The "Four-in-One" Reform of Electrical Engineering Course Experiment Teaching

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ABSTRACT

A four in one teaching reform plan is proposed to address the problems of insufficient innovation in the content of electrical experimental courses, single methods for connecting theory and practice, and systematic lack of ideological and political education. The plan includes the combination of course competition, virtual and real integration, digital intelligence empowerment, and three-dimensional education. By constructing a layered and progressive curriculum system that integrates courses and competitions, integrating the interweaving of reality and virtuality with digital intelligence empowerment, and designing an ideological and political system with "four connections and integrated design", teaching practices have been carried out in five electrical majors, including communication engineering, effectively enhancing students' innovative practical abilities and teachers' teaching abilities.

Keywords: *Electrical experimental courses, Teaching reform, Four-in-one.*

1. INTRODUCTION

In recent years, the Ministry of Education has successively issued a series of documents, including the "Opinions of the Ministry of Education on Deepening Undergraduate Education Reform and Improving the Quality of Talent Cultivation" and the "Outline of the Plan for Building an Education Strong Country (2024-2035)", which put forward new requirements for the reform of experimental teaching and the cultivation of practical abilities in universities, emphasizing the strengthening of practical teaching links such as experimental internships, practical training, and graduation design, and particularly pointing out the promotion of experimental teaching resource construction and the application of virtual simulation experimental projects. From the guidance spirit of the Ministry of Education's series of policies on experimental teaching and practical education, it can be seen that experimental teaching in universities plays a crucial role in helping new productivity and improving the quality of scientific and technological talent cultivation. Experimental teaching plays a more prominent role in the curriculum system of higher education institutions and is a key link in cultivating high-quality professional and technological talents. Cultivating a solid engineering foundation, outstanding innovation ability, and strong sense of social responsibility are the national teaching quality standards for electronic information majors. The university also clearly states in the undergraduate education talent training program that talent training must meet the needs of professional and technical positions, achieve national teaching quality, and possess strong innovative and practical abilities.

In order to further enhance the quality of information and communication talent cultivation in our university, this article is aimed at the undergraduate education program of military officers, focusing on strengthening the cultivation of students' engineering practice ability and comprehensive quality. The core courses of electronic information majors, including "Analog Electronic Technology Foundation", "Digital Electronic Technology Foundation" and "Electronic Comprehensive Practice Course", are used as carriers to address the problems of insufficient innovation ability and single teaching methods in traditional experimental teaching. The article closely connects with real engineering application scenarios, reconstructs a project driven, virtual real integration, and layered delivery experimental content system; Integrating simulation and AI technology tools; Implement a training format for electronic technology courses that integrates classroom and offline activities, and is driven by internal and external competitions; Strengthen the cultivation of engineering practice and innovation ability, cultivate the belief and character of strengthening the military through science and technology and being rigorous and pragmatic, and build a teaching mode for electronic technology experimental courses that combines courses and competitions, integrates virtual and real, empowers with digital technology, and cultivates students in a three-dimensional way. The implementation of curriculum reform is not only a positive response to the call of the Ministry of Education for practical teaching, but also a vivid transformation of experimental teaching in electronic technology courses. It is a close combination of abstract theoretical knowledge and concrete experimental tasks, which can greatly enrich the connotation and extension of electronic technology courses and better support the teaching of professional basic courses in school.

2. PROBLEMS AND REFORM PLANS IN PRACTICAL TEACHING

2.1 Problems in Practical Teaching of Electronic Information Major

In recent years, the experimental teaching of electronic technology courses has undergone multiple reform practices. The course team has successively clarified the content of electronic technology practical teaching through provincial teaching reform projects such as "Research on CDIO Teaching Reform of Electronic Technology Courses", "Construction and Practice of Electronic Technology Comprehensive Practice Courses for Engineering Education Certification", "Research and Practice of Ideological and Political Teaching Reform of Electronic Technology Courses", and national defense education scientific planning projects. They have established a project led hierarchical construction idea, practiced the CDIO group training mode, deeply explored the ideological and political education elements contained in the courses, and formed an integrated electronic technology course teaching system. The relevant reforms have achieved certain results in strengthening the reserve of students' basic knowledge and skills, cultivating their practical abilities, and improving their comprehensive literacy. However, there are still the following problems:

Firstly, the advanced and innovative nature of experimental teaching content is still insufficient. Although the current experimental teaching content has been layered to meet the needs of students at different levels, the proportion of basic and confirmatory experimental content is still relatively large. The quantity and quality of comprehensive and advanced innovative experimental content are relatively lacking. The support for providing innovative training opportunities in practical teaching is insufficient, and the innovative ability of students has not been deeply explored and fully exercised. The integration of high-level academic or engineering problems is not deep enough, which affects the comprehensive ability cultivation of students and restricts the expansion of their academic horizons.

The second is that the methods and means of connecting theoretical knowledge and practical ability are relatively simple. In the teaching of electronic technology courses, hands-on experimental operations are the "lever" for solving the transition between knowledge and ability. However, it has been observed from the actual learning process of students that there is often a "gap" between theoretical knowledge and experimental operations. The phenomenon of "not mastering" and "difficult to understand" in theoretical learning often occurs. In the experimental stage, theoretical knowledge cannot be effectively used to solve practical problems. Difficulties such as "relying on intuition" and "not knowing how to use" often exist in experimental operations. The conversion link between theoretical knowledge and practical ability is not smooth enough, mainly due to the lack of flexible teaching forms, the lack of comprehensive and multi angle help for students to understand and master, and relatively single teaching methods and means.

The third issue is the insufficient systematic design of quality enhancement and ideological and political education in practical teaching. Actively participating in practical activities is an important link for students to transform from theoretical thinking patterns to engineering application thinking. Experimental teaching is the main way for students to carry out practical activities. By integrating ideological and political education into experimental teaching, strengthening the cultivation of engineering thinking, engineering ethics, and other aspects, it has a positive effect on improving students' ideological and political literacy, scientific thinking, comprehensive abilities, etc. In the teaching process, the integration of ideological and political implementation points is scattered and disorderly, and the coupling between various elements is insufficient. A clear and definite chain of ideological and political education personnel has not been formed, and the collaborative effect of ideological and political education in curriculum teaching is not fully demonstrated.

2.2 *Reform Plan for Solving Practical Teaching Problems*

In response to the educational philosophy of "student development as the center" and the fundamental requirements of "outcome oriented (OBE)" education and "curriculum ideological and political education", based on the training characteristics of "strong foundation, emphasis on practice, and promotion of innovation" in electronic information majors, focusing on the educational goals of "knowledge imparting, ability cultivation, and value shaping", a systematic reform of "system reconstruction method innovation technology empowerment ideological and political integration" is carried out. The specific plan is shown in “Figure 1”.

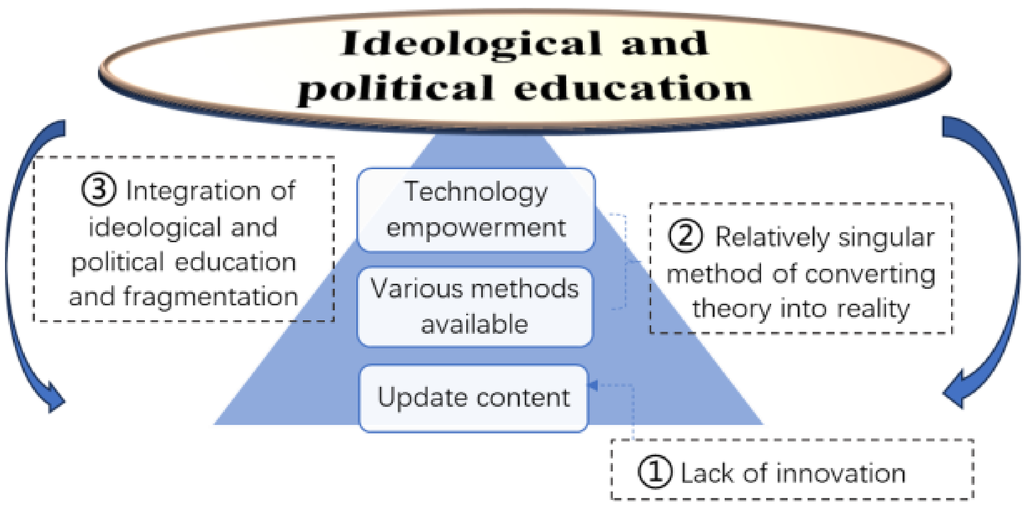

Figure 1 Reform plan for practical teaching of electrical courses.

Mainly from the four dimensions of teaching content, teaching organization methods, teaching process technical support, and process education penetration, we aim to solve the pain points of "insufficient innovation, single theoretical and practical transformation, and fragmented ideological and political infiltration" in our school's electrical practical courses, and construct a new practical teaching mode of "ability advancement has a path, technology empowerment has a grasp, and value guidance has a warmth", cultivating high-quality electronic information technology talents with engineering practice ability, innovative thinking, and patriotism.

3. SPECIFIC MEASURES FOR IMPLEMENTING REFORMS

3.1 *Refactoring the Teaching System*

To solve the problem of insufficient high-level and innovative practical content, taking "solid foundation comprehensive application innovative breakthrough" as the main line of ability development, a progressive teaching content framework of "basic experiment → comprehensive design experiment → exploratory research experiment" is designed. The practical content corresponding to the knowledge point level in the basic experiment stage is completed using pocket laboratory and virtual instruments to master the use of basic components and circuit analysis amplification; In the stage of comprehensive design experiments, corresponding to the implementation of small comprehensive functional circuits, the main task is to complete the neutralization design of the circuit, exercise the students, and guide them to apply their knowledge and skills to achieve certain functions in comprehensive experiments; The innovative experimental stage of research is based on practical military application requirements, designing innovative and challenging complex electronic systems that involve specific engineering problem analysis and processing, cultivating students' practical innovation ability to actively explore and independently practice to solve complex engineering problems. The specific content is as follows:

3.1.1 Basic Experimental Layer

Integrating experimental projects based on the classic original knowledge points that must be mastered in the course (such as basic device usage, basic amplifier circuit principle verification, differential amplification experiment, linear region application of operational amplifiers, power amplification experiment, DC voltage regulator experiment, combinational logic sequential logic circuit) as the carrier, strengthening the basic connection between theory and practice.

3.1.2 Comprehensive Design Layer

Through "course comprehensive experiments + pre-competition training" (such as the National College Student Electronic Design Competition, Robot Competition, Embedded System Competition, etc.), the competition questions are disassembled into relatively independent functional circuits and designed into experimental projects, further promoting the transformation of knowledge and basic skills into engineering applications.

3.1.3 Exploring Research Innovation Layer

Driven by "competition projects + real military background needs", conducting exploratory synthesis Experiments, such as the development of intelligent battlefield drug delivery vehicles and military mixed signal wireless communication systems, aim to achieve a leap from "verification" to "creative" practice.

3.2 Integration of Course Competition and Teaching System

To promote the implementation of progressive practical content, a combination of "in class, in class, off campus, and on campus" training methods will be adopted, and skill competitions and subject competitions at different levels will be held at different stages to stimulate students' interest in combining theory with practice and innovation. The basic training layer includes internal communication electronic circuit competitions and club production competitions; The comprehensive design team mainly participates in school level electronic design competitions, provincial electronic design competitions, the "Dream Cup" hardware design competition of the Ministry of Electronics, and innovation and entrepreneurship competitions; The exploration innovation layer mainly participates in high-level innovation competitions such as the National Electronic Design Competition, Challenge Cup, and Datang Cup. At the same time, teachers are encouraged to participate extensively in military civilian competitions and exchanges, keep up with the forefront of technology, accelerate the innovation and construction of curriculum experimental teaching, promote continuous optimization of curriculum, and through the two-way integration of "curriculum competition", the curriculum reserves the ability for competition, and competition feeds back the updating of curriculum content, forming a virtuous cycle of "learning preparation and competition ability, competition learning mutual promotion, curriculum construction progress, and competition education integration", ultimately achieving comprehensive improvement in teaching quality. The teaching system combining progressive content and competition is shown in “Figure 2”.

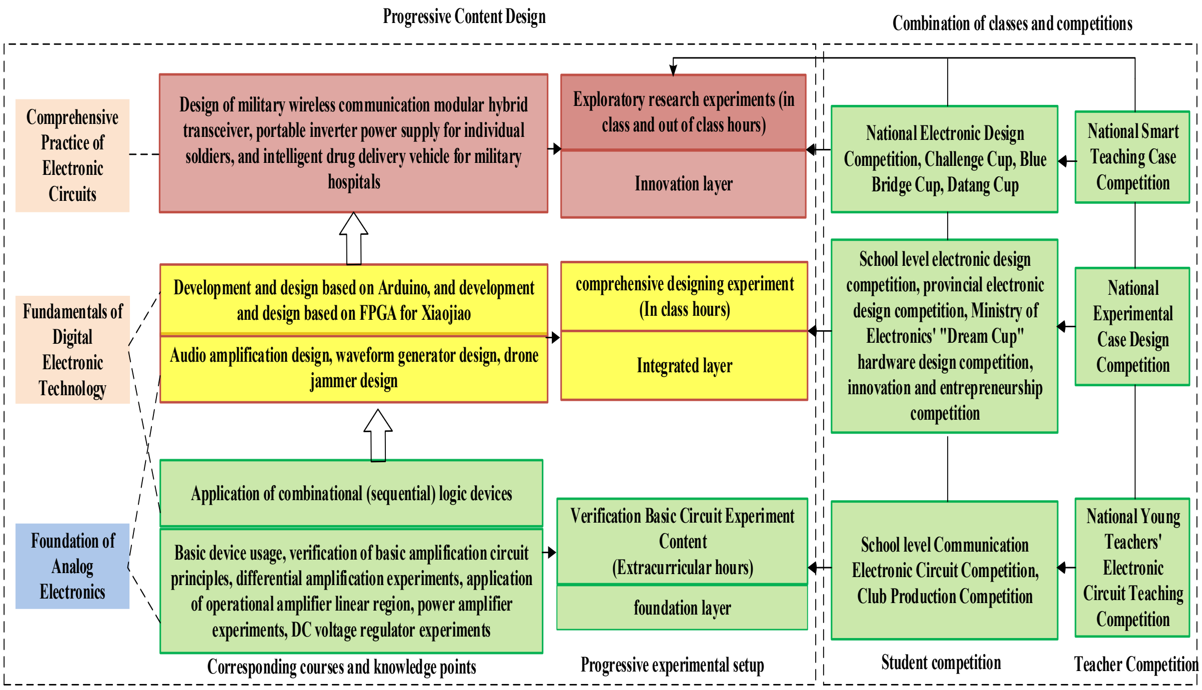

Figure 2 Teaching system with progressive content and combination of course and competition.

3.3 *Innovation of Methods and Means*

The implementation process of the experimental content follows the basic process of engineering implementation, organized in six steps: knowledge reserve, task analysis, plan formulation, task implementation, inspection and evaluation, and retrospective analysis. In experimental teaching, virtual simulation technology is integrated with physical hardware platforms, and digital and intelligent tools are used to enhance teaching effectiveness. Students use virtual simulation software such as Multisim and Proteus to visualize their knowledge of electronic technology principles, turning abstract "not learned" into concrete "understandable"; By using simulation results to understand the actual circuit construction and debugging, timely attention can be paid to experimental prompts through digital human guidance, online scanning, and other forms, eliminating the habit of "feeling based" operation, and achieving the "ability to design" and "applicability" of circuit functions. During the teaching process, encourage and guide students to use a wide range of information and intelligent methods, utilizing AI models (Deepseek, Kimi, Coze, etc.) and various digital tools (Mermaind, Figma, Canva, etc.) to assist in innovative experimental projects and subject competitions, helping the college to "dare to do" and "innovate", and providing comprehensive and three-dimensional support for students' ability advancement process. The innovative design of the fusion of reality and virtuality, and the empowerment of digital intelligence, is shown in “Figure 3”.

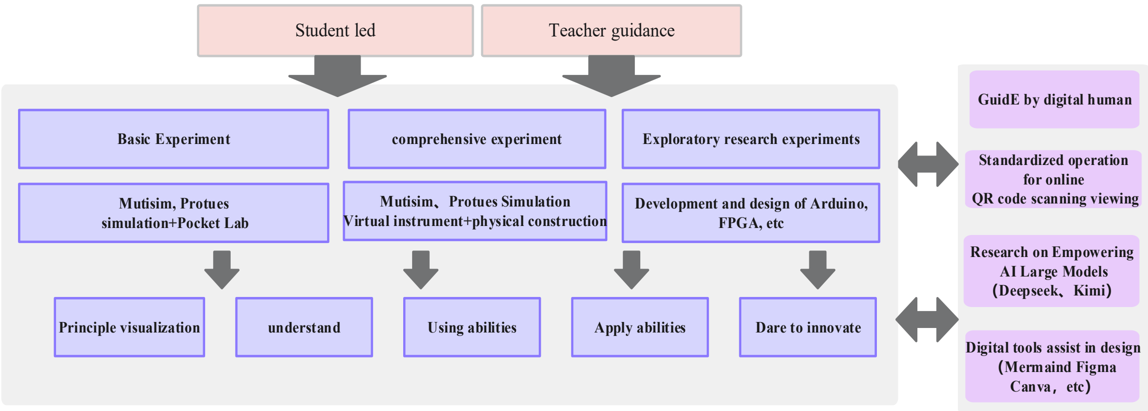

Figure 3 Methods and means of combining reality and virtuality, and empowering digital intelligence.

3.4 Integrated Ideological and Political Design

It is necessary to build a curriculum ideological and political education system with four-way connections and integrated design to enhance the quality and efficiency of education. With the goal of improving students' ability to correctly recognize, analyze, and solve problems, a teaching activity design corresponding to the "six steps" of experimental teaching is proposed.

At the same time, combined with the project implementation characteristics of electrical engineering background, the "four connections" ideological and political elements of "communication connectivity proficiency flexibility" are integrated throughout, strengthening students' engineering literacy education in six aspects such as "attitude", "standardization", "criticism", "innovation", "humility", and "diligence", as shown in “Figure 4”, to stimulate students' patriotism and mission of serving the country with science and technology.

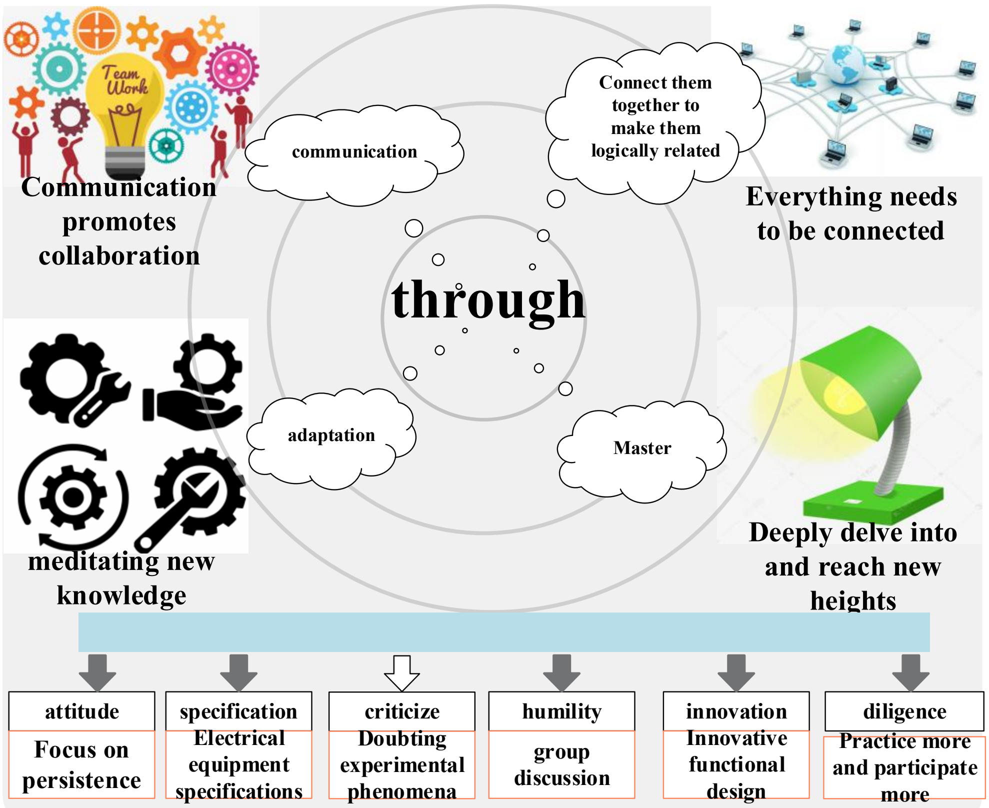

Figure 4 The ideological and political system with four-way connections and integrated design.

4. CONSTRUCTION EFFECTIVENESS

4.1 *For Students*

In terms of ability improvement, the practical learning of students in electrical basic courses has achieved a positive transformation from the anxious state of "abstract and difficult to understand" to "immersive exploration". The reform effectively promotes the step-by-step advancement of students' abilities through the deep integration of the "basic comprehensive innovation" hierarchical content system and digital intelligence tools. In terms of learning experience, the virtual simulation platform supports students to repeatedly rehearse real experimental scenes before class, completely eliminating the inefficient link of "relying on experience operation and repeated trial and error" in physical experiments, and significantly reducing the "anxiety and confusion" during hands-on learning. At the same time, various intelligent technologies accurately meet the personalized learning needs of students, further stimulating their interest in exploring experimental phenomena, and promoting the transformation of students' learning motivation and behavior patterns from "passive listening and operation" to "active thinking and exploration". Students are more willing to participate in innovative activities to confirm and promote their exploration in unknown fields. In the past two years, the enthusiasm of students to participate in various innovation and entrepreneurship competitions has increased by 60%. The registration and participation of students in the "Insulated Electronics Club" supported by the teaching team have increased significantly. Students have won provincial first prizes, national second and third prizes, and other awards in innovation and entrepreneurship competitions such as the National College Student Electronic Design Competition, Dream Cup, and Datang Cup. In terms of comprehensive literacy, the systematic curriculum design and implementation of ideological and political education based on the "four connections" element promotes the organic integration of electrical basic course education and value shaping, helping students to advance from "knowledge receivers" to "technology application-oriented" and gradually grow into "responsible persons".

4.2 *Regarding Teachers*

After the implementation of teaching reform, students' learning initiative has significantly increased, and they have shown a more urgent interest in exploring new technologies. This change has forced teachers to deepen research and knowledge mining in their professional fields; At the same time, the widespread application of intelligent tools is driving a transformation in the role of teachers - from traditional "knowledge transmitters" to "learning guides" for students, with profound upgrades in teaching philosophy and methods, and significant improvements in professional competence and teaching level. In addition, in the past three years, team members have achieved excellent results in various teaching competitions and experimental case design competitions, winning a total of 3 national first prizes, 2 national second/third prizes each, and 2 regional first prizes. The team deeply integrated the competition results into teaching reform practice and developed two characteristic experimental textbooks empowered by digital and intelligent technology.

5. CONCLUSION

The reformed electrical experimental courses are more deeply aligned with job requirements and the growth patterns of students: students demonstrate stronger problem-solving and engineering practice thinking abilities in design and innovative experiments. Through the full process practice of "learning, thinking, understanding, doing, and using", the sense of responsibility for technological self-reliance is deeply cultivated; Through the reconstruction of course content, development of teaching methods, and integration of ideological and political elements, teachers have achieved a role transition from "knowledge transmitters" to "growth guides", and their teaching abilities have been systematically upgraded in sync with educational concepts. The research value of this article lies not only in providing a replicable reform paradigm for electrical experimental courses, but also in making substantive explorations on the feasibility and effectiveness of "empowering curriculum construction with digital technology". In the future, we will continue to track the trend of technological evolution, deepen the expansion and innovation of experimental teaching scenarios for "digital intelligence empowerment", improve the long-term mechanism of "virtual real mutual promotion and digital intelligence collaboration", provide more universal experience and reference for the reform and construction of similar engineering courses, and help higher education achieve high-quality development of talent cultivation in the new journey.

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