Research on the Digital Transformation of Integrated Circuit Major in Vocational Colleges

Qianwen Jiang*

Technology Department，Beijing Information Technology College, *Beijing*, China
*Corresponding author email:jiangqw@bitc.edu.cn

Abstract. The digital economy is a representative of new quality productivity and a strong driving force for high-quality economic development. The integrated circuit industry is the technological foundation of the digital economy era, and the key to developing integrated circuits is talent cultivation. In the face of the huge talent gap in the integrated circuit profession, digital education has broad coverage and fast dissemination, which is the most effective solution. Explore the digital transformation of integrated circuit majors in vocational colleges, establish "industry education integration" bases, develop digital teaching resources, build digital teaching platforms, fully leverage the advantages of school enterprise cooperation, customize training plans, and provide high matching integrated circuit talents for enterprises.

Keywords: integrated circuit major，digital transformation，virtual reality space teaching.

1   Introduction

The digital economy is a representative of new quality productivity. With the deep integration of digital technologies such as "East to West Calculation" and data security with the economy and society, there is a high demand for artificial intelligence computing chips, memory interface chips, and other components. At the national strategy level, the "14th Five-Year Plan" identifies frontier areas such as artificial intelligence, quantum information, integrated circuits, life health, and brain science as key development directions. From the perspective of the international environment, the implementation of a series of semiconductor bans by the United States has restricted the development of China's semiconductor enterprises, which in turn has intensified the drive for independent innovation within the industry, fostering the creation of an economic "dual-circulation" system. As a crucial support for the development of integrated circuits, the digital transformation of education should explore innovative models for cultivating high-skilled talents in the digital era. This endeavor is aimed at promoting high-quality education, expanding digital teaching resources, and enhancing students' abilities to face future societal challenges.

2   Research background

The integrated circuit (IC) industry serves as the foundational pillar of the digital economy. Currently, China has entered the crucial five-year period of "consolidating

the foundation and striving for greater progress" in the IC industry. The linchpin of developing the IC industry lies in talent. Presently, there is a mismatch between the supply of talent and the demand for high-end positions in China. To continue advancing towards the high end of the industrial chain, establishing a hub for original technology innovation, and fostering high-tech industrial clusters, the cultivation of professionally skilled talent is an indispensable and fundamental basis [2]. Deepening the development and upgrading of the IC industry not only provides a solid foundation for the digital economy but also leverages the transformative power of informatization to deeply reshape traditional economic forms, and even create unprecedented new economic forms. This, in turn, accelerates the digitization of industries and the industrialization of digital technology, and drives high-quality economic development.

3   The current situation and problems of the development of integrated circuit major in vocational colleges

Currently, the talent output in the IC industry from higher vocational colleges significantly lags behind the urgent needs of the industry, both in quantity and quality, presenting a notable gap [3]. Furthermore, the national future plans have clearly outlined an ambitious blueprint for the development of the IC industry and AI industry, indicating that these fields will usher in unprecedented opportunities and challenges for development.

3.1   The current situation of the development of integrated circuit major in vocational colleges

By the end of 2023, approximately 67 higher vocational colleges nationwide have established programs in integrated circuit technology. The rapid technological advancements in the field of IC contrast sharply with the predominantly traditional teaching methods employed in IC education, where textbooks have not been promptly updated. Consequently, it is imperative to strengthen the construction of experimental and practical training facilities in educational institutions. Integrating new technologies, processes, standards, norms, and typical projects from the industry into textbooks and curricula, and fostering in-depth school-enterprise partnerships are crucial [4].

3.2   The Challenges Faced by the Development of Integrated Circuit Specialty in Vocational Colleges

The digital transformation of integrated circuit majors in vocational colleges faces the following problems:

- The shortage of educational resources from industry enterprises has emerged as a pivotal issue [5]. To a certain extent, the scarcity of educational resources in the field of IC has constrained the participation of IC-related enterprises in school-enterprise cooperation. This has hindered the effective transformation of the latest technologies, advanced processes, innovative materials, and high-end equipment within the industry into specialized training resources. Consequently, a discrepancy arises between the teaching content in academic institutions and the actual production requirements, adversely impact the quality of talent developed. This situation gives rise to a "negative cycle" in the integration of industry and education.

- The practical teaching capabilities of teachers are relatively lacking. The technology in the IC industry updates and iterates extremely rapidly. Teachers, being separated from the corporate work environment, rarely have the opportunity to directly participate in corporate project practices, resulting in their engineering experience and skills failing to keep up with the latest developments. This makes it challenging for their students to quickly meet the demands of the industry and lacks the ability to solve practical engineering problems.

- Students lack practical experience in production projects. Due to the high costs of manufacturing equipment, high precision requirements, and stringent quality standards in the integrated circuit industry, most enterprises rarely arrange for students to directly participate in hands-on operations on the production line. Constrained by limitations in fund-raising and facility conditions, vocational colleges lack the capability to independently establish production practice laboratories. Coupled with inadequate deep integration of industry and education, and a scarcity of real-world project cases, the skills acquired by students are insufficient to meet the needs of enterprises.

4   Suggestions for the Digital Transformation of Integrated Circuit Majors in Vocational Colleges

In the process of cultivating digital talents, universities need to focus on aligning with the needs of enterprises and transforming the latest industry technical standards into educational standards within the institution. Only in this way , talents cultivated can meet the demands of the industry.

Currently, in the development of the IC industry, there is an urgent need for composite technical talents, who not only understand IC production processes, but also possess knowledge of core IC equipment. Therefore, in response to the new talent demands of the IC industry, vocational colleges should focus on reforming their educational philosophy, establishing IC specialty clusters, and cultivating talents that meet the needs of industrial development.

4.1   Building a 'Industry Education Integration' Base faculty development

Firstly, deep cooperation between schools and enterprises should be carried out by inviting professional technicians in IC from enterprises to participate in curriculum development, either in collaboration with school teachers or independently producing curriculum resources. Secondly, teachers should regularly visit enterprises to engage in job practices, gain insights into the latest technologies and development trends in the industry, thereby enhancing their teaching and professional competence.

Building a laboratory platform for the school: Due to the exorbitant cost of cutting-edge hardware and software equipment for integrated circuits, it is impractical for schools to purchase them in full. Relevant enterprises can make appropriate donations of near-expiry equipment or establish school-enterprise cooperation practical training bases. These bases should be fully utilized and developed into next-generation laboratory platforms that cater to both students' practical training needs and enterprises' engineering project research and development. Additionally, they can undertake ser-

vice-oriented and open industrial-educational integration practical training services for the society. The practical training platform integrates four major functions: practical teaching, social training, real production, and technical services. It provides students with a campus environment that seamlessly connects them to employment positions, thereby significantly enhancing their practical abilities and employment competitiveness.

4.2   Developing digital teaching resources

Digital educational resources constitute the foundation of the digital transformation in education, such as digital textbooks, online courses, subject-specific tools, question banks, virtual experimentation platforms, and so on. On the one hand, through school-enterprise collaboration, teachers should visits enterprises and collaborate with technicians to develop digital resources based on existing curricula. According to the job division within the IC industry chain, the digital curriculum system design for IC major in vocational colleges is illustrated in Fig. 1. On the other hand, the college invites enterprise technicians to record digital courses, such as hands-on courses for 3D IC equipment, process courses for 3D IC production lines, enterprise project practical training courses, and professional core technology courses, to create educational resources that can be iteratively updated. Alternatively, the college may purchase project resources and internal training resources from enterprises, and convert them into digital textbooks, subject-specific tools, and more. Ultimately, the curriculum settings need to be adjusted and innovated according to the actual job demands of the collaborating enterprises.
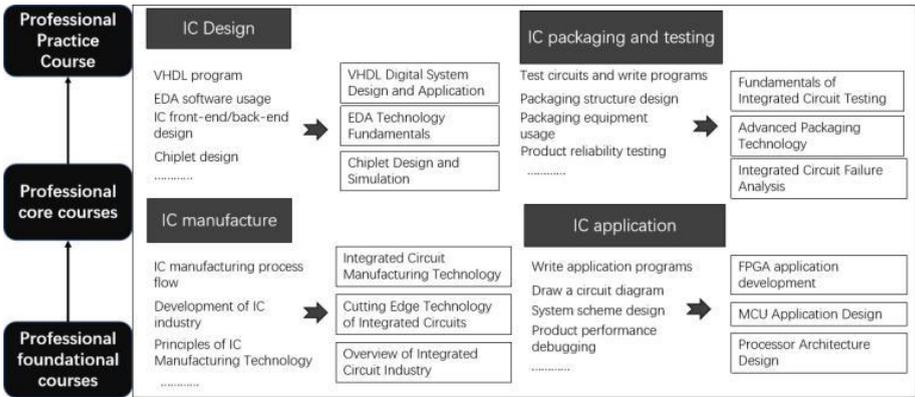

Figure 1. The digital curriculum system design for IC major in vocational colleges

The curriculum can be delivered online through digital humans, as illustrated in Fig. 2, facilitating students to revisit and learn at their convenience. Digitized courses enable students to immerse more easily, leading to higher learning efficiency. The appearance and voice of the digital humans can be customized, adding an element of fun to the learning process and making specialized IC courses less dry and difficult to understand, thereby lowering the professional barrier.
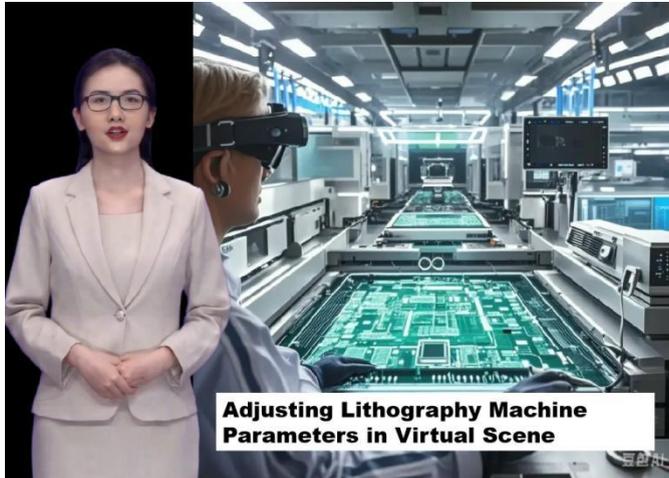
Figure 2. A practical course for digital humans to explain virtual operation of lithography machines online

To address the issue of high costs associated with IC equipment, which limits hands-on practice opportunities for students, the most crucial approach for digital transformation in vocational colleges is to employ cutting-edge VR/AR/MR technologies. These technologies enable students to engage in online learning and simulated hands-on practice, thereby enhancing their practical operational skills. As shown in Fig. 3, AIGC is utilized to create a scenario where students, wearing VR glasses in a safe laboratory environment, enter a virtual operation space on an IC production line. In this virtual space, students operate integrated circuit equipment to complete the process flow according to actual production requirements. This virtual scenario needs to be refined by technical personnel from industry to ensure its realism, which makes it more in line with the actual manipulation process. Furthermore, it should be continuously updated in accordance with technological advancements.

Figure 3. A scenario where students, wearing VR glasses in a safe laboratory environment, enter a virtual operation space on an IC production line.

This innovative teaching model can efficiently cultivate a large number of high-quality talents for the IC industry, precisely meeting the personnel demands of enterprises. The adoption of digital transformation in teaching within the IC majors of vocational colleges, not only invigorates the IC industry, but also promotes deeper integration of industry and education, achieving a "positive cycle" of mutually beneficial cooperation between schools and enterprises.

4.3   Building a digital platform

The technical origin of digital transformation lies in the digitization of various analog resources. The introduction of innovative technological means such as AI and blockchain can drive the modernization and development of education, cultivating high-quality technical talents in integrated circuits for universities and enterprises through digital empowerment. The core significance of establishing digital education platforms is to enhance education quality, promote educational equity, optimize resource allocation, and advance the process of education digitization [6].
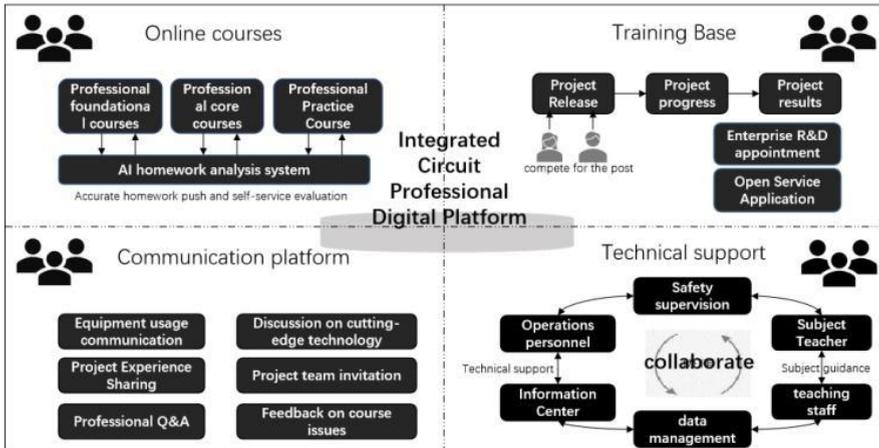

Figure 4. Digital teaching platform for IC major.

The digital transformation platform for the IC major, as illustrated in Fig. 4, consists of online courses, practical training bases, communication platforms, and technical support. The online courses is divided into digital teaching resources and an AI homework analysis system, which can be capable of precisely delivering assignments based on students' characteristics and facilitate self-assessment. The practical training bases publish training projects, where students compete for project positions based on their skill sets, regularly update project progress, and ultimately present project outcomes. These bases also support appointments for corporate research and development, assisting enterprises in engineering research. Furthermore, they are open to the public, fully utilizing resources to serve society and achieving deep integration of industry and education. The communication platform serves as a bridge for teacher-student communication, facilitating exchanges on the use of IC equipment, discussions on cutting-edge IC technologies, sharing of practical training project experiences, invitations to form project teams, Q&A sessions on IC major difficulties, and feedback on IC course issues. Technical support encompasses the operation and maintenance of the entire

platform, including specialized personnel at the information center who provide maintenance services, resource data management, and security supervision. Subject researchers provide teaching guidance to teachers, update data resources, and support supervision. All departments collaborate to maintain the platform healthily.

5   Conclusions

The IC industry serves as the industrial foundation the digital economy era. There exists a significant shortage of professionals in the IC field. The key to advancing the IC industry lies in talent cultivation. Digital education, with its wide reach and rapid dissemination, represents the most effective approach to addressing this gap. Vocational colleges and universities are undergoing digital transformation in their IC majors by establishing industry-education integration bases, developing digital teaching resources, and building digital teaching platforms. These initiatives strengthen close cooperation with enterprises to jointly formulate talent training programs tailored to the IC sector. Furthermore, they collaborate to discuss and develop digital curriculum standards and suitable textbooks, ensuring that the educational content keeps pace with industry trends.

6   Acknowledgment

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