutions to cultivate high-end skilled talents serving the domestic-chip independent-innovation strategy.

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