Exploration and Practice of Sustainable Development in "Innovation Training" for STEM University Students: a Case Study of the Electronics and Information Engineering Major

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Abstract. To establish a comprehensive sustainable development model for the "innovation training" that is suitable for STEM university students, this article explores how our university's Electronics and Information Engineering program, through top-level design and the cultivation of innovative concepts, integrates various measures such as classroom teaching, experimental practice, industry demand, guidance from research mentors, and competition-driven learning. This approach has gradually formed a new reform and practice of the "One Two Three Four" innovative training teaching system, based on "four methods" and "three combinations." The research results provide new ideas for the reform of STEM education and contribute to the cultivation of high-quality talents with innovative spirit and practical ability.

Keywords: Innovation training, innovative ability, research mentor, electronics information.

1 Introduction

In today's rapidly developing technological era, innovation capability has become an important hallmark of high-quality STEM talent. In the face of increasing global competition and technological advancement challenges, innovation training for STEM university students is particularly important. Traditional teaching models often focus on the transmission of theoretical knowledge, paying insufficient attention to the cultivation of students' practical abilities and innovative thinking, leading to a lack of effective solutions when students encounter complex real-world problems. Therefore, exploring sustainable development paths for innovation training among STEM university students has become a significant topic in educational reform.

To establish a sound sustainable development model for "innovation training" in the field of electronics and information engineering[1-2], our university has vigorously reformed innovation training methods in recent years. We are committed to adopting var-

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ious training models and layered training methods, emphasizing the systematic cultivation of students' innovative spirit and practical abilities, and optimizing the talent training model. Gradually, we have formed a "One Two Three Four" innovative training teaching system, which aims to enhance students' innovation awareness and capabilities.

2 Specific Content of Our University's "Innovation Training" Teaching System Construction

Constructing an innovative training system is fundamental to ensuring the sustainable development of "innovation training." Through years of practice and exploration, our Electronics and Information Engineering program has taken "four methods" and "three combinations" as concrete focuses and starting points, under the support of "two pillars." All work revolves around "one goal," gradually forming a distinctive "One Two Three Four" innovative training teaching system, as illustrated in Figure 1.

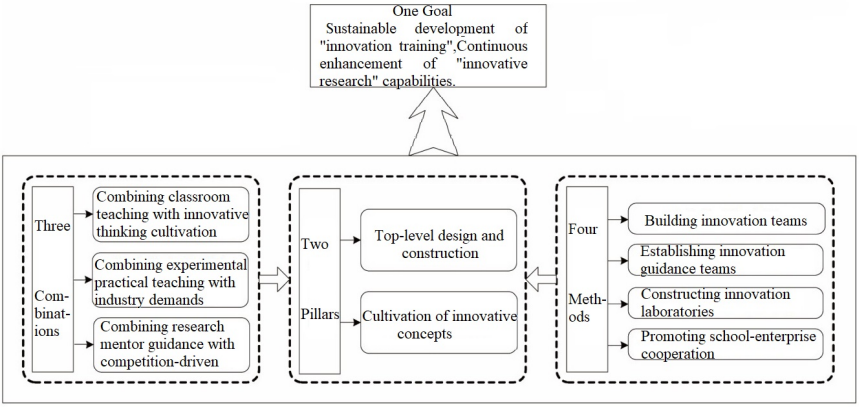

Fig. 1. Structure of the "One Two Three Four" innovative training teaching system.

2.1 One Goal

"One goal" refers to the core objective of cultivating students' "basic operational skills, integrated engineering design capabilities, and innovative research abilities" as the foundation, with all work implemented around the sustainable development of "innovation training" and the continuous enhancement of "innovative research" capability.

2.2 Two Pillars

The first pillar is top-level design. The sustainable development of "innovation training" relies on leadership attention and strong support. In recent years, school leaders have particularly focused on cultivating digital and information-oriented innovative talents, issuing a series of documents from the institutional level to support this. For instance, the "Qualification Review Conditions for Professional Technical Positions of

Teachers at Hubei University Zhixing College" and the "Interim Measures for Public Service Work Management of Teachers at Hubei University Zhixing College" have been established to inspire teachers to seriously participate in and guide students in various innovative activities or competitions. Moreover, the school has issued various regulations for cultivating innovative talents, such as the "Management Measures for Academic Degree of Ordinary Undergraduates at Hubei University Zhixing College," which stipulates that all students must earn 5 innovation (entrepreneurship) credits to graduate. In addition, the recently issued "Digital Education Action Plan of Hubei University Zhixing College" provides detailed responsibilities, main tasks, and construction content for accelerating the digital transformation of education.

The second pillar is the cultivation of innovative concepts. As President Xi pointed out: "Concepts are the forerunners of action; all development practices are guided by certain developmental concepts." Under the guidance of the aforementioned regulations and documents, our Electronics and Information Engineering program prioritizes innovating talent cultivation as its primary task and actively fosters students' innovative thinking and concepts. For example, an "Innovation Space" lab for the electronics information major meets the basic hardware requirements for collective training, project development, group discussions, and, additionally, has set up displays for past excellent student works to motivate innovative awareness. Since 2022, our university has organized the "Hubei University Zhixing College Student Electronics Design Competition" annually, attracting over 30 teams to participate in the preliminary round each year. In the 2024 competition, the team organized by the College of Arts achieved excellent results in the finals, and the university's "Electronics Association" has become one of the top three student organizations in terms of membership.

2.3 Three Combinations

First, combining classroom teaching with innovative thinking cultivation. In the construction and reform of the curriculum, teaching content is adjusted and enriched according to professional development needs. New teaching methods are explored continuously based on students' practical situations, and teaching methods are improved according to the characteristics of specific courses to enhance students' learning enthusiasm. In daily teaching, we fully utilize flipped classrooms, seminar-style learning, and problem-oriented teaching methods, rationally applying platforms like Rain Classroom, MOOCs[3], and Cloud Classroom to continually optimize teaching methods and cultivate students' innovative thinking. Additionally, special attention is placed on guiding innovative thinking. For example, in the "Circuit Analysis" course, for specific content in Chapter 2, the equivalent resistance of a circuit is explained through one question with three solutions for topics like series, parallel, mixed circuits, and bridge balance, as well as Y–Δ equivalent transformations, thus encompassing all knowledge points of the chapter to inspire students' innovative thinking[4].

Second, combining experimental practical teaching with industry demands. In the teaching process, we emphasize aligning teaching content with industry needs. For example, during the "Electronic Circuit Design Experiment" practical class, we have

noted that students' foundational knowledge is relatively weak, absent of strong innovation awareness; prior knowledge is systematic but lacks practical applications; and the reference textbook knowledge is complex yet unsystematic. We therefore reformed the original teaching plan of having students solder 3-4 physical items per semester, such as radios, LED banners, adjustable DC power supplies, and minimum systems for microcontrollers, to larger-scale reforms involving contents such as "Circuit and PCB design, soldering and development practice based on STM32F103C8T6 microcontroller for capacitive touch key and PC communication[5]," "Experiment circuit boards based on microcontrollers," and "Design of signal generator based on single chip microcomputer[6]," etc. Students are tasked with researching design requirements and performance parameters, collecting and analyzing similar circuit performance, eventually leading to a process that includes design, soldering, and debugging, ensuring that electronic products meet the performance indicators stated in their tasks. Through this process, students have not only gained systematic knowledge but also have gradually mastered general project development procedures.

Third, combining research mentor guidance with competition-driven learning. We emphasize learning through competition, encouraging students to participate in various skills competitions such as the "National College Student Electronics Design Competition," the "National College Student Internet of Things Innovation Application Design Competition," and the "National College Student Mathematical Modeling Competition." In competitions, an undergraduate research mentor system is established to guide students in formulating competition training and research plans tailored to their actual situations. Students learn the processes for equipment applications, experimental methods, data analysis, paper writing, and patent applications through mentorship. Additionally, during the summer vacation, intensive training is specifically arranged for the "National College Student Electronics Design Competition (Hubei Division TI Cup)," with daily guidance from 3-5 teachers and invited corporate engineers to enhance students' research capabilities. By participating in these competitions, students not only apply their learned knowledge practically but also receive indirect assessments of their teaching reform achievements through competition outcomes and accolades.

2.4 Four Methods

First, innovation team building. Establish sustainable research teams so that limited research projects can nurture more students' innovative capabilities while leveraging team dynamics. High-year students can guide low-year students, thus realizing a process in developing innovation capabilities from "entry-level—improvement—competition—research," achieving sustainable development. Following this approach, our university's Electronics and Information Engineering program established the "Electronics Association," utilizing its professional and promotional advantages to focus on team building, yielding considerable results. For instance, in the 2023 "Hubei University Zhixing College Electronics Design Competition," a joint project called "Smart Digital Clock" was developed by students from Electronics Information and Mechanical Engineering, where mechanical students utilized 3D printing technology for design and production, while electronics students implemented the digital functionalities,

achieving a notable ranking. In another program, the application for the "Hubei University Zhixing College College Student Innovation and Entrepreneurship Training Project" in 2024 was submitted by teams consisting of students from different grades and majors.

Second, innovation guiding team building. Establish incentive and constraint mechanisms to enhance faculty engagement and initiative in guiding students' scientific research teams. Accordingly, the university has integrated the achievements of guiding teachers into regular professional evaluations. The "Qualification Review Conditions for Professional Technical Positions of Teachers at Hubei University Zhixing College" stipulates that teachers' guidance leading to various student awards will be included in the evaluation criteria, adding points accordingly. Simultaneously, the university has instituted a public service workload accounting system to quantify faculty participation in competitions, research projects, and paper awards as part of their service workload. These mechanisms incentivize and motivate faculty to be more actively involved.

Third, innovation laboratory construction[7-8]. Ensure that students participating in "innovation training" have ample access to training venues and equipment outside of class hours, necessitating an expansion of extracurricular innovation activity venues, construction of innovation laboratories, and innovation spaces. This creates a three-in-one system for foundational training, professional innovation training, and an innovation space. Through daily teaching, we have found that the laboratories for our electronics information major, including lab courses and course designs, effectively fulfill fundamental training needs. However, due to weak bases for innovation space construction, meeting excess student demands remains a challenge. To resolve this issue, prior to the summer of 2024, the college allocated two experimental rooms to build an "Electronics Information College Innovation Space." One will be equipped with fundamental experimental tools and necessary instruments, available to students around the clock, offering a "shared space" for students with innovative aspirations. The other will undergo professional modifications to meet students' collective training and project development hardware demands, which will play an essential role in the "2024 National College Student Electronics Design Competition Training."

Fourth, school-enterprise cooperation[9-10]. "School-enterprise cooperation and collaborative education" are essential for cultivating engineering talents, following principles of mutual advantages, shared resources, win-win relationships, and joint development. Such strategies help promote the integration of educational priorities, talent guidance, industrial innovation, and sustainable economic growth. To enhance school-enterprise collaboration and industry-education integration, our Electronics and Information Engineering program has successfully established two additional training bases in partnership with enterprises, joining the existing five practice bases established by mid-2023. During the 2024 summer internship of students, these new bases will be put into use. Furthermore, the college invites senior engineers from enterprises to provide specialized courses, allowing students to gain practical insights and industry knowledge, thereby enhancing their innovative capabilities and vocational skills.

3 Effectiveness of Our University's "Innovation Training" Teaching System Construction

Since the establishment of the "innovation training" teaching system, our university has deeply constructed and reformed the course system for the electronics information major, intending to provide robust support for the knowledge structure and level of innovative talent training. Through cooperation with enterprises and integrating education with industry, our university has established multiple internship bases relevant to electronics and information, enabling students to effectively combine their professional knowledge with real-world work during their university years, thus enhancing practical capabilities. Additionally, the university actively guides students to participate in various academic competitions, encouraging them to showcase their professional skills and innovative capabilities. Students have achieved excellent results in these competitions, not only enhancing their personal abilities but also elevating the university's reputation. Over time, the university's accomplishments in innovative talent cultivation and discipline building have begun to show results, laying a solid foundation for future development.

In the past three years, electronics and information students participating in the "National College Student Electronics Design Competition (Hubei Division TI Cup)" achieved 2 provincial first prizes, 4 second prizes, and 9 third prizes. In the "Seventh Hubei Province College Student Physics Experiment Innovative Design Competition," students received 1 provincial first prize, 2 second prizes, and 1 third prize. Additionally, regarding the "National College Student Innovation and Entrepreneurship Training Project," one national-level project and four provincial-level projects were approved, alongside eight university-level projects.

4 Conclusion

The sustainable development of "innovation training" is not only a crucial means to enhance students' comprehensive qualities but also a key driving force for advancing technological progress and social development. Through our exploration and practice in this round of educational reform, we have profoundly realized that innovation training is a systematic process closely linked with every detail of the teaching work. We must tightly integrate and perfectly align these components to create a healthy ecosystem that promotes proactive learning and enhances students' innovative abilities.

In the context of educational digitization, future developments will focus more on personalized and intelligent learning. Under the framework of the "One Two Three Four" innovative training teaching system, how to incorporate digital and intelligent elements into the sustainable development of "innovation training" will be a topic worth exploring further. We also hope to provide new ideas for the reform of STEM education, drive innovation in educational and teaching models, and cultivate more high-quality talents with innovative spirits and practical abilities, contributing to the sustainable development of society.

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