Teaching Exploration of Integrated Circuits Under the Background of Informatization

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Abstract. This paper explores the teaching mode in digitalization and informatization, taking integrated circuit major as an example. By introducing practical engineering projects into curriculum practice and taking discipline competitions as the guide, it is explored new method to improve the ability to solve complex problems. It is built a self-circulating, self-iteration, scientific and technological innovation platform for students, building online and offline mode by cloud service to meet their requirements. After years of practice, this method can effectively stimulate students' internal driving force, improve their comprehensive qualities such as knowledge mastery, professional practice and application ability. It is proved that this way is effective to cultivate high-quality compound new engineering talents with strong practical ability, strong innovation ability and international competitiveness.

Keywords: Teaching reform · Teaching online · EDA · Digitalization and informatization

1 Introduction

In higher education, undergraduate education shoulders the vital responsibility of cultivating high-quality professional talents for the society. Practical teaching is an important part of undergraduate education [1], which is an important way to improve students' comprehensive quality, such as knowledge level, professional practical application ability, and the ability to solve complex problems. New tasks and challenges are put forward for the curriculum practice system future engineer training, with the continuous improvement of engineering education system in the context of new engineering [2–4].

In traditional curriculum, on one hand, there is a problem that teaching and engineering are not connected to the real industry. Engineering degree is not enough, students are not aware that what they have learned and what practical skills they have acquired link to what they have applied specifically in the industry [5–6]. Besides, the relatively fixed experiment content setting gives students limited room for improvement in practical ability and innovation ability. High quality, full coverage of engineering ability training is insufficient. On the other hand, the combination of knowledge content with various

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types and multi-level practice activities is not close enough, and the audience of high-level practice activities, the level of engineering capability and the ability of self-study and iteration still need to be greatly improved.

By the development of computer and information technology, EDA (Electrical Design Automation) tools help design of integrated circuits faster and more convenient and simulation results more accurate. In this paper, the integrated circuit major is taken as an example, and the CDIO (Conceiving-Designing-Implementation-Operation) model [3] is referenced, the latest development mode of international engineering education, to explore the experimental practice teaching mode combining engineering and discipline competition.

By means of reorganizing the course content, innovating experimental practice, the classroom teaching is paid close attention, and the actual engineering projects are introduced into the course practice. Depend on discipline competitions, the outside-classroom learning is strengthened, and the education way combining courses, competitions and practical training is explored, which provides students with multi-direction and multi-level practical activities, and builds a self-circulating, layer-by-layer scientific and technological innovation platform for students.

2 Experimental Practice Teaching Under the New Engineering Background

The cultivation of new engineering talents should establish a new concept of engineering education, take students as the center, pay attention to learning results, and continuously improve the level of engineering talent training. To enable students to master more advanced knowledge, including natural science, mathematics, engineering science, humanities and social sciences, professional and disciplinary knowledge; obtain comprehensive abilities include applying knowledge to solve practical engineering problems, engineering design, innovation, creation and entrepreneurship, teamwork, communication and leadership skills, lifelong learning ability, and core skills involved in the profession and career attitude [7].

Therefore, in the context of new engineering, the education of professional should combine elements that noted above. It is necessary to further integrate teaching content and teaching resources, design and adopt new methods of experiment teaching, and explore new experimental practice teaching and talent training mode in the direction of integrated circuit [8]. This paper mainly carries out the following aspects of innovation and reform.

(1) Strengthen curriculum integration, focus on improving students' ability to solve complex engineering problems, implement research-based teaching methods such as project-based teaching, and pay attention to comprehensive project training. The innovative and full-cycle engineering education concept is integrated to shorten the distance between professional education, talent cultivation and industrial development, and to cultivate students' full-cycle concept of innovative design of products and systems, operation and service to society.

(2) On the basis of professional courses, with innovative discipline competitions as the starting point, provide targeted training paths for students, and establish a

curriculum-based, race-led, and training-oriented education model to achieve the purpose of comprehensively improving students' quality and ability.

(3) In the face of students' strong demand for scientific and technological innovation and the problem of insufficient scientific and technological innovation guidance resources and ways, it is paid close attention to the classroom teaching based on the curriculum, guided the independent outside-classroom learning for students vigorously, and pioneeringly established an self-circulating, self-iteration and spiraling upward science and technology club for students, which provide an environment and platform for students' learning, scientific research and innovation.

3 Teaching Reform Measures

3.1 Project-Oriented Professional Experiment Teaching

In the process of introducing engineering project into professional experiment teaching, the curriculum has formulated and carried out the main idea of "engineering-oriented, ability-oriented, application-oriented". The "engineering-through type" training mode is designed, which takes the actual engineering project as the carrier, including the whole life cycle from product development to product operation, as Fig. 1 showed, and constructs the advanced learning content enhancing learning initiative. Based on the theoretical knowledge system, it leads students to explore in the breadth and depth of knowledge. With the help of teaching method, engineering and curriculum organically linked, students are guided to expand their thinking ability, problem-solving ability, and interdisciplinary thinking. The students' knowledge and ability progress step by step, link with each other, realize self-iterative innovation, and finally obtain the comprehensive breakthrough of basic engineering knowledge, personal ability, interpersonal and team ability and engineering system ability.

Taking the course "Integrated Circuit Design Practice" as an example, to achieve the goal that students can master the whole process of conception, design, implementation and operation of electronic engineering products, the course mainly takes the open topic selection of Analog-to-digital converter (ADC) as the basic learning content. It is operated such like CDIO model. The course takes project team as unit and at the beginning of the course, teachers introduce the specific project background, market application and actual process of engineering in the industry, so as to cultivate students'

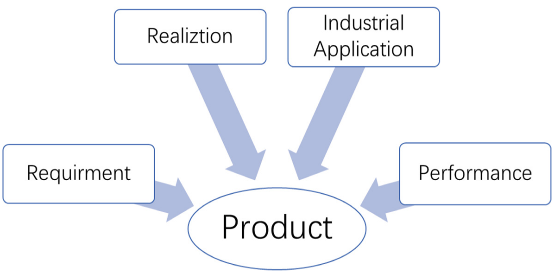

Fig. 1. Product development and product operation

overall view in the project. Teachers cooperate with enterprise technical engineers to put forward specific project requirements from the perspective of engineering application, including the process required to complete the project, the simulation platform, the specific accuracy, bandwidth, power consumption and other product indicators of the ADC, which can strengthen the connection between the course and the project. Teachers are encouraged to introduce cutting-edge science and technology into teaching activities. Based on the integrated circuit module of ADC, which connects analog signals and digital signals, the application of intelligent science, medical and engineering integration, and industrial and engineering integration are expanded and extended [9–11]. For example, a 6 bits SAR ADC (Successive Approximation Register ADC) is introduced to students, as shown in Fig. 2, and the circuit structure implement in EDA tools. The Simulation result of SAR ADC in frequency domain is shown in Fig. 3. After this project, students can learn design and simulation flow of an ADC circuit.

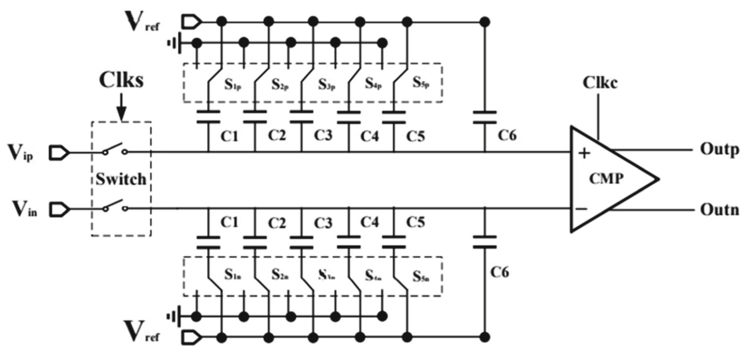

Fig. 2. 6 bits SAR ADC

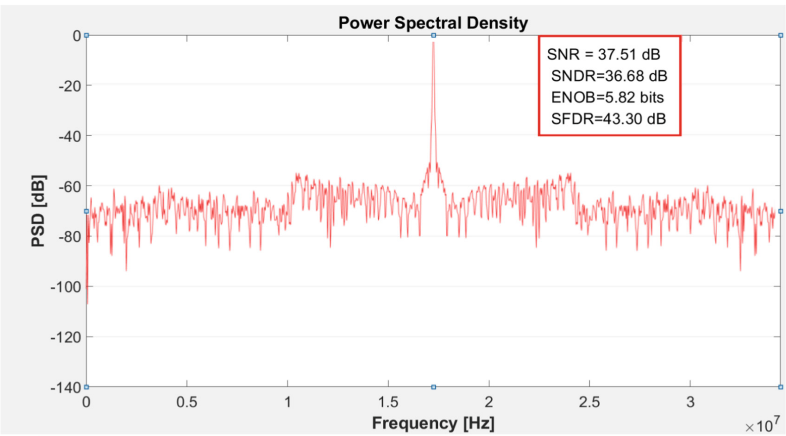

Fig. 3. Simulation results in frequency domain

At the same time, the technical engineer will introduce the latest technology, advanced organization management concept, team operation mode, product design concept and so on. Students formulate project plans and implementation plans according to specific requirements. Within the project team, students work independently and study cooperatively to stimulate students' motivation to learn. With theory guiding practice, solve problems encountered in practice, improve students' sense of urgency and achievement in learning, and promote students' sense of learning responsibility and teamwork spirit.

Under the influence of traditional teaching mode, students have a strong dependence on teachers, and which leads that the students' learning feeling in the new mode will be vague and unclear to a certain extent at the beginning. In this regard, teachers should determine their role of "teaching people to fish". Based on the knowledge required by the project content, teachers discuss with students to find solutions and directions for relevant problems, instead of providing complete solutions directly, to allow students to explore and learn with problems. After self-study by searching materials, group discussion in project teams, and discussion with teachers and engineers, students gradually have a clear understanding of the project, and finally determine the implementation plan.

In the assessment and performance evaluation of students, the proportion of process assessment indicators should be increased, and the rigor should be advocated, practical ability, comprehensive analysis ability and innovation ability should be taken as the main assessment content. Simultaneously in addition to the rationality and innovation of the program, project completion, teamwork, team achievement display and so on, the assessment and evaluation system should also add the "team mutual evaluation" sub-item. Further it's that according to the actual performance of each student in the process of the project, the rest of the students in the team score the student. The average score achieved after removing the highest and lowest scores from the assessment is the student's score in this sub-item. This avoids the non-participation and inaction of individual members in the team. In view of the course topic selection and its openness, the topic used in the course is formulated by teachers in combination with their own scientific research and understanding of students before the start of the course and at the same time students are allowed to determine the topic by themselves to ensure the flexibility in the difficulty and scope of the topic. The following problems are that it is too difficult for students that the topics identified by themselves, and it is difficult to unify different scoring standards of students' topics.

From the habit of studying alone and arranging by oneself, to the cooperation mode with definite time nodes and work quality requirements for work completion. From unknowing where to start when encounter problems, to gradually mastering the methods and ways to solve problems under the guidance of teachers. From passive overall acceptance of knowledge, to active exploration of knowledge, complete absorption, application, criticism, rumination, and then form their own cognitive system. From the fragmentation of knowledge and experimental skills, to be able to clearly connect and synthesize and integrate the knowledge and skills learned. After a complete engineering project process, students' working ability, learning attitude and cognition ability have been greatly and holistically improved.

3.2 The Education Mode of Curriculum, Competition and Practical Training

Theoretical courses and experimental practice courses are the cornerstone of the whole educational professional curriculum system, providing strong support for theoretical knowledge system and basic professional skills for innovative competition and project practice. Based on professional courses, the project practice training prepares for relevant competitions. Through pre-competition practical training, the integration of the knowledge system and practical skills are further improved. At the same time, in the course teaching, the introduction of competition projects, and the reasonable integration of the specific tasks of the competition projects with the professional experimental practice links can train and improve students' ability to apply knowledge, practical analysis and problem solving. To promote learning by competition, consolidate the foundation. Students complete the understanding and deepening of theoretical knowledge in practice. Under the organic integration of " curriculum ", "competition" and "practical training", students' innovative thinking, innovative practical ability and innovative spirit have been cultivated, exercised and enhanced.

Take microelectronics and integrated circuits as an example. "Integrated Circuit Engineering" is one of the important core courses of this major, the main modules of which are "Analog Integrated Circuits" and "Digital Integrated Circuits". In course of teaching, competitions such as "National University Students IC Innovation and Entrepreneurship Competition" are introduced to guide students to understand the model, content and required knowledge and skills of this kind of large-scale technology competition. In the analog integrated circuit theory class, the teacher introduces the structure and principle of CMOS single-stage amplifier circuit, constant current source circuit, differential amplifier module circuit, and operational amplifier circuit and other unit. Further, on the basis of teaching on structure and principles take the operational amplifier circuit as an example. Teachers introduce circuit design methods, the relationship between parameters and indicators, and the analysis method with circuit structure changing, leading students to think deeply, analyze and explore.

In the analog integrated circuit experiment, students should complete the circuit design of operational amplifiers based on the analog integrated circuit design software, master the basic skills of practical analog integrated circuit design, and further understand circuits' the analysis, design methods and indicators' inner compromise and methods for optimization in the process of analog integrated circuit design. During pre-competition practical training, based on the course and experiment process, according to the different competition modes and contents of the "National University Students IC Innovation and Entrepreneurship Competition" and the "Beijing University Students IC Innovation and Entrepreneurship Competition", the teacher organizes and guides the students to carry out targeted and project-based training, the realization of circuits such as bandgap reference source, low noise amplifier, oscillator, ADC/DAC, in small groups. After years of practical exploration, it has been found that practical training is the internalization of theoretical courses, which can strengthen students' understanding of relevant knowledge, expand experimental practice courses, and improve students' cognition of engineering design. Finally, for the benefits of competition, students have a deeper understanding of the knowledge content involved in the theoretical courses, and accumulate a lot of practical experience. Teachers can improve the quality of the courses and cultivate more

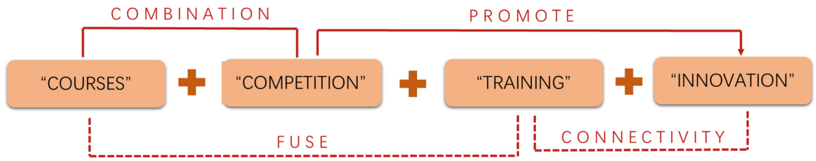

Fig. 4. The education mode

students with engineering thinking and practical ability by continuously integrating the professional experimental and practical skills involved in the competition into the experimental courses of professional education.

After years of exploration, it is found that "Course", "competition" and "training" trinity of education model, as shown in Fig. 4, which is based on "professional courses", led by "innovative discipline competition" and take "project practice training" as the way, is an effective method to cultivate and improve students' engineering innovation ability.

3.3 A Science and Technology Innovation Club with Self-circulating of and Spiraling Upward for Students

Many junior undergraduates have great enthusiasm and strong willingness to participate in disciplinary innovation activities. However, due to their lack of experience in scientific and technological innovation activities before university, there is a certain distance between them and teachers and their peers who have relevant experience, in terms of knowledge system, practical ability and way of thinking.

This dampens their enthusiasm and diminish its motivation to a great extent. Therefore, the traditional model can no longer support the current undergraduate science and technology innovation activities. There are three contradictions here. One is the contradiction between students' strong demand for scientific and technological innovation and the lack of guidance resources and the shortage of access. The second is the contradiction between the cross-integration of knowledge in different disciplines becoming the mainstream and the limitations of knowledge fields brought about by single teacher guidance. The third is the contradiction between the teacher's uniformization of student guidance within the team and the difference in the level of personal acceptance of students. The science and technology club came into being, which creatively constructed a new organizational model that can be self-circulating and step-up within the student collective. In the science and technology innovation club with students as the main body, senior students lead junior students, and students of different majors learn from each other, breaking the professional boundaries and realizing knowledge exchange and integration. The club is operated in digitalization and informatization as shown in Fig. 5.

The teacher leads students to build a sustainable development model, comprehensively promoting the integration of multi-dimensional, multi-angle and multi-faceted capabilities, such as in-depth professional knowledge, improvement of practical ability, transfer of focused ability, expansion of technical direction, improvement of organizational level and optimization of development structure. Through their own experience in the club, students understand their personal strengths in the process of independently

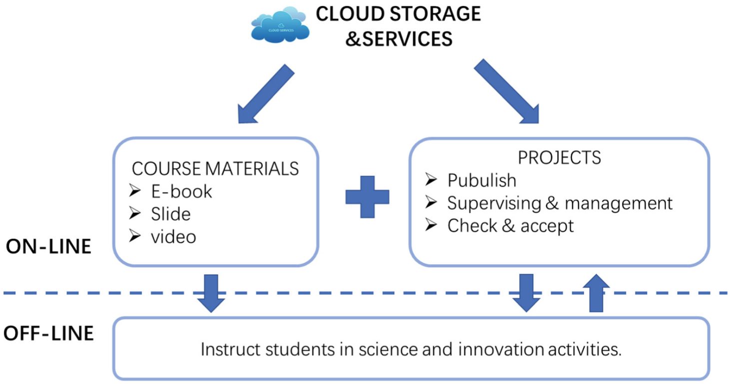

Fig. 5. Operation in Digitalization and informatization

establishing their interest in science and technology and its further development, elevate their interest to expertise, enhance curiosity to intrinsic driving force, expand patience into perseverance, and develop group cooperation and mutual help into a sense of responsibility, values, and the overall situation. Teachers in the club guide students with the principle of gradient and differentiation, resulting in the gradual formation of a pattern of teachers from top to bottom and students from bottom to top. After several years of development, the academic performance of club members in the classroom has been significantly improved, and at the same time, in various discipline competitions, scientific and technological innovation competitions, and scientific research projects, the achievement level and the scale of the number of people have increased year by year.

4 Conclusion

To meet the requirements of new engineering talents training, it is necessary to reform the traditional experimental teaching method and explore new practical teaching and talent training mode. The experimental form driven by practical engineering projects has narrowed the connection between curriculum, talent training and the engineering industry. The mode led by innovative discipline competitions has comprehensively improved the integration of students' knowledge system and engineering practice skills. The student-centered scientific and technological innovation club has provided a wealth of scientific and technological practice projects, breaking professional barriers, expanding the boundaries of students' knowledge and practical ability, and enhancing the diversity of talent training.

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