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Teaching Research on Digital Integrated Circuit Design Oriented to Enterprise Needs

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Abstract

With the rapid development of the integrated circuit industry, enterprises' demand for digital integrated circuit design talents has been increasing day by day. This paper aims to explore how to improve the teaching effect of the Digital Integrated Circuit Design course and enhance students' practical abilities and employment competitiveness by taking enterprise needs as the guide. By analyzing the skill requirements of enterprises for digital integrated circuit design talents and the pain points in course teaching, this paper proposes ideas and methods for curriculum teaching reform, including optimizing course content, improving the practical teaching system, cultivating students' comprehensive abilities through innovation and entrepreneurship training projects, and deepening school-enterprise cooperation, so as to cultivate high-quality applied talents meeting enterprise needs.

Keywords

Enterprise Needs; Digital Integrated Circuits; Practical Projects; Curriculum Construction.

1. Introduction

With the vigorous development of the digital economy, integrated circuits, as the core cornerstone of information technology, have shown a rapid industrial development trend [1]. From indispensable smart phones and tablet computers in daily life, to artificial intelligence devices and high-performance computers leading the cutting-edge technology, and then to communication networks and automotive electronic systems that form the foundation of modern society, all rely on the strong support of integrated circuit systems. As a key link in the integrated circuit industry, digital integrated circuit design has an increasingly urgent demand for professional talents, which presents diversified and practical characteristics [2]. However, the traditional Digital Integrated Circuit Design course has a certain disconnect from the actual needs of enterprises in talent training, making it difficult for students to quickly adapt to enterprise work scenarios. Carrying out curriculum construction and teaching research on Digital Integrated Circuit Design oriented to enterprise needs can become an important way to boost industrial development and student growth, and it is of non-negligible significance for the collaborative development of education and industry.

2. Analysis of Enterprise Talent Demand

Under the sweeping tide of the global digitalization wave, enterprises' demand for digital integrated circuit design talents has shown a sustained growth trend. The growth of this demand is not only reflected in the sharp expansion in quantity, but also in the strict requirements for talent quality and professional literacy. Digital integrated circuit design is a complex and huge field, including multiple subdivided positions. Each position has its unique

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responsibilities and talent demand characteristics, and talents in various positions jointly promote the development of the digital integrated circuit design industry.

The front-end design position is mainly responsible for the logic design and algorithm implementation of digital integrated circuits, serving as the starting point of the entire design process. This role requires professionals to have a solid foundation in digital circuits, logic design, and algorithms, and be familiar with hardware description languages and relevant design tools. Focused on the physical implementation of chips, the back-end design position involves tasks such as place and route, timing optimization, and power consumption analysis to ensure that chip indicators like performance, power consumption, and area meet design requirements. Talents in this role need to be familiar with semiconductor manufacturing processes and possess strong physical design and optimization capabilities. The verification position is tasked with functional verification and performance testing of digital integrated circuits to ensure chip quality and reliability. It requires professionals to understand design principles and functional characteristics, and be proficient in verification methodologies and testing technologies. Beyond the above professional skills, the digital integrated circuit design industry's complex project processes and technical challenges impose higher demands on students' practical abilities and professional literacy. Students with project experience, problem-solving skills, communication skills, teamwork spirit, innovation ability, and learning capacity demonstrate strong employability.

3. Pain Points in Curriculum Teaching

3.1. Disconnect Between Curriculum Content and Actual Enterprise Needs

In some universities, the theoretical teaching content of the Digital Integrated Circuit Design course is updated slowly, failing to timely incorporate the latest industry developments and trends. There is limited coverage of emerging design technologies in the curriculum, such as the integration of artificial intelligence and integrated circuit design [3], 3D integrated circuit design, and reconfigurable processing-in-memory chips. This leads to a gap between the knowledge acquired by students and the actual needs of technology-based enterprises.

The practical teaching content is often limited to basic experimental projects, such as the design and analysis of simple circuits, which involve a small number of transistors and are far from the actual engineering projects in enterprises. The experiments that students encounter in class usually involve building and functional testing of simple logic gate circuits, or completing circuit design for a specific function according to fixed procedures. They lack the complete project practice process from project requirement analysis, architecture design, detailed design to testing and optimization. In contrast, in actual enterprise projects, design tasks are complex and comprehensive, requiring the balance and optimization of multiple factors such as performance, power consumption, and area.

3.2. Weakness in Practical Teaching Links

Advanced experimental equipment and software tools are essential for digital integrated circuit design. However, due to insufficient funding and other constraints, some universities struggle to meet current teaching needs. For example, the software used by students may differ in type or version from that in enterprises, leading to discrepancies in functionality, user interfaces, and operational workflows. As a result, students cannot master these tools during their studies and must undergo retraining upon employment, increasing enterprise training costs and delaying their ability to quickly adapt to work. In terms of experimental equipment, aging instruments with outdated performance and precision fail to meet the testing requirements of modern integrated circuit design. These limitations prevent accurate detection of chip

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performance under complex working conditions, depriving students of exposure to realistic and effective testing scenarios.

During practical teaching, due to limited faculty resources, teachers struggle to provide adequate guidance to each student. When students encounter problems in experiments, they cannot receive timely and effective assistance, leading to shallow understanding of experimental content and poor practical results. Additionally, the practical teaching evaluation system is imperfect, primarily focusing on experimental reports and results as evaluation indicators, while lacking comprehensive assessment of students' comprehensive qualities such as innovation ability and teamwork skills during the practical process.

3.3. Inadequate Cultivation of Students' Innovation Ability

The traditional curriculum teaching mode is mainly based on teachers' lectures, with students passively accepting knowledge and lacking opportunities for active thinking and innovation. In the digital integrated circuit design course, students often complete tasks in accordance with the experimental steps and requirements given by teachers, making it difficult to stimulate students' innovative thinking and spirit of exploration. Meanwhile, the course teaching lacks guidance and support for students' innovation projects. Students lack direction and resources in innovation practice, resulting in the difficulty of effectively cultivating students' innovation ability and meeting the demands of enterprises for innovative talents.

3.4. Insufficient Depth of School-Enterprise Cooperation

At present, the cooperation between universities and enterprises in the teaching of Digital Integrated Circuit Design largely remains at a superficial level, such as enterprises occasionally providing internship opportunities or organizing lectures for students. Enterprises rarely participate in core aspects like curriculum construction, textbook compilation, and teaching plan formulation, failing to fully integrate real enterprise needs and advanced technologies into curriculum teaching. Additionally, the school-enterprise cooperation lacks a long-term mechanism, with cooperative projects often being temporary and random. This makes it difficult to form stable cooperative relationships, affecting the in-depth promotion of teaching reform and the improvement of talent cultivation quality.

4. Teaching Reform Measures for Digital Integrated Circuit Design Oriented to Enterprise Needs

4.1. Optimizing Curriculum Content

Keep track of the industry development trends in a timely manner, update the theoretical teaching content, and integrate the latest digital integrated circuit design technologies and concepts into the course teaching. For instance, add contents such as the application of artificial intelligence in integrated circuit design, challenges and solutions in integrated circuit design under advanced manufacturing processes, and green low-power design technologies. Invite industry experts to the school to hold lectures, introduce the latest development trends of the industry, and broaden students' horizons.

Design comprehensive and complex practical projects to strengthen practical teaching content and simulate actual enterprise engineering projects. For example, students can be grouped to complete a full-cycle digital integrated circuit design project, covering the entire process from requirement analysis, architecture design, logic design, circuit design to layout design and verification. By introducing real enterprise project cases and decomposing them into several teaching modules, students can analyze and discuss these cases in class, thereby improving their ability to solve practical problems.

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4.2. Improving the Practical Teaching System

Universities should increase investment in the construction of digital integrated circuit design laboratories, update experimental equipment and software tools to ensure alignment with those actually used by enterprises. Meanwhile, establish innovation and entrepreneurship practice platforms to provide students with more advanced and comprehensive experimental environments.

Form a practical teaching guidance team composed of university teachers and enterprise engineers to jointly guide students in participating in practical projects. University teachers are responsible for theoretical knowledge instruction, while enterprise engineers, combining with their practical project experience, provide students with guidance on practical operations and technical applications. Additionally, establish a practical teaching tutoring mechanism to timely address problems encountered by students during project practice through a combination of online and offline approaches. Meanwhile, improve the practical teaching evaluation system by incorporating students' performance in projects, such as project completion quality, innovation ability, teamwork skills, etc., into assessment indicators to comprehensively evaluate students' practical abilities and comprehensive qualities.

4.3. Cultivating Students' Comprehensive Abilities through Innovation and Entrepreneurship Training Projects

Adopt a project-driven teaching model, using university students' innovation and entrepreneurship training program projects as a carrier to guide students to learn and explore actively. During project implementation, encourage students to propose innovative design ideas and solutions to cultivate their innovative thinking and capabilities. For example, allow students to independently select research directions in digital integrated circuit design for projects, such as reconfigurable chip design, intelligent chip design, etc., and carry out project research under teacher guidance, exercising their innovation abilities through practice.

Integrating with the College Students' Innovation and Entrepreneurship Training Program, organize innovation and entrepreneurship competitions, academic lectures, technical exchanges, and other activities to foster a favorable innovation and entrepreneurship atmosphere. Competition activities can stimulate students' competitive awareness and innovation enthusiasm, while academic lectures and technical exchanges enable students to keep abreast of the latest industry trends and cutting-edge technologies, broaden their horizons, and provide inspiration and ideas for their innovative practices. For example, regularly hold innovation and entrepreneurship competitions in digital integrated circuit design, encouraging students to form teams to participate, showcase, and exchange their innovative achievements.

4.4. Deepening School-Enterprise Cooperation

Universities should establish long-term and stable cooperative relationships with enterprises, sign school-enterprise cooperation agreements, and clarify the rights and obligations of both parties in curriculum teaching, talent cultivation, scientific research cooperation, and other aspects. In addition to providing internship positions, enterprises should deeply participate in curriculum construction. They should work with university teachers to formulate course teaching syllabi, ensuring that the curriculum content meets enterprise needs. Enterprises can also participate in textbook compilation, incorporating actual project cases and experience into teaching materials.

Universities can encourage enterprises to actively participate in teaching activities by establishing an incentive mechanism. For example, providing certain policy preferences or rewards to enterprises involved in teaching, and issuing honorary certificates to enterprise engineers who excel in teaching. Meanwhile, strengthen communication and coordination with

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enterprises, reasonably arrange the time for enterprise engineers to participate in teaching, and ensure that both enterprise production and teaching activities are not affected.

5. Conclusions

Carrying out the teaching reform of the "Digital Integrated Circuit Design" course in response to the demands of enterprises is an effective way to cultivate high-quality applied integrated circuit design talents. By analyzing the demands of enterprises and addressing the existing problems in the current course teaching, and taking reform measures such as optimizing the course content, improving the practical teaching system, introducing enterprise projects, and deepening school-enterprise cooperation, the quality of course teaching can be effectively enhanced, and digital integrated circuit design talents with solid professional knowledge, strong practical ability and innovative spirit can be cultivated. To meet the demand of enterprises for high-quality talents, achieve an efficient connection between the talent cultivation of colleges and universities and the demands of enterprises, and promote the development of the integrated circuit industry. In future teaching, we should continuously pay attention to the development trends of the industry and changes in enterprise demands, constantly improve the teaching reform plan, and cultivate more outstanding professional talents for the integrated circuit industry.

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