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Construction of a Diverse and Collaborative Curriculum Cluster in the Field of Electronic Information for Emerging Engineering

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Abstract: *The development of the new economy and emerging industries presents new challenges for the cultivation of talent in the field of electronic information. The Emerging Engineering Education is a significant strategic choice for engineering education reform in our country. Universities should align themselves with their own development positioning and expedite the reform of traditional engineering education models. This article analyzes the new requirements for cultivating electronic information talents under the Emerging Engineering paradigm and elucidates the significance of constructing characteristic curriculum clusters in the field of electronic information. Henan University of Science and Technology has identified its own distinctive advantages and integrated them with the development of the local information industry. As part of this effort, they have established a specialized research and teaching team in electronic information engineering and constructed a diverse and collaborative curriculum cluster. The goal is to cultivate high-end electronic information engineering talents with outstanding interdisciplinary integration capabilities and practical innovation skills.*

Keywords: *Emerging Engineering Education; Multivariate Collaboration; Electronic Information Specialty Group; System building*

1. Introduction

In the new era, a new round of scientific and technological revolution and industrial transformation, led by information technology, is sweeping across the globe. With the implementation of major strategies in China such as "Belt and Road Initiative," "Made in China 2025," "Artificial Intelligence," and "Internet+," core technologies like mobile communications, the Internet of Things (IoT), big data, artificial intelligence, and large-scale integrated circuits have been developing rapidly. Representative industries of the new economy, new business models, and new technologies, such as autonomous driving, smart cities, cloud computing, intelligent manufacturing, and robotics, have emerged [1]. The historical transformation of the electronic information industry urgently requires diversified and innovative engineering talents to support the country's innovation and development strategies.

The Emerging Engineering Paradigm, based on new technologies, new industries, and the new economy, is a significant strategic choice for engineering education reform in China. It represents a new way of thinking and a new approach for the future development of engineering education in our country [2]. Under the goal of constructing Emerging Engineering and achieving "Double First-Class" status, Henan University of Science and Technology's electronic information programs rely on the school's traditional disciplinary advantages and reform traditional research and teaching plans. They explore innovative talent cultivation models for electronic information programs, aiming to broaden students' research horizons, enhance the breadth of disciplinary knowledge, deepen practical innovation, and nurture a group of interdisciplinary and compound engineering talents with innovative and entrepreneurial spirits.

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2. New Challenges in Cultivating Electronic Information Talents under the Emerging Engineering Education

The cultivation of electronic information talents is highly aligned with the direction of industry transformation and the future development trends in the technology sector, as the increasingly complex engineering scenarios are deeply integrated into the engineering education process [3]. The Emerging Engineering Paradigm is characterized by new ideas, new models, new methods, new content, and new quality. Universities can meet the basic requirements of Emerging Engineering construction and educational reform by establishing Emerging Engineering programs or transforming existing ones [4]. The construction of Emerging Engineering goes beyond merely reforming the existing traditional engineering education methods; it is more importantly about the collision and integration of interdisciplinary knowledge, breaking through disciplinary barriers, and constructing a diverse and interdisciplinary training system [5,6]. This poses many new challenges for the cultivation of electronic information talents.

2.1 Broad and Cross-disciplinary Knowledge

Educational reforms under the backdrop of the Emerging Engineering Paradigm play a leading role in the cultivation of talent in the field of electronic information. Electronic information programs need to nurture engineering and technical professionals for emerging information industries such as integrated networks, microelectronics technology, intelligent control, and digital twins. Electronic information is a multidisciplinary field that involves modern electronics technology, communication engineering, coding theory, control engineering, computer science, and other engineering disciplines. It covers various engineering domains, demanding students to master knowledge in mathematics, foreign languages, circuits, microelectronics, electromagnetic fields, communication, coding, control, and programming, among others [7,8]. Talents in this field should possess a broad and interdisciplinary knowledge base to meet the development demands of the new economy and new business models driven by information technology in the new era.

2.2 Outstanding Cross-Boundary Integration Ability

The "New" in the Emerging Engineering Paradigm is reflected in its typical characteristics of interdisciplinary, cross-domain, and cross-industry integration [9]. In the context of the new economy, driven by information technology, industrial transformation is sweeping across the globe. The barriers between traditional disciplines are gradually dissolving, and engineering barriers across different fields are being broken. Economic, scientific, technological, and engineering education development is entering a new era of cross-disciplinary integration. Smart healthcare, autonomous driving, intelligent manufacturing, "Internet+," and the sharing economy all rely on the technological support of multiple disciplines such as big data, artificial intelligence, mobile communications, and automatic control. The electronic information industry has become a new driving force for the secondary leap of many traditional industries [10]. This calls for talents with strong cross-disciplinary integration capabilities, who can build new thinking, generate new momentum, and develop new technologies through the collision and integration of knowledge from multiple fields.

2.3 Broad Technological Frontier Vision

The development of the new economy is based on the information technology revolution and institutional innovation, and electronic information engineering is at the core of driving this new economy forward. The future development of electronic information technology will focus on quantumization, intelligence, miniaturization, and integration [11]. Quantum technology will become a significant carrier for specific data computation and information transmission. New concepts like neuromorphic computing will gradually become practical, and the integration of the virtual and physical worlds will continuously expand the boundaries of human information dissemination. Wafer-level integration technology will continue to drive innovations in the field of integrated circuits [12].

The rapidly evolving electronic information technology demands that relevant talents have a broad perspective on technological frontiers. They should possess the ability to cope with rapid technological innovations in the future, construct their own technical research roadmap from a developmental perspective, use new technologies to address future challenges, and promote the advancement of advanced electronic information technologies.

2.4 Strong Engineering Innovation Capability

Compared to traditional engineering disciplines, the Emerging Engineering Paradigm emphasizes practicality and innovation. As pointed out by Li Peigen [13], innovation in engineering and technology must ultimately be connected to real-world demands. Innovations that arise from supplying and creating demand are often the most significant ones. Universities need to contemplate effective ways to enhance students' engineering innovation and entrepreneurial capabilities and achieve practical outcomes [14]. It is essential to focus on cultivating talents who are application-oriented, innovative, and versatile in engineering and technology. These talents should be capable of using knowledge and skills from different disciplines creatively to address development challenges in the era of information technology in traditional industries. By doing so, they can contribute to the sustainable development of future professions.

3. The Significance of Constructing an Electronic Information Curriculum Cluster under the Emerging Engineering Paradigm

In the context of the Emerging Engineering Paradigm, the field of electronic information places greater emphasis on the integration of multiple technologies, disciplines, and domains. Li Peigen [15] suggests that the "Emerging Engineering" should help students develop interdisciplinary awareness, establish connections between professional nodes or information sources, and cultivate the habit of observing and thinking about problems in multidisciplinary spaces. Professional clusters possess dual characteristics of disciplinary and industrial relevance, making them an important carrier for the construction of Emerging Engineering [16]. Through the integration of related research platforms, sharing of advantageous educational resources, and optimization of disciplinary settings, professional clusters can effectively promote interdisciplinary integration, nurture students' "spatial awareness" and "associative ability," and enhance students' innovative capabilities.

3.1 Resource Integration Facilitating Disciplinary Exchange

Specialized educational resources are crucial for constructing the electronic information curriculum cluster, and the Information Engineering College at Henan University of Science and Technology has integrated the educational resources and platforms of four disciplines: Control Engineering, Communication Engineering, Computer Science and Technology, and Software Engineering. This integration provides students with more flexible course options, innovative interdisciplinary practices, and broader perspectives on cutting-edge research. It helps students gradually break through disciplinary barriers, encouraging them to explore beyond the confines of their own discipline and develop a unique and comprehensive thinking method. By creating a platform where different disciplines' knowledge and ideas collide, it facilitates the generation of new ideas, practices, and research.

Moreover, the construction of the electronic information curriculum cluster optimizes the utilization efficiency of the limited educational resources in the college. As some foundational courses in different majors may have similar content, the integration of relevant courses and practical platforms through the electronic information curriculum cluster allows for the extension of unique technical directions and challenging points within each discipline, all while using the foundation of large laboratories and platforms. This enables students to connect and comprehend the differences and connections between disciplines in a more vivid and profound way, guiding them to continually contemplate the development direction of their knowledge and skills in the context of the Emerging Engineering Paradigm.

In the aspect of course teaching, the electronic information curriculum cluster integrates relevant foundational courses from provincial and national first-class majors, such as electronic information, control science and engineering, and computer science and technology. C language programming is a procedural programming language that combines the characteristics of high-level and assembly languages. It has the advantages of rich data types, direct memory manipulation, high flexibility, and ease of modularization. Before the integration, each major offered this course with slightly different course requirements and teaching emphases, but there were some overlapping parts in the basic knowledge experiments.

After the integration, the basic part of the course is uniformly taught in large lecture halls, and the management of students' basic experiments is standardized. After completing the basic part of the course, each major's instructor extends it to the unique aspects of their own discipline. For example, computer science and technology pay more attention to algorithm implementation and innovation, while also cultivating students' ability to collaboratively develop large-scale applications such as data management systems and games. Control engineering emphasizes real-time system performance and user-friendliness, while communication engineering focuses on algorithm efficiency and accuracy, often used in the field of digital signal processing.

In terms of practical platforms, Henan Province has established 16 key laboratories and engineering centers at the provincial and ministerial levels, including the Henan International Joint Laboratory for Cybersecurity Applications, the Henan Cloud Computing and Information Service Engineering Technology Research Center, and the Henan Engineering Laboratory for Mobile IoT and Big Data. These centers have constructed multidisciplinary integrated practical teaching platforms and innovation practice centers, avoiding redundant construction of similar laboratories across different disciplines. For instance, before integration, both communication engineering and computer science and technology had embedded systems laboratories with slightly different teaching focuses. After integration, the level of the embedded systems laboratory was enhanced, and the content of practical teaching was enriched, leading to improved efficiency in utilizing laboratory resources and facilitating the flow of knowledge between different disciplines. With the assistance of these large practical platforms, students can easily access the distinctive content of other disciplines, which fosters the collision of new technological sparks.For example, integrating machine learning into the development of embedded devices enables electronic devices to possess not only simple signal-triggered actions but also logical judgment capabilities. This allows them to perform comprehensive tasks in complex and dynamic scenarios.

In terms of research and communication, collaborative efforts with technology companies and research institutes such as 360 Group, 612 Institute, and 613 Institute have been established to set up industry practice platforms and research innovation bases. This collaboration aims to promote the implementation of creative ideas, create robust technological entities, and nurture practical engineering talents who are daring to innovate and willing to put their ideas into practice. Additionally, the introduction of international educational resources from institutions like Tomsk Polytechnic University and University of Wollongong helps in building a platform for student international exchanges, enhancing students' international perspectives and capabilities for external communications.

3.2 Disciplinary Integration Promoting Technological Innovation

The establishment of the electronic information curriculum cluster can facilitate the creation of new directions in disciplinary knowledge, broaden students' horizons, promote interconnection and communication between different disciplines, drive interdisciplinary integration, and foster students' "spatial awareness" and "associative ability."

The establishment of the electronic information curriculum cluster provides favorable conditions for interdisciplinary integration. The curriculum cluster integrates the advantageous educational resources of related disciplines such as communication engineering, control engineering, computer science and technology, and software engineering. Foundational engineering courses include principles of mobile communication, information theory and coding, analog electronics, digital electronics, modern control theory, principles of microcontrollers, principles of microcomputers, computer organization, and advanced programming language design. These foundational courses are taught in a unified manner, while specialized branches develop independently, creating opportunities for mutual exchange between students from different disciplines.

This approach helps students establish a comprehensive knowledge and skill system in their respective majors while showcasing the research characteristics and technological diversity of different disciplinary directions. It encourages students to break free from traditional engineering learning approaches by emphasizing both vertical and horizontal knowledge expansion. By using new technologies and methods creatively, students are guided to solve engineering problems holistically. For example, applying theories from computer science and technology, such as neural networks and deep learning, to the signal reconstruction process in communication systems can significantly enhance the system's anti-interference ability and stability. Furthermore, it promotes the development of information systems with perceptual capabilities of the surrounding environment.

The integration of disciplines also imposes higher demands on practical platforms. Traditional laboratories have single functionalities and are constructed solely for the practical needs of a single course. As interdisciplinary integration deepens, the traditional telecommunication course laboratory can no longer meet students' requirements for validating new ideas and experiments. For example, the traditional DSP (Digital Signal Processing) laboratory's experimental equipment provides a validation

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platform for classic digital signal processing algorithms related to communication. However, the development environment of the experimental platform uses a fixed microprocessor platform with limited flexibility for secondary development, only suitable for reproducing and validating textbook classic algorithms.

Through transformation, the DSP laboratory is expanded to include innovative applications. After mastering the algorithm principles on the traditional platform, students can port them to real application platforms such as mobile communication and image processing projects to further test and improve algorithms. This enables students to deeply understand the practical significance of the theory and sparks their innovation.

The integrated large practical platform includes various laboratories such as Microcomputer Principles and Interface Technology Laboratory, EDA (Electronic Design Automation) Laboratory, High-Frequency Electronics Laboratory, Signal and System Laboratory, Automatic Control Principles Laboratory, Single Chip Microcontroller Control Technology Laboratory, Network Security Laboratory, and Embedded and Mobile Internet Laboratory. Supported by the interdisciplinary integration and the large practical platform, a series of electronic information characteristic technologies in line with the development of the times have been developed.

By integrating neural networks and machine learning into coding and modulation technology, the efficiency of spectrum resource utilization can be effectively improved. The fusion of artificial intelligence, automatic control, and mobile communication has led to the development of technologies such as autonomous driving, smart cities, and intelligent networking. Combining microcontroller principles with mobile communication allows for tasks like remote data collection and environmental monitoring to be carried out without human intervention.

4. Building Multidisciplinary Cross-Characteristic Teaching and Research Teams

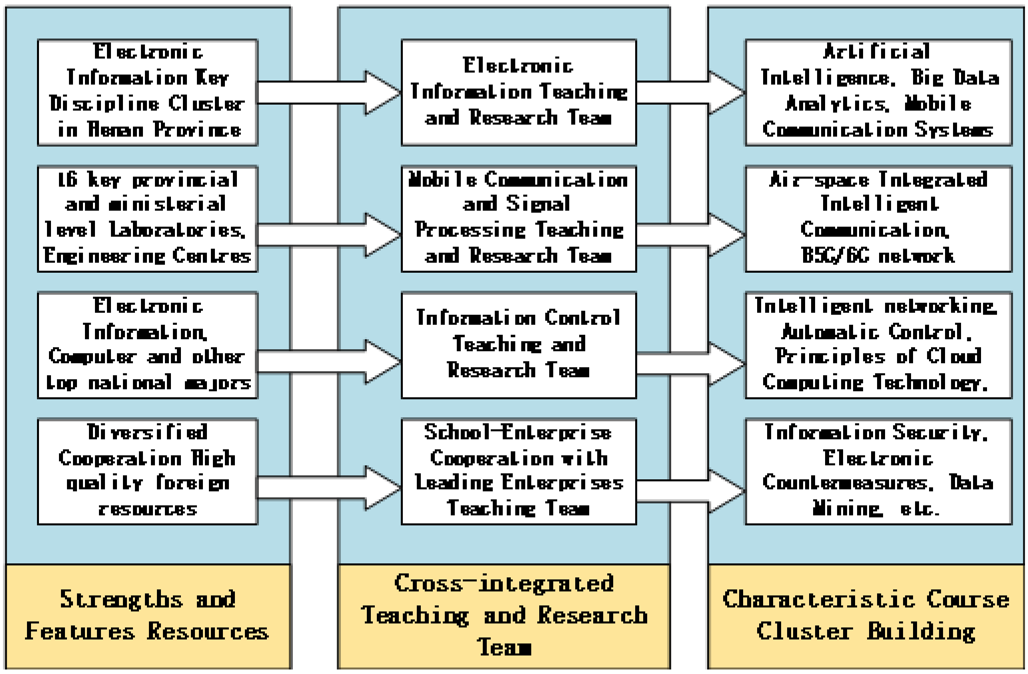

Figure 1: Multidisciplinary Cross-Disciplinary Teaching and Research Team

An important step to ensure the implementation of the characteristic curriculum cluster is the establishment of interdisciplinary teaching and research teams. Under the background of the Emerging Engineering Education, the construction of the electronic information characteristic curriculum cluster breaks through the traditional training approach of electronic information programs. Disciplines are no longer isolated and parallel, but are organically integrated and collide with each other in the teaching process. This exploration of interdisciplinary integration explores the possibilities of engineering applications, stimulating students' thinking and creativity. Additionally, there is a greater emphasis on enhancing students' engineering practical abilities, thus providing advanced engineering talents for the development of the information industry, as shown in Figure 1.

Relying on the advantageous educational resources such as the Electronic Information Key Discipline Group of Henan Province, 16 provincial and ministerial key laboratories and engineering centers, nationally renowned majors like Electronic Information and Computer Science, as well as international cooperation in education, Henan University of Science and Technology's School of Information Engineering has established four teaching and research teams: Electronic Information, Mobile Communication and Signal Processing, Information Control, and Industry-University Cooperation. These teams aim to facilitate the construction of the characteristic curriculum cluster.

4.1 Teaching and Research Team with a Focus on Electronic Information Specialization

In the 2021 professional certification conducted by the Ministry of Education, the Electronic Information Engineering program at Henan University of Science and Technology's School of Information Engineering received positive evaluations from the review experts, and it has been approved as a nationally recognized first-class undergraduate program. The Electronic Information Teaching and Research Team, leveraging the advantages of the Electronic Information Key Discipline Group of Henan Province and other educational resources, is responsible for teaching and practical tasks related to the characteristic courses in electronic information.

The Electronic Information characteristic curriculum cluster offers specialized courses such as Neural Networks, Artificial Intelligence, Big Data Analysis, Modulation and Coding, Mobile Communication Systems, Microcontroller Principles, and Single-Chip Systems. The curriculum is designed to integrate relevant theoretical knowledge from computer science, such as deep learning and big data, into the teaching of communication foundation courses, to meet the demands of the modern intelligent development in the electronic information industry.

The institution has established five provincial and ministerial-level research bases, including the Henan Province Mobile Internet of Things and Big Data Engineering Laboratory, the Equipment Manufacturing Intelligent Control Henan Province Engineering Laboratory, the Henan Province Intelligent Technology Academician Workstation, the Henan Province Key Open Laboratory of Intelligent Technology and Systems, and the Aeronautical Guidance Weapon Aviation Technology Key Laboratory (co-built).

During the teaching and practical process, a unified teaching plan for relevant electronic information courses has been developed, integrating computer science-related theories such as deep learning and big data into the teaching of communication basic courses, in order to adapt to the development demands of modern intelligent electronic information industry.

4.2 Teaching and Research Team with a Focus on Mobile Communication and Signal Processing Specialization

The Mobile Communication and Signal Processing characteristic curriculum cluster offers specialized courses such as B5G/6G Networks and Integrated Intelligent Communication in Aerospace, aiming to cultivate advanced mobile communication and network engineering professionals for the future. By exposing students to cutting-edge industry technologies, the courses aim to stimulate students' research interests.

The practice teaching center includes 13 laboratories and 1 practical and innovative laboratory, covering areas such as Communication Principles, Signals and Systems, High-Frequency Electronic Circuits, Digital Signal Processing (DSP), Microcomputer Principles, Single-Chip Systems, Mobile Communication, Softswitch, Embedded Systems, and Embedded Training Center.

In terms of innovative practice, we creatively reconstruct traditional communication, control, and computer science-related practice plans to establish a large-scale practical platform. For example, by integrating traditional communication technologies with emerging theories such as neural networks and machine learning, we lead students to explore Cognitive Radio technology. Cognitive Radio systems can perceive the external environment using artificial intelligence and adjust signal transmission parameters in real-time according to changes in the electromagnetic environment to achieve efficient utilization of spectrum resources.

The Communication Engineering Department was awarded the Excellent Grassroots Teaching Organization in Henan Province in 2020. It has also been approved for 3 provincial-level excellent online courses, 9 provincial and ministerial-level teaching and research practice platforms, and a Henan Province Emerging Engineering Innovation and Entrepreneurship Base for university students.

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4.3 Teaching and Research Team with a Focus on Information Control Specialization

The Information Control characteristic curriculum cluster integrates the educational resources from Communication Engineering, Computer Science and Technology, and Control Engineering. It is designed to meet the demands of major intelligent manufacturing equipment industries and aims to cultivate high-end manufacturing engineering professionals.

The Information Control Experimental Teaching Center includes various practical platforms, such as the Automatic Control Principles Laboratory, Intelligent Technology Laboratory, Intelligent Control Laboratory, Process Control Laboratory, Virtual Simulation Laboratory, Embedded Systems and Mobile Internet Laboratory, and Network Engineering Laboratory. The cluster offers specialized courses such as Intelligent Networking Technology, Principles of Automatic Control, and Cloud Computing Technology Principles.

4.4 Teaching and Research Team with a Focus on Multi-party Collaborative Practical Approach

In the context of the Emerging Engineering education, the focus is on cultivating talents with practical and innovative skills. The education should be market-oriented, considering the future development direction of the information industry, and highlighting local characteristics to serve the growth of new industries and the new economy in the region.

Building upon the existing engineering education infrastructure, including basic teaching laboratories and provincially co-built key laboratories, Henan University of Science and Technology is actively promoting cooperation between the university and enterprises, as well as the integration of production and education. Collaborations have been established with over 20 well-known enterprises in the new generation of information and communication technologies, such as Zhengzhou Xinyingda Electronics Co., Ltd., Julong Communication Equipment Group, Xuji Electric, Henan Sida High-Tech Group, and Luoyang Peony Communication. These partnerships involve various forms of professional practice and education, such as customized training and enterprise internships, leading to the establishment of a practical education system that combines on-campus education with off-campus practical experiences.

5. Conclusion

The development of the Emerging Engineering education represents a historic opportunity for the advancement of national engineering education. Electronic information technology is a crucial scientific force driving the future development of the new economy. Henan University of Science and Technology, leveraging the strengths of its top-class programs in electronic information and its expertise in hardware implementation and software development, integrates the characteristics of the local information industry. The university has established interdisciplinary teaching teams, undertaken the construction of core and first-class characteristic courses, and promoted reforms and innovations in teaching methods to adapt to the era of digitalization.

In recent years, the Electronic Information Engineering program at Henan University of Science and Technology has achieved significant results. It has been awarded four national-level extracurricular scientific research and training programs for university students, three provincial-level programs, and 23 university-level programs. The program has also achieved more than 60 awards at the provincial level and above in various competitions, such as "Internet Plus" and the "Challenge Cup." The employment rate of graduates has remained consistently above 98%, and through follow-up surveys, it has been found that over 85% of graduates have become key employees in their respective workplaces within three years of graduation.

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