

# *Research on Curriculum Construction of Electrical Majors under the Background of Emerging Engineering Education*

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**Abstract:** Within the framework of Emerging Engineering Education, the reform of the curriculum system and the development of courses in emerging engineering disciplines require the balance of four crucial relationships. These encompass adhering to the essence of engineering education without neglecting the characteristics of higher education, meeting the general requirements of discipline construction while leveraging the distinctive advantages of universities, adapting to current industrial trends with an emphasis on the requirements of future industrial upgrading, and integrating the experiences of developed countries in accordance with the realities of China's engineering education. This study conducts an analysis of the challenges confronted by electrical engineering majors in the new context. It concentrates on the construction and adjustment of their curriculum system and explores the optimization of teaching content. The objective is to provide a reference for enhancing the quality of curriculum construction in electrical engineering majors, realizing the organic integration of ideological and political education within the curriculum and professional teaching, and cultivating high-quality engineering and technical talents to meet the requirements of national industrial development.

## 1. Introduction

In the context of Emerging Engineering Education (3E) initiatives, the talent cultivation frameworks for electrical engineering programs should be led by the renewal of educational philosophies [1,2]. It is essential to actively integrate the latest achievements from domestic and international educational reforms and draw on the advanced undergraduate education practices of world-class universities [3,4]. The ultimate objective is to promote in-depth alignment between program development and three core aspects: the requirements of national economic and social development, the development trends of academic disciplines, and the personalized development aspirations of students [5,6]. At present, driven by the dual forces of professional accreditation and Emerging Engineering Education initiatives, electrical engineering programs at universities of different levels around the world are continuously exploring and iteratively refining their cultivation

plans and curriculum structures [7,8,9].

Specifically, universities like Stanford University and Imperial College London have carried out valuable explorations regarding the construction of electrical engineering curriculum systems, the optimization of teaching content, and the reform of teaching models, and put forward their respective reform initiatives. Nevertheless, these programs are mostly based on local educational ecosystems and industrial demands, thus presenting certain geographical limitations [10, 11, 12]. In contrast, leading domestic institutions such as Tsinghua University, Zhejiang University, and Xi'an Jiaotong University, as key players in China's electrical engineering field, have not only amassed profound educational legacies but also actively promoted reforms and innovations. Guided by the "Grand Engineering Outlook" at the conceptual level, they have eliminated disciplinary boundaries at the organizational level and utilized research platforms and university-industry collaboration resources at the practical level, aiming to enhance students' autonomous learning and innovative capabilities through engineering-practice-driven teaching models [13, 14, 15].

Grounded in the core connotations of Emerging Engineering Education (3E) initiatives, this paper systematically identifies the pain points and deficiencies in the current curriculum systems and teaching content of electrical engineering programs. Building on the reform experiences of comparable programs at both domestic and international universities, it proposes a systematic solution that addresses these issues from two key dimensions: curriculum system reconstruction and teaching content optimization, with a view to bridging the gaps identified in existing practices and better adapting to the development needs of the discipline[16].

## **2. Problems in the Development of Electrical Engineering Disciplines**

First, there exists a disconnection between the curriculum system and industrial demands. The curriculum design of electrical engineering programs in certain universities continues to center on traditional core content, such as power systems and electrical machinery, and inadequately covers emerging fields, including new-energy power generation, smart grids, and power electronics and electrical drives. This leads to a mismatch between students' knowledge structures and the current industrial development needs, such as energy transition and intelligent manufacturing, rendering it difficult for them to rapidly meet enterprises' skill requirements for interdisciplinary electrical talents [17].

Secondly, the practical teaching component is relatively insufficient. Although the majority of universities offer experimental courses and internship programs, certain experimental projects still concentrate on confirmatory experiments, lacking comprehensive and design-oriented experiments that can cultivate students' innovative capabilities and engineering practice skills. Furthermore, the linkage with enterprises' actual production processes is not tight enough. Consequently, students often encounter difficulties in accessing core technologies and cutting-edge equipment during internships, resulting in limited enhancement of their practical skills [18].

Thirdly, the structure of the teaching faculty requires optimization. Among the existing teaching staff, the proportion of "dual-qualified" teachers with extensive enterprise engineering experience is relatively low. The majority of teachers concentrate their research on theoretical domains and lack a sufficient in-depth understanding of new industrial technologies and processes. As a result, it becomes challenging for them to incorporate the latest industrial trends and engineering cases into classroom teaching during the teaching process, which impacts the advancement and practicality of teaching content. In addition, insufficient interdisciplinary integration is also a prominent problem.

## **3. Construction and Adjustment of the Curriculum System**

In response to the aforementioned issues present in the curriculum system of electrical

engineering disciplines, and to incorporate the four aspects of relationships that require balancing in the curriculum system reform of Emerging Engineering Education programs, the construction and adjustment of the curriculum system should be systematically advanced from the following aspects.

### **3.1. Optimize Curriculum Content Structure and Strengthen Emerging Interdisciplinary Course Setup**

While preserving core foundational courses such as electrical machinery and power system analysis, it is essential to substantially augment the proportion of courses in emerging fields. These fields encompass new energy power generation technologies (e.g., principles and technologies of wind power generation, solar photovoltaic power generation systems), smart grids (covering microgrid technology, power system automation and intelligent control), power electronics and electrical drives (e.g., power electronic technology for new-energy vehicles, high-frequency power conversion technology), and intelligent sensing and Internet of Things (IoT) technologies.

Simultaneously, endeavors should be exerted to break down disciplinary barriers by incorporating interdisciplinary course modules, including the application of artificial intelligence in electrical engineering (e.g., machine learning and power system load forecasting, the application of intelligent control in electrical equipment), digital twins, and intelligent manufacturing.

Students are encouraged to select elective courses from related disciplines such as computer science, control engineering, and materials science. This is to construct a knowledge system featuring "solid foundations, broad scope, and strong interdisciplinarity" and to ensure that the curriculum content is closely aligned with the frontiers of industrial development, such as the energy Internet and intelligent manufacturing [19].

### **3.2. Reconstruct Practical Teaching System to Boost Students' Engineering Practice and Innovation Capabilities**

The practical teaching segment should transition from being dominated by confirmatory experiments to being led by comprehensive, design-oriented, and innovative experiments. Specifically, a number of laboratories concentrating on emerging fields should be established, such as integrated new energy microgrid experimental platforms, innovative laboratories for power electronics and electrical drives, and intelligent electrical equipment testing laboratories. A series of comprehensive experimental projects should be initiated, including "design and simulation of wind-solar-storage microgrid systems", "condition monitoring and fault diagnosis of electrical equipment based on digital twins", and "design and development of intelligent charging piles", guiding students to participate in the entire process from scheme design, component selection, system construction to performance testing [20].

Meanwhile, strengthen university-industry cooperation. We will collaborate with leading enterprises in the industry to jointly establish modern industrial colleges or internship and training bases, and incorporate real enterprise engineering projects (such as the commissioning of intelligent substation secondary systems and the operation and maintenance optimization of new-energy power stations) into practical teaching. Universities and enterprises will jointly implement "project-based teaching" and "mentorship-based internships", allowing students to actively participate in the research and development of actual projects under the joint guidance of enterprise engineers and university teachers, gain access to core technologies and cutting-edge equipment, and effectively enhance their ability to solve complex engineering problems.

### 3.3. Reform Teaching Models and Methods to Promote Personalized and Collaborative Learning

Fully utilize information technology to empower teaching reform and vigorously promote models such as blended online-offline teaching, flipped classrooms, and case-based teaching. For instance, in courses like Power System Relay Protection, virtual simulation technology can be introduced to construct virtual scenarios for power system fault simulation and protection setting, enabling students to conduct fault analysis and protection configuration training in a virtual environment. For courses such as Intelligent Control Technology, the case-based teaching approach can be adopted, selecting real cases such as intelligent robot control and the application of UAV inspection in power systems to guide students in applying theoretical knowledge to solve practical problems[21].

Additionally, interdisciplinary curriculum projects ought to be developed. For example, universities can assemble teams composed of students majoring in electrical engineering, computer science, automation, and other disciplines to jointly undertake projects such as "AI-based Home Energy Management Systems" and "Design and Construction of Small Intelligent Photovoltaic Power Stations," thereby cultivating students' teamwork and interdisciplinary innovation abilities. Simultaneously, universities should institute a flexible credit management system that enables students to earn credits through participation in scientific research projects, innovation and entrepreneurship competitions, paper publication, patent acquisition, etc., to promote personalized development.

### 3.4. Strengthen Faculty Team Construction and Build a High-Level "Double-Qualified" Teacher Team

Formulate specific policies to recruit senior engineers and technical experts with extensive enterprise engineering experience as full-time or part-time teachers, particularly industry leaders with profound achievements in emerging fields such as new energy, smart grids, and power electronics, in order to enrich the "dual-qualified" teaching staff. On the other hand, universities should intensify their efforts in cultivating the engineering practice capabilities of existing teachers. Universities can regularly arrange for teachers to take temporary posts in enterprises, participate in enterprise project R&D, or conduct joint scientific research with enterprises. Universities should also encourage teachers to obtain professional qualifications such as Registered Electrical Engineer to enhance their understanding and application abilities of new industrial technologies and processes.

Furthermore, encourage teachers to engage in teaching research and reform, and motivate them to convert their scientific research achievements into teaching cases, experimental projects, or teaching materials. For instance, teachers can incorporate research findings on new energy power generation control strategies into the teaching of the "*New Energy Power Generation Technology*" course and introduce research progress in intelligent sensing technology into experimental teaching. This guarantees the advancement and practicality of teaching content and achieves the in-depth integration of scientific research and teaching.

By implementing the aforementioned multi-dimensional measures for curriculum system construction and adjustment, the objective is to overcome the limitations of the traditional curriculum system. This will enable the electrical engineering curriculum system to be more consistent with the talent cultivation objectives of Emerging Engineering Education. The ultimate goal is to cultivate high-quality interdisciplinary electrical talents. These talents should have a solid foundation in electrical theory, innovative thinking, engineering practice abilities, and interdisciplinary collaboration capabilities, and be capable of adapting to and leading the future

development of industries.

## 4. Optimization and Adjustment of Teaching Content

The optimization and adjustment of teaching content represent a core element in the effective implementation of the curriculum system. It is essential to closely align with the talent cultivation objectives of emerging engineering education, incorporate industrial development trends and cutting-edge technologies, and systematically organize, update, and supplement the existing teaching content to guarantee its advancement, practicality, and relevance.

### 4.1. Integrate Cutting-Edge Technologies and Industrial Applications into Core Professional Courses

Firstly, take the course of *Power System Analysis* as an example. Apart from the traditional classic content such as power flow calculation and short-circuit current calculation, content including the impact analysis of large-scale new energy grid connection on power system stability, wide-area measurement and control technology of power systems, demand response, and virtual power plants should be incorporated. This enables students to understand the new characteristics and challenges of modern power systems. Regarding the course of *Electrical Machinery*, the length of theoretical derivation for traditional DC motors and synchronous motors can be appropriately shortened, while the principles, design, and control methods of new types of motors such as permanent magnet synchronous motors and switched reluctance motors should be added. Teaching should be integrated with practical application cases such as new energy vehicle drive systems and industrial servo systems to strengthen the engineering orientation of the course.

Regarding the course "*Power Electronics Technology*", emphasis should be placed on enhancing the features and applications of fully controlled power electronic devices (such as IGBT and SiC MOSFET), high-frequency and modular power electronic conversion technology, and the electromagnetic compatibility design of power electronic systems. Additionally, typical cases of application system analysis and design, such as those of new-energy grid-connected inverters, electric vehicle charging piles, and rail transit traction converters, should be introduced to enable students to master the core applications of power electronics technology in fields like new energy and transportation.

### 4.2. Align Practical Teaching Content with Engineering Practice and Enhance Comprehensiveness and Innovation

The content of experimental courses should minimize confirmatory experiments, such as simple component parameter testing and circuit function verification, and substantially increase design-oriented and comprehensive experimental projects based on actual engineering problems. For instance, in the Power System Relay Protection experiment, an experiment titled "*Power Grid Fault Analysis and Protection Configuration Optimization Based on Digital Simulation*" can be designed. Students are required to employ simulation software, such as PSCAD, to construct typical power grid models, simulate various types of faults, analyze the operational behavior of protection devices, and optimize the protection settings in accordance with the simulation results.

In the Intelligent Control Technology experiment, an experiment titled "*Design of Intelligent Sorting System Based on PLC and Machine Vision*" can be established. This requires students to comprehensively apply knowledge of PLC programming, sensor technology, and machine vision recognition to complete the design of automatic material identification, grabbing, and sorting control logic, as well as system debugging.

Additionally, endeavors should be made to actively introduce real-world enterprise engineering cases and project data as practical teaching materials. For example, universities can collaborate with power equipment manufacturing enterprises to convert the technical challenges encountered during their product research and development processes into topics for students' course design or graduation projects. This enables students to enhance their engineering practice capabilities and innovative thinking while solving practical problems.

### 4.3. Systematize and Deepen Interdisciplinary Teaching Content Integration

In response to the trend of interdisciplinary integration between electrical engineering disciplines and fields such as information technology and artificial intelligence, the core concepts, methods, and tools of related fields should be systematically incorporated into the teaching content. For instance, in introductory courses like *Introduction to Electrical Engineering*, an overview of the applications of technologies such as artificial intelligence, big data, and the Internet of Things in the field of electrical engineering can be included to foster students' interdisciplinary awareness. In the course *Control Theory*, intelligent control algorithms such as reinforcement learning and deep learning can be introduced and combined with practical issues such as power system load forecasting and power equipment fault diagnosis to illustrate the application effects of intelligent algorithms. In the course *Power System Automation*, content such as power grid operation state evaluation based on big data analysis and power system simulation and optimization based on digital twins can be added to enable students to master the application methods of interdisciplinary knowledge in solving complex electrical problems. Meanwhile, interdisciplinary elective courses or micro-majors, such as *"Artificial Intelligence and Electrical Engineering Applications"* and *"Energy Internet and Smart Grids"*, can be offered to provide students with a more systematic platform for learning interdisciplinary knowledge.

Furthermore, the presentation approach of teaching content should also be optimized, emphasizing the amalgamation of theory and practice and the integration of abstract concepts and specific cases. For instance, when elucidating abstract circuit theories or control algorithms, techniques such as animation demonstrations, simulation software operations, and physical model displays can be employed to assist students in comprehending the concepts intuitively.

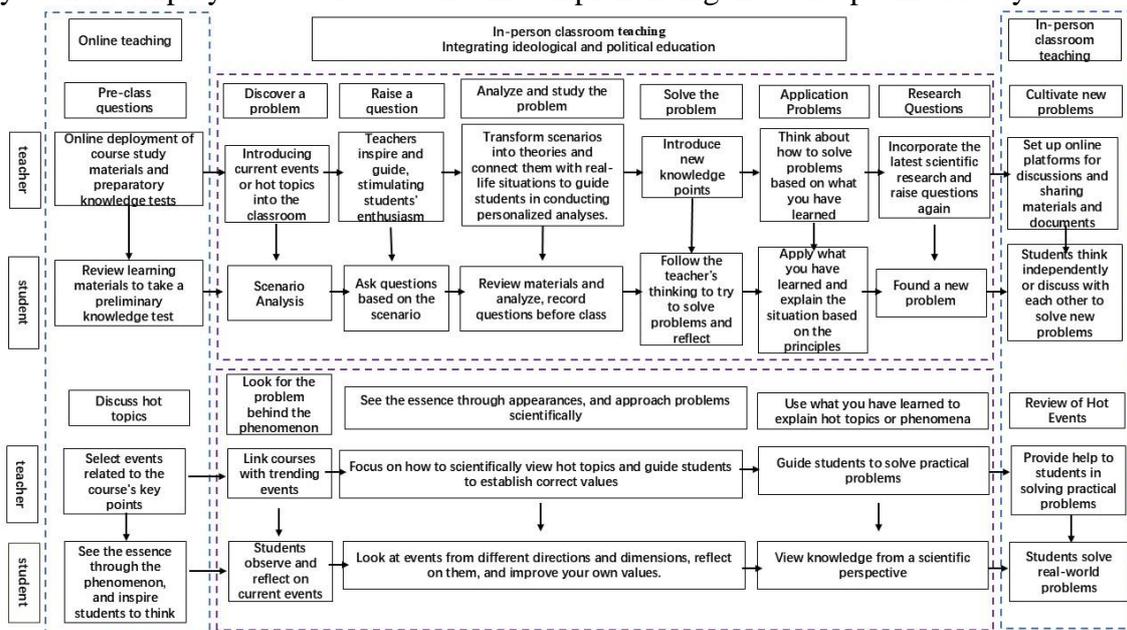


Figure 1: Implementation process for online and offline blended course development

The compilation of textbooks and teaching materials shall break the chapter constraints of traditional textbooks and organize the content in a project-driven or problem-oriented manner, integrating knowledge points into specific engineering projects or practical problems. Simultaneously, diversified teaching resources, including open online courses, virtual simulation resources, industry technical reports, and academic journal articles, shall be fully utilized to update teaching content in a timely manner, enabling students to access the latest technological advancements and research findings, as depicted in Figure 1. For example, the latest policies in the new energy field, demonstration project cases of smart grids, and the latest development trends of power electronic devices can be regularly collected and shared with students through course websites, teaching WeChat groups, and other channels to broaden students' professional perspectives.

#### **4.4. Integrate Ideological and Political Elements into Teaching for In-Depth Content Optimization**

It is necessary to integrate value guidance throughout the entire teaching process and achieve the in-depth integration of knowledge imparting and ideological and political education. Specifically, ideological and political elements such as patriotism, craftsmanship spirit, innovation spirit, and sense of responsibility contained in the curriculum content can be explored and excavated. Teachers, for example, when explaining new energy power generation technologies, can combine with China's "dual carbon" goals and energy transition strategies, and introduce the world-renowned achievements made by China in wind power, photovoltaic and other fields, such as large-scale wind power bases in the "Three Norths" regions and the Qinghai Talatan Photovoltaic Power Station are presented to arouse students' national pride and their sense of mission to engage in the energy industry. When analyzing the development of smart grids, teachers can introduce the independent innovation process of China's UHV transmission technology and the Global Energy Interconnection initiative, guiding students to recognize the significance of technological self-reliance and self-improvement for national development. In the practical teaching section, by introducing the striving stories of China's power equipment manufacturing enterprises evolving from "lagging behind" to "keeping abreast" and then to "taking the lead", such as the persistent efforts of enterprises like Tebian Electric Apparatus Stock Co., Ltd. and NARI Group Corporation in breaking through core technologies, students' striving spirit of pursuing excellence and innovative awareness of bravely surmounting difficulties and obstacles are cultivated. Meanwhile, teachers can combine content such as the safe operation of electrical equipment and the stable control of power systems, emphasize the professional ethics and responsibility of engineers, guide students to establish the professional ethics of prioritizing safety and quality, and cultivate their sense of responsibility of being rigorous, pragmatic, and adhering to the bottom line in engineering practice [22]. Additionally, experts, scholars, and outstanding alumni with profound patriotism in the industry can be invited to give special lectures, sharing their struggle experiences and dedication in the field of electrical engineering. Through the power of role models, students are inspired and motivated to establish a correct worldview, outlook on life, and values while learning professional knowledge and grow into new-era electrical talents with both excellent professional skills and noble moral character.

Through the aforementioned optimization and adjustment of teaching content, the instructional content of electrical engineering programs can be more closely aligned with industrial requirements and technological frontiers. This effectively resolves the disconnect between traditional teaching content and practical applications, and offers robust support for cultivating interdisciplinary electrical talents with solid theoretical foundations, outstanding practical abilities, and a spirit of

innovation.

## 5. Conclusion

In conclusion, the development of electrical engineering programs within the context of Emerging Engineering Education faces challenges such as the disconnect between curriculum systems and industrial requirements, insufficient practical teaching, the necessity for optimizing the faculty structure, and inadequate interdisciplinary integration. In response to these issues, this paper presents reform approaches from two aspects: the construction and adjustment of curriculum systems and the optimization of teaching content. Regarding the construction of curriculum systems, it is essential to strengthen the establishment of courses in emerging interdisciplinary fields, reconstruct the practical teaching system, reform teaching models and methods, and enhance the development of a high-level "double-qualified" faculty team. Concerning the optimization of teaching content, efforts should be exerted to deeply integrate cutting-edge technologies with industrial applications, closely adhere to engineering practice to enhance comprehensiveness and innovation, systematically integrate interdisciplinary content, and optimize presentation methods. Through these multi-dimensional reform measures, the objective is to break the limitations of traditional education models and establish a new-type curriculum and teaching system characterized by "solid foundations, wide scope, strong interdisciplinarity, and emphasis on practice" to cultivate high-quality interdisciplinary electrical talents capable of adapting to and leading the development of future industries such as the energy internet and intelligent manufacturing. In the future, it will be necessary to continuously monitor industrial trends and technological changes and conduct dynamic adjustments and improvements to professional development on a continuous basis to ensure that the quality of talent cultivation in electrical engineering programs is in line with national strategies and industrial development needs.

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## References

- [1] W. Li. (2024) *On the curriculum system and teaching content optimization of electrical majors under the background of engineering certification and new engineering*. *Journal of Zhejiang Business Technology Institute*, 23 (4), 24-29.
- [2] S. Zhao, H. Zhang, J. Wang. (2018) *Cognition and system construction of civil engineering innovation and entrepreneurship system in emerging engineering education*. *Cognitive Systems Research*, 52, 1020-1028.
- [3] W. Hao, J. Yuan, X. Xu. (2018) *Establishment of the practical education system for civil engineering majors in local colleges and universities under the emerging engineering background*. *Educational Sciences-Theory & Practice*, 18 (6), 2641-2651.
- [4] M. Gheisari, B. Becerik-Gerber, C. S. Dossick (2023) *Emerging learning technologies for future of work and education in engineering*. *Advanced Engineering Informatics*, 56, 101775.
- [5] F. Li, J. Li. (2023) *The subject accessibility of ideological and political courses for electrical and electronic majors*. *International Journal of Computational Intelligence Systems*, 16 (1), 45.
- [6] M. Li, Y. Guo, H. Zhao, P. Gao, G. Wang. (2020) *The innovative curriculum construction of "computer fundamentals" course based on spoc+mooc in higher education*. *15th International Conference on Computer Science Education (ICCESE)*, 137-141.
- [7] D. E. Hancher, F. J. Chapuran. (1978) *Education of the engineer for electrical construction*. *IEEE Transactions on Education*, 21 (3), 132-134.

- [8] L. Yan, Z. Li, J. Wang. (2021) Reform of engineering drawing curriculum system based on emerging engineering education concept and first-class curriculum construction. *The 3rd International Conference on Applied Machine Learning (ICAML)*, 169–173.
- [9] N. Zhang, J. Xie. (2022) Auxiliary decision-making system for college curriculum construction based on big data technology. *International Conference on Edge Computing and Applications (ICECEAA)*, 205–208.
- [10] Q. Yu, A. Dong, F. Wang, F. Yu. (2009) Modern teaching method and instrument's teaching reform and curriculum construction for "measuring technology and process automation instrumentation". *The First International Workshop on Education Technology and Computer Science*, 1, 778–781.
- [11] P. Zhang, X. Luo, Y. Wang. (2023) Research on digital implementation way of international curriculum construction. *International Conference on Engineering Education and Information Technology (EEIT)*, 5–8.
- [12] T. Chen, Q. Shen, W. He, J. Wang, N. Bao, (2008) Model curriculum construction of embedded system in zhejiang university. *International Conference on Computer Science and Software Engineering*, 5, 671–674.
- [13] E. Donaire, R. Belo, M. B. Ghalia, M. Al Mestiraihi. (2024) Wip: Investigating teachers' perceptions of engineering majors. *IEEE Frontiers in Education Conference (FIE)*, 1–4.
- [14] K. A. Smith, R. Streveler, R. C. C. Guerra. (2015) Connecting and expanding the emerging engineering education research innovation (eeri) communities. *IEEE Frontiers in Education Conference (FIE)*, 1–3.
- [15] K. Beddoes, (2014) Methodology discourses as boundary work in the construction of engineering education. *Social Studies of Science*, 44 (2), 293–312.
- [16] W. Chen, Y. Lin, Z. Ren, D. Shen. (2021) Exploration and practical research on teaching reforms of engineering practice center based on 3i-cdio-obe talent-training mode. *Computer Applications in Engineering Education*, 29, 114–129.
- [17] J. Zhang, S. Peng, P. Wang, F. Zhang, Q. Wang, Z. Dou. (2024) Reconstruction of curriculum system for chemical safety undergraduate education under emerging engineering education requirements. *ACS Chemical Health & Safety*, 31 (5), 378–392.
- [18] A. B. Bradley, R. M. Allen. (2007) Engineering education in the Australian context. *Asia-Pacific Journal of Chemical Engineering*, 2 (5), 368–373.
- [19] C. Nagamani, M. V. Kirthiga, M. S. Thomas. (2018) Power engineering education. *IEEE Power & Energy Magazine*, 16 (5), 42–52.
- [20] J. van Grunsven, T. Stone, L. Marin. (2024) Fostering responsible anticipation in engineering ethics education: how a multi-disciplinary enrichment of the responsible innovation framework can help. *European Journal of Engineering Education*, 49 (2), 283–298.
- [21] P. de Vries. (2022) The ethical dimension of emerging technologies in engineering education. *Education Sciences*, 12 (11), 754.
- [22] M. Cao. (2024) The mining method of integrating the thinking and political elements of curriculum into English teaching based on big data technology. *Applied Mathematics and Nonlinear Sciences*, 9 (1), 1–13.