

Reform and Exploration of the Integrated Circuit Design Practical Course for College Students Driven by the Integration of Courses and Competitions

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Abstract: The integrated circuit industry is a national strategic emerging industry, which serves as an important pillar for boosting the development of the digital economy and guaranteeing the security of the electronic information industry. With the rapid development of the industry, the demand for high-quality applied talents majoring in integrated circuit design keeps rising. The integration of courses and competitions is an important mode for practical teaching reform in universities in the new era. Taking disciplinary competitions as the starting point for talent cultivation, it integrates competition standards, competition contents, and competition thinking into daily course teaching, which can effectively solve the pain points and difficulties of traditional practical teaching. Centering on the integrated circuit design practical course in universities and combining the talent-cultivation philosophy of course-competition integration, this paper systematically analyzes the current status and existing problems of course teaching, explores the educational value and practical significance of curriculum reform under the mode of integrating courses and competitions, and puts forward concrete reform paths from multiple perspectives. It aims to build a new-generation practical teaching system characterized by taking courses as the foundation, promoting learning and practice through competitions, and realizing the integration of courses and competitions. Thereby, students' practical operation capabilities, innovation capabilities, and engineering literacy in integrated circuit design can be comprehensively improved. High-quality applied innovative talents can be cultivated for the integrated circuit industry, and high-quality development of practical teaching for electronic information-related majors in universities can be promoted.

Keywords: Integration of courses and competitions; Integrated circuit design; Practical course; Teaching reform

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1. Introduction

With the continuous advancement of digital industrialization and industrial digitalization in China, the

integrated circuit industry is in a golden age of rapid development. Its industrial scale keeps expanding, and technology iteration speeds up, putting forward higher requirements for talents' engineering practical capabilities, innovative design capabilities, and teamwork capabilities. Majors such as electronic information and microelectronics science and engineering in universities undertake the important task of cultivating professional talents in the integrated circuit field. As a core practical major course, the integrated circuit design practical course consolidates students' chip-design foundations, cultivates their circuit-debugging capabilities, and shapes their engineering-innovative thinking, which exerts a direct influence on the quality of professional talent cultivation. Disciplinary competitions constitute a major approach for practical and innovative talent cultivation in universities. In particular, various disciplinary competitions for integrated-circuit design and electronic design can stay close to cutting-edge industrial technologies and actual industrial demands. Their assessment focuses on key capabilities including chip design, circuit optimization, and system development. Meanwhile, their competition concepts, assessment criteria, and project contents are consistent with the educational objectives of the integrated circuit design practical course. Therefore, against the background of full-scale development of emerging-engineering construction and continuously expanding shortage of integrated-circuit talents, promoting the reform of integrated circuit design practical courses via the course-competition integration mode is an inevitable choice for universities to optimize practical teaching systems, improve talent-cultivation quality, and meet industrial development demands.

2. Current teaching status of integrated circuit design practical courses for college students

After years of construction, integrated circuit design practical courses in domestic universities have formed a basic and systematic teaching framework, which can complete basic practical teaching tasks, equip students with basic procedures, software operations, and practical-training methods for integrated circuit design, and lay a certain foundation for the cultivation of students' professional abilities ^[1]. Nevertheless, in view of emerging engineering educational requirements and talent demands from the integrated circuit industry, current course teaching still has many deficiencies, and there exists a big gap between the overall educational effect and the training objectives for innovative engineering talents. Specifically, teaching content is updated slowly and disconnected from industrial frontiers and competition standards. Technologies in the integrated circuit industry are updated and upgraded rapidly, and new chip architectures, design methods, and simulation technologies keep emerging. However, practical teaching content in most universities remains at basic practical training, such as traditional basic circuit design and fundamental simulation verification. They seldom involve mainstream advanced design technologies, engineering applications, and innovative design concepts in the industry. Moreover, teaching contents are not optimized according to assessment focuses and project orientations of various integrated-circuit-design disciplinary competitions. Consequently, knowledge and skills acquired by students fall behind industrial development and cannot satisfy the requirements of new-industry technologies and posts ^[2]. In terms of teaching modes, the overall modes are unitary and rigid, failing to give play to students' subjectivity. Traditional integrated circuit design practical courses mostly adopt the indoctrination-oriented teaching mode of "theoretical lecture + demonstration operation + student imitation." Teachers dominate the whole practical-training process, and fixed criteria are set for the

selection of practical-training projects, formulation of operation procedures, and inspection of experimental results. Students only conduct mechanical and verifiable practical-training operations following teachers' instructions, without independently considering design schemes or locating problems in practical operations. Such passive practical-training modes greatly narrow the space for students' independent innovation, make students form rigid thinking in general, and deprive them of capabilities for independent design and tackling problems independently. In addition, the integration of course teaching and disciplinary competitions is very insufficient, leading to obvious separation in talent cultivation^[3]. Most universities regard course teaching and disciplinary competitions as two independent educational systems. Daily practical courses only complete basic teaching tasks without training related to competition content. Disciplinary competitions only organize intensive training for a small number of top students instead of covering all students. Competition resources, training methods, and innovative concepts cannot be popularized in regular teaching. Most students have no access to competition-related exercises and innovative practical operations, so it is difficult to improve the innovativeness and practicality of course education^[4].

3. Significance of reforming integrated circuit design practical courses driven by integration of courses and competitions

3.1. Optimize course teaching systems and solve pain points in traditional teaching

The fundamental advantage of the course-competition integration mode lies in breaking the closed and rigid situation of traditional practical courses. Disciplinary competitions serve as a reverse driving force to improve course-teaching systems and fundamentally resolve various pain points of traditional teaching^[5]. The proposition design of various high-level integrated-circuit-design disciplinary competitions keeps close contact with cutting-edge industrial technologies, practical engineering applications, and assessment of innovative capabilities, featuring prominent practicality, innovativeness, and comprehensiveness. It can accurately reflect industrial requirements for the capabilities of integrated-circuit-design talents. Curriculum reform carried out under course-competition integration can bring project systems, technical standards, and innovation requirements of competitions into course teaching, and push the renewal of traditional rigid and lagging teaching contents, teaching modes, and practical-training systems^[6]. Therefore, the integration of courses and competitions can effectively break the barriers between course teaching and competition training, turn niche competition-oriented innovative training into regular classroom-teaching contents, enable every student to get access to innovative practical-training projects, and fundamentally address drawbacks of traditional teaching including weak innovation, single practical-training forms and narrow educational coverage. It comprehensively improves the scientific nature, cutting-edge nature, and effectiveness of the teaching system for integrated circuit design practical courses.

3.2. Strengthen students' comprehensive capabilities and cultivate high-quality talents adapted to the industry

The integrated-circuit industry is technology-intensive and innovation-driven. Talent requirements have shifted from basic theoretical knowledge and practical operation capabilities to innovative-design capabilities, engineering practical capabilities, problem-solving capabilities, and teamwork capabilities. Traditional practical courses can only equip students with basic circuit-design and software-simulation skills. They cannot effectively cultivate students' comprehensive engineering literacy and innovative capabilities, which

may easily result in poor post-graduation adaptability and weak innovative competitiveness of graduates. Curriculum reform under the course-competition integration mode can take competition projects as practical-training carriers and decompose complex, comprehensive, and innovative competition projects into gradient classroom practical-training tasks. It promotes the transformation of students' practical training from basic reproduction exercises to comprehensive practical training covering independent design, innovative optimization, and system development ^[7]. In the course of study, students need to complete the whole process, including scheme design, circuit construction, simulation debugging, problem troubleshooting, and result optimization, which can effectively cultivate their abilities in independent thinking, independent innovation, and tackling practical problems. Regular training brought by course-competition integration can comprehensively enhance students' innovative capabilities, engineering literacy, and overall competitiveness. It thoroughly solves the educational drawbacks of valuing theory over practice and valuing reproduction over innovation in traditional teaching, and cultivates high-quality applied and innovative talents that meet the development demands of the integrated circuit industry.

4. Reform paths for integrated circuit design practical courses driven by integration of courses and competitions

4.1. Reconstruct course-teaching content system and realize in-depth connection between course and competition contents

Teaching contents are vital carriers for course education. To promote teaching reform of course-competition integration, we shall first reconstruct course-teaching contents based on competition standards and industrial demands, and form gradient, innovative, and systematic teaching contents, so as to realize seamless connection between basic course teaching and competition-oriented innovative training ^[8]. On the one hand, teachers shall fully sort out assessment outlines, competition subjects, and capability requirements of various authoritative disciplinary competitions for integrated-circuit design and electronic design. In this way, teachers can accurately extract core knowledge points, practical-skill points, and innovative assessment orientations of competitions. On this basis, they optimize course-teaching outlines, adjust the structure of teaching contents, break the traditional teaching mode divided according to textbook chapters, and build a three-level gradient teaching-content system consisting of basic practical training, comprehensive practical training, and innovative practical training. On the other hand, the basic practical-training module shall retain essential contents for integrated-circuit design such as basic principles, basic software operations, and basic circuit simulation to ensure students master professional basic skills and lay the foundation for competition training and innovative practice. Furthermore, the comprehensive practical-training module shall integrate regular basic competition projects. Practical-training projects shall be set based on frequently-examined competition contents such as analog-circuit design, digital-circuit development, chip simulation and verification, as well as circuit optimization and debugging, so as to improve students' comprehensive practical capabilities and meet basic capability requirements of competitions ^[9]. In addition, teachers shall establish a dynamic updating mechanism for teaching contents. Keeping up with iterations of industrial technologies and changes in competition propositions, they shall eliminate outdated practical-training contents in a timely manner and add cutting-edge contents including new chip-design technologies, intelligent-circuit development and system-integrated design, to guarantee that course-teaching contents always conform to competition standards.

4.2. Innovate diversified teaching modes and build educational scenarios integrating courses and competitions

Aiming at drawbacks of traditional practical courses such as rigid teaching modes, insufficient student subjectivity, and a weak innovation atmosphere, teachers shall adopt diversified innovative teaching modes guided by the philosophy of integrating courses and competitions. Fundamentally changing indoctrination-oriented and reproduction-based teaching methods, immersive, inquiry-based, and project-oriented educational scenarios integrating courses and competitions shall be created. First of all, teachers shall fully carry out the project-oriented teaching mode. Complete competition projects of integrated-circuit design shall be decomposed into phased practical-training tasks suitable for classroom teaching, and competition projects shall run through the whole course teaching. Moreover, course teaching shall no longer take knowledge-point explanation as the major objective, but take project implementation, design innovation, and problem solving as core goals. Students shall independently finish the whole workflow from project-scheme design, circuit construction, simulation, and debugging to result optimization. Teachers only play the roles of guidance, Q-and-A, and tutoring, highlighting students' principal position in teaching, and cultivating their capabilities for independent design and tackling problems independently^[10]. Secondly, adopt the teamwork-based teaching mode to help students adapt to the team-participation mechanism of integrated-circuit-design competitions. Divide students into several practical-training groups to finish comprehensive and innovative practical-training projects as well as pre-competition projects in groups. Within each group, members take respective responsibilities for scheme design, circuit debugging, simulation analysis, and result summarization. They solve project difficulties through teamwork. Practical training in class cultivates students' capabilities for teamwork, communication, organization, and planning, which meets the requirements of team-based competition and corporate post-graduation teamwork. Finally, after class, teachers can push extended competition materials, cutting-edge technical tutorials, and excellent-work cases via online teaching platforms, and provide regular Q-and-A tutoring. Teaching scenarios are further expanded to form a regular educational mode featuring in-class practical training plus after-class in-depth study, so as to comprehensively improve students' innovative practical capabilities.

4.3. Optimize assessment-evaluation and guarantee mechanisms and consolidate foundations for curriculum reform

Scientific and sound assessment-evaluation systems and guarantee mechanisms are important prerequisites for the implementation and effectiveness of course-competition-integrated teaching reform. Therefore, teachers must break traditional single assessment methods, build diversified, process-oriented and innovation-focused assessment-evaluation systems, and improve guarantee systems for teaching staff, platforms and resources to underpin curriculum reform. In terms of assessment and evaluation, abandon single assessment dominated by attendance, practical-training reports and basic results, and build a comprehensive assessment system attaching equal importance to process assessment, result assessment and innovation assessment. Process assessment comprehensively inspects students' daily learning performance, including participation in in-class practical training, project progress, enthusiasm for problem exploration and teamwork, and records their whole learning and growth process. Result assessment mainly examines basic practical outcomes such as completion of practical-training projects, rationality of circuit design, and effects

of simulation debugging. Innovation assessment focuses on innovative performances including novelty of schemes, technical improvements, independently-developed works, and competition participation. Students' participation in disciplinary competitions, competition awards, and finished innovative design works shall be included as bonus items in course assessment, which greatly stimulates students' enthusiasm for innovation and competition participation. Meanwhile, standardized and unified assessment criteria shall be downplayed. Students' personalized innovative designs shall be respected, encouraging them to try new ideas and new methods, so as to build an inclusive innovative teaching environment. In terms of guarantee mechanisms, universities shall attach importance to the cultivation of teaching staff and build professional teaching teams for course-competition integration. Special training, industrial exchanges, competition seminars and enterprise on-the-job attachments shall be adopted to improve teachers' mastery of cutting-edge technologies, innovative teaching capabilities and competition-guiding abilities. In this way, teachers can accurately grasp competition rules, proposition orientations and industrial-technical requirements, laying the foundation for subsequent integrated teaching and competition guidance.

5. Conclusion

The integrated circuit design practical course is a major channel for universities to cultivate innovative talents in the integrated-circuit specialty. Given the demands of rapid industrial development and the requirements of emerging-engineering teaching reform, traditional rigid course-teaching modes can no longer meet the talent-cultivation requirements of the new era. Hence, it is imperative to promote curriculum reform oriented toward the integration of courses and competitions. Taking disciplinary competitions as innovative starting points, the course-competition integration mode can effectively improve course-teaching systems, enhance students' comprehensive literacy, and enrich educational carriers in universities. It bears very important practical significance for improving the teaching quality of integrated circuit design practical courses, cultivating industry-adapted innovative talents, and advancing emerging-engineering teaching reform.

Disclosure statement

The authors declare no conflict of interest.

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