Engineering Education Review

PRACTICE

Design of the main teaching line for the major of electrical engineering and its automation under the guidance of new engineering education

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ABSTRACT

The new engineering education (NEE) initiative has been implemented to address the imbalance between theory and integration in the context of the energy transition and advancements in smart grids. This initiative involves curriculum reform in the field of electrical engineering and its automation. Utilising Anhui University as a case study, this work delineates a 'main teaching line'—a curriculum design method that fosters versatile talents skilled in intelligence, energy and practice, integrating vertical knowledge building and horizontal industry–academia integration. The model outlines a four-tier vertical structure (Foundation–Professional Foundation–Major–Comprehensive) and two horizontal dimensions (interdisciplinary and industry-education integration). The curriculum is structured around a series of core courses, including circuit theory, electrical machinery and power system analysis. The pedagogical approach is founded on a reverse decomposition strategy, with the curriculum meticulously designed to align with the national electrical code (NEC) objectives. This approach involves a systematic analysis of knowledge links and a comprehensive assessment of outcomes, ensuring that the educational objectives are effectively met. The approach establishes a model for NEE reform at local universities and cultivates talent aligned with the needs of the energy revolution.

Key words: new engineering education, electrical engineering and automation, main line, teaching, integration of industry and education

INTRODUCTION

Following China's accession to the Washington Accord, administered by the International Engineering Alliance (IEA) in 2016, higher engineering education has entered a new phase of 'new engineering education (NEE)' development. The primary objective of this initiative is to foster a harmonious alignment between the cultivation of engineering talent and the demands of the industrial sector. This alignment is achieved through the integration of diverse disciplinary perspectives and collaboration between industry and education. As a core major supporting strategic fields such as the energy revolution, smart grids and new energy vehicles, the Electrical Engineering and Automation Curriculum must evolve to align with the objectives of 'carbon peaking and carbon neutrality' and the advancements in artificial intelligence technology. This initiative must address the deficiencies inherent in conventional educational programs, such as the fragmented instruction of 'circuits–electrical machinery–systems' and the disparity between academic learning and industry practices (Ministry of Education of the People's Republic of China *et al.*, 2018; Zhang *et al.*, 2025).

The major of Electrical Engineering and Automation at

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Anhui University is affiliated with the School of Electrical Engineering and Automation. Relying on the 'Anhui Provincial Key Laboratory of Power Electronics and Motion Control' and the 'Anhui Provincial Engineering Technology Research Centre for Smart Grids', the institution has formed three distinctive directions. The subject of this text is 'Power System–Power Electronics–New Energy'. Nevertheless, the prevailing curriculum system exhibits certain deficiencies. Primarily, the correlation between courses is inadequate. For example, the correlation between power electronics technology and new energy power generation technology is minimal, impeding students' development of systematic thinking. In addition, the practical applications are underdeveloped. Conventional experiments are predominantly confirmatory in nature and deficient in engineering training in cutting-edge scenarios such as smart grids and virtual power plants. Lastly, the integration of interdisciplinary disciplines remains inadequate, failing to fully incorporate novel engineering technologies such as computer simulation and machine learning (Chen *et al.*, 2021; Ke *et al.*, 2025; Zhao & Qi, 2020).

In consideration of the aforementioned context, this research employs the case study of a major at Anhui University to conceptualise a novel engineering-oriented primary teaching line. The objective is to enhance students' engineering practice capabilities and innovative thinking by clarifying the curriculum hierarchy, optimising content connections and improving evaluation indicators. Furthermore, the initiative seeks to provide a replicable, practical path for the new engineering reform of similar majors in local universities (Zhang *et al.*, 2021).

DEFINITION AND STRUCTURE OF THE MAIN TEACHING LINE

Definition of the main teaching line

The Electrical Engineering and Automation major at Anhui University diverges from the conventional electrical engineering curriculum, which is typically organised by course categories. Instead, it integrates the principles of NEE, which emphasises cutting-edge technology, interdisciplinary integration and industrial participation. The curriculum is structured to cultivate electrical engineering talents with a comprehensive understanding of energy systems, proficiency in applying intelligent technology and an international perspective. These objectives are achieved by following a vertical progression of knowledge, encompassing the 'Foundation-Professional Foundation-Major-Comprehensive' hierarchy. In addition, interdisciplinary resources from 'Electrical Engineering + Computer Science + Control Engineering + New Energy' are integrated, and collaborative platforms amongst universities, enterprises and research institutes are established. This approach establishes a coherent and systematic curriculum teaching design method.

This definition must satisfy three core requirements. Firstly, it must demonstrate technological adaptability, which is achieved by integrating cutting-edge industrial technologies, such as smart grids and new energy grid connection. For example, a chapter on 'digital twin grids' has been incorporated into the course Power System Analysis. Secondly, the program emphasises competence orientation, which involves cultivating students' engineering capabilities of 'problem analysis–solution design–system implementation' through project-driven teaching. For example, the course on electrical machinery necessitates the development of a 'permanent magnet synchronous motor speed control system'. Thirdly, the integration of resources is emphasised, with the collaboration between Anhui University and prominent entities such as State Grid Anhui Electric Power Company and Jianghuai Automobile Group Corp., Ltd. (JAC), transforming authentic enterprise projects into educational cases.

Structure of the main teaching line

The 2024 Edition Talent Cultivation Program for the major of Electrical Engineering and Automation at Anhui University is predicated on a 'four-tier progressive' main teaching line structure. The curriculum setup and cultivation objectives for each tier are as follows.

Fundamental level: The disciplinary foundation must be consolidated

The curriculum is structured to establish a foundational understanding of 'Mathematics–Physics–Electrical Fundamentals', with core courses encompassing Advanced Mathematics, University Physics (Electromagnetism), Circuit Theory, Engineering Drawing and C Language Programming. This instructional level aims to facilitate the mastery of fundamental concepts and instruments pertinent to the electrical major. For example, Multisim experiments in Circuit Theory facilitate students' comprehension of fundamental principles such as Kirchhoff's laws and transient analysis, thereby establishing a theoretical and tool-based foundation for subsequent professional courses.

Professional foundation level: The construction of a professional framework is imperative

The curriculum is designed to provide a comprehensive foundation of knowledge in the fundamental theories and practical skills associated with the electrical engineering discipline (Yang *et al.*, 2022). Notable core courses include 'Electrical Machinery', 'Principles of Automatic Control', 'Fundamentals of Power Electronics Technology' and 'Signals and Systems'. This level underscores the integration of 'theory and simulation'. For example, in the course Fundamentals of Power Electronics Technology, students are required to utilise matrix laboratory (MATLAB)/Simulink to construct Buck and Boost converter models and to analyse their topological structures and control strategies (Wang *et al.*, 2021). Concurrently, interdisciplinary knowledge is integrated (Wu *et al.*, 2022b). In particular, the chapter entitled 'Application of proportional-integral-derivative (PID) Control in Motor Speed Regulation' is appended to principles of automatic Control with the objective of establishing a nexus between the control discipline and the electrical discipline.

Professional level: One's proficiency in the directional domain must be enhanced

The academic program is centred on three distinctive fields at Anhui University: 'Power System–Power Electronics–New Energy'. Course offerings include Power System Analysis, Power System Relay Protection, New Energy Power Generation Technology and Electric Drive Automatic Control System. This level places particular emphasis on the integration of theoretical concepts and practical engineering applications. For example, the course, New Energy Power Generation Technology, mandates students to complete the parameter design and debugging of a 'photovoltaic grid-connected inverter' based on a photovoltaic module experimental platform (Liu *et al.*, 2022). Students are encouraged to participate in collaboration with the 'Anhui Provincial Engineering Technology Research Center for Smart Grids' by engaging in the scientific research sub-project of 'microgrid energy management', thereby fostering the cultivation of their technical application capabilities.

Comprehensive level: The enhancement of innovative literacy is imperative

At the pinnacle of the primary instructional trajectory, this level has been designed to facilitate knowledge integration through a multifaceted approach that incorporates comprehensive projects, graduation design and collaborative efforts between industry and education. The core projects include 'comprehensive design of smart grids', 'development of electric vehicle charging piles', and 'simulation and optimisation of virtual power plants' (Zhao *et al.*, 2023). For example, Anhui University and JAC Motors Group have collaboratively developed a course entitled 'On-board Power Electronic Systems'. In this course, students are required to integrate knowledge from Power Electronics Technology and Electrical Machinery to design a scheme and verify its simulation of an 'electric vehicle drive motor controller'. Moreover, over 30% of graduation design topics are selected from actual enterprise requirements, such as 'optimisation of distribution network fault location algorithms', which promote students to solve practical engineering problems (Chen *et al.*, 2023).

CURRICULUM DESIGN AND EVALUATION INDICATORS FOR THE MAIN TEACHING LINE

Main teaching line across courses

The primary pedagogical approach across courses is used to elucidate the 'logic of knowledge progression' and 'interdisciplinary connections'. This method is designed to prevent knowledge repetition or disconnection. The Electrical Engineering and Automation major at Anhui University has established a system for organising the knowledge connections of its core courses. This system, which involves 'collective lesson preparation + participation of enterprise consultants', has resulted in the identification of two primary strands. The sequence of courses is as follows: circuits → electrical machinery → power systems and power electronics → new energy → smart grids.

Main Line 1 (Power System Direction): The subject of 'Transient Analysis' in Circuit Theory is addressed in the section entitled 'Transient Characteristics of Synchronous Motors' in electrical machinery. The topic is further discussed in the section entitled 'Power System Transient Stability' in Power System Analysis, and is subsequently covered in the section titled 'Transient Protection Scheme Design' in Power System Relay Protection. This approach ensures the knowledge coherence of 'component characteristics– system behaviour–protection strategies'.

Main Line 2 (Power Electronics and New Energy Direction): 'Inverter Topology' in Fundamentals of Power Electronics Technology → 'Design of Photovoltaic Grid-Connected Inverters' in New Energy Power Generation Technology → 'Motor Variable-Frequency Speed Regulation' in Electric Drive Automatic Control Systems → 'Electric Vehicle Charging Pile Development' comprehensive project. These topics form a progression of 'topology design, energy application and system control'.

The effectiveness of the primary teaching approach across courses was evaluated using the evaluation indicators outlined in Table 1. These indicators encompass dimensions such as 'knowledge connection degree', 'interdisciplinary application' and 'practical linkage'. On a semesterly basis, the teaching team and enterprise mentors undertake a collaborative evaluation. In the Power System Analysis course, for example, students are expected to demonstrate their ability to apply the synchronous motor model acquired in Electrical Machinery to perform power flow calculations. This assessment serves to ensure the logical coherence between the two courses.

Main teaching line within a course

The primary teaching line within a course must cover the 'core knowledge — practical operation — innovative expansion' framework to ensure a logical system that aligns with industrial needs. The primary instructional framework of the Power System Analysis course at Anhui University is structured as follows: The sequence of events begins with the fundamental theoretical underpinnings, encompassing the calculation of power flow and the analysis of stability. It is followed by the implementation of simulation tools, such as power systems computer aided design (PSCAD)/bonneville power administration (BPA), which serve as the foundation for engineering applications, particularly in the domains of power grid planning and fault handling. The culmination of this sequence is marked by the advent of innovative expansion, exemplified by the concept of a digital twin power grid (Liu *et al.*, 2021b; Zhang & Liu, 2023). The objectives and evaluation criteria for each section are as follows. (1) Fundamental theory: The Newton–Raphson method must be mastered for power flow calculations and power-angle characteristic analyses for transient stability. Assessments will be administered through in-class quizzes and assignments. (2) Simulation tools: This study aims to explore the utilisation of PSCAD in the construction of a three-bus power system model, focusing on the execution of power flow calculations under conditions of load variations. The assessment of outcomes should be conducted through the analysis of laboratory reports. (3) The engineering application is as follows: The 'distribution network planning' case from the State Grid Anhui Electric Power Company is used to design a 10 kV distribution network wiring scheme. The scheme is evaluated through a meticulous analysis of case reports. (4) Innovative expansion: A review of the extant literature pertaining to digital twin power grids is hereby proposed, along with a Python-based power grid state monitoring scheme. The scheme is assessed through innovation report analysis (Wang *et al.*, 2022).

As demonstrated in Table 2, the evaluation indicators for the primary teaching line of the course must consider 'theoretical mastery' and 'practical innovation'. This pedagogical approach is designed to ensure that students develop a comprehensive understanding of the subject matter and are able to apply it to real-world engineering scenarios. Furthermore, it fosters the ability to propose innovative ideas, a critical skill in any engineering discipline.

CASE ANALYSIS

Course features and main teaching line design

Three fundamental courses of the Electrical Engineering and Automation major at Anhui University are selected for this study: Circuit Theory, Electrical Machinery and Power System Analysis. The primary teaching objective for each course is determined by a reverse decomposition of the 'talent cultivation objectives for electrical engineering in the context of emerging engineering education'. Specifically, one of the objectives may be 'ability to design smart grid systems and solve new energy grid-connection problems'. The specific features are as follows. (1) Circuit Theory: As an essential course, it establishes the cognitive framework for electrical engineering. (2) Focus: The curriculum is structured around the concept of 'circuit analysis and simulation', encompassing topics such as direct current (DC) circuits, alternating current (AC) circuits and transient analysis. The primary objective of this approach is to cultivate students' competencies in circuit modelling and simulation.

The following tools are to be utilised in the development process: (1) Multisim is employed for circuit simulation, whereas MATLAB is used for transient analysis. Multisim experiments account for 30% of the course score, requiring students to complete the simulation and physical verification of the 'Resistor-Inductor-Capacitor (RLC) series resonant circuit'. (2) Key assessment focuses: The first component, circuit theory, accounts for 60% of the total score, whereas the second component, simulation and experimental operation, accounts for 40% of the total score. In the final assessment, students are required to design a 'household lighting circuit' using Multisim and analyse its power loss. (3) Main line connection: It provides the foundation for 'motor winding circuit analysis' in Electrical Machinery and 'converter circuit topology' in Power Electronics Technology. The chapter on 'mutual inductance circuits' establishes the foundation for understanding the mutual inductance characteristics of motor windings. (4) Electrical machinery: As a professional fundamental course, it establishes connections between components and systems. (5) Focus: The curriculum is anchored in 'motor modelling and control', encompassing the structural, theoretical and functional characteristics of synchronous motors, asynchronous motors and DC motors. The program emphasises cultivating students' competencies in motor analysis and the design of speed control systems. (6) Development tools: The motor simulation platform (PSIM) and the 'permanent magnet synchronous motor experiment bench', which was developed autonomously by Anhui University, are the subjects of this study. The course design necessitates the construction of an 'asynchronous motor variable frequency speed regulation system' that uses PSIM, followed by its validation through experimentation. (7) Key assessment focuses: The distribution of the total credit hours is as follows: motor theory (40%), simulation design (30%) and experimental operation (30%). In assessments, students are required to analyse

Table 1: Setting and evaluation indicators of the teaching main line between courses

Number	Key point	Detailed description	Evaluation indicators
1	Degree of knowledge cohesion	Whether the knowledge points between core courses are progressive, such as the logical coherence of Principles of Circuits → Electrical Machinery → Power System Analysis	Whether students can apply knowledge from preceding courses to complete assignments/experiments in subsequent courses; the repetition rate of knowledge points between courses is ⩽ 10%* (State Grid Anhui Electric Power Company, 2023)
2	Degree of interdisciplinarity	Whether the courses in the fields of electrical engineering, computer science, control engineering and new energy are interconnected, such as the integration of Power Electronics Technology and Principles of Automatic Control	Whether students can complete interdisciplinary projects (*e.g.,* optimising power electronic converters using control algorithms) ; the proportion of interdisciplinary courses is ⩾ 30%#
3	Degree of practical linkage	Whether the course experiments/projects are connected, such as the linkage between the experimental platform of Electrical Machinery and the course design of Electric Drive	Whether students can carry out subsequent projects based on the results of preceding experiments; the linkage rate of practical projects is ⩾ 80%&
4	Degree of industrial adaptability	Whether the main thread between courses aligns with enterprise needs, such as the actual enterprise workflow of 'Power System → Relay Protection → Distribution Network Project'	Enterprise mentors evaluate that the matching degree between the course main line and industrial needs is ⩾ 90%; the knowledge adaptability of students when participating in enterprise projects is ⩾ 85%$

*The threshold of 'knowledge repetition rate ⩽10%' is determined by: (1) Literature support: Wang *et al.* (2023) pointed out that a repetition rate exceeding 10% reduces learning efficiency by 35% (Huang & Li, 2023); (2) Expert consultation: 8 experts (4 from universities, 2 from enterprises) scored an average of 9.2%, so 10% is set as the upper limit (Wang *et al.*, 2023); (3) Measurement method: 'Course knowledge mapping' by three independent raters, Cronbach's α = 0.91 (Huang & Li, 2023; State Grid Anhui Electric Power, 2023) . #The threshold is based on: (1) Policy: Ministry of Education requires ⩾25% for new engineering (Ministry of Education of the People's Republic of China *et al.*, 2018); (2) Literature: Wu *et al.* (2022a) confirmed 30% is effective for compound ability cultivation; (3) Practice: 2024 program has 22 interdisciplinary courses out of 68, accounting for 32.4% (State Grid Anhui Electric Power, 2023) . &The threshold is supported by: (1) Wang *et al.* (2023) showed ⩾ 80% linkage avoids fragmented practical ability; (2) Enterprise demand: State Grid and JAC require ⩾ 80% linkage in cooperation agreements (Li *et al.*, 2022; School of Electrical Engineering and Automation, Anhui University, 2024); (3) Data: 21 out of 25 projects in spring 2024 were linked, with a rate of 84% (Wang *et al.*, 2023). $ '⩾ 90% matching' is evaluated by 12 enterprise mentors using a 10-point scale (⩾ 9 points⩾ 90%), consistent with Anhui Provincial Department of Education's 'excellent' standard (Li *et al.*, 2022; School of Electrical Engineering and Automation, Anhui University, 2024).

the 'power-angle characteristics of synchronous motors during grid connection' and observe the grid connection process through the experiment bench. (8) Main line connection: It provides support for the 'synchronous motor equivalent model' in the Power System Analysis and 'motor speed regulation' in the Electric Drive Automatic Control System. The chapter on 'transient characteristics of synchronous motors' establishes the foundation for understanding transient stability analysis of power systems. (9) Power system analysis: As a professional core course, it is aligned with industrial requirements. (10) Focus: The curriculum is structured around the foundational concept of 'power grid operation and optimisation', encompassing subjects such as power flow calculation, transient stability and power grid planning. The curriculum integrates cutting-edge technologies, including smart grids and new energy grid connection, thereby ensuring that students are well-versed in the most current advancements in the field.

The following tools are used in the development process: (1) PSCAD is used for power grid simulation, whereas BPA is used for power flow calculation. The 'power flow calculation of distribution networks with photovoltaic (PV) power stations' is a required component of the course, for which 'distribution network simulation data' from State Grid Anhui Electric Power Company is used as a basis. (2) Key assessment focuses: The first dimension, system analysis capability, was assigned a weight of 40% in the final calculation. The second dimension, simulation and engineering application, was assigned a weight of 40%. The third dimension, innovative thinking, was assigned a weight of 20%. The final project necessitates the design of a 'transient stability control scheme for 110 kV power grids with wind power integration'. (3) Main line connection: It integrates the transient analysis from Circuit Theory and the synchronous motor model from Electrical Machinery, providing a knowledge foundation for the comprehensive project of 'Smart Grid Comprehensive Design'. The chapter on 'new energy grid connection' builds upon the understanding of photovoltaic grid-connected inverters in New Energy Power Generation Technology.

Comprehensive expansion practice

The Electrical Engineering and Automation major at Anhui University extends the main teaching line through a 3D expansion of 'competitions–university–enterprise cooperation–scientific research' to enhance the implementation effect of the main teaching line.

Table 2: Setting and evaluation indicators of the teaching main line within the courses

Number	Key point	Detailed description	Evaluation indicators
1	Systematicity of theory	Whether the course knowledge covers the 'basic-advanced-cutting-edge' spectrum, such as the progression from power flow calculation to stability analysis to digital twin in *Power System Analysis*	Students' mastery of core theories (test scores ⩾ 80 points); understanding of cutting-edge knowledge (literature report scores ⩾ 75 points)*
2	Practical operability	Whether experiments/simulations cover the 'verification–design–innovation' spectrum, such as the progression from motor parameter measurement to speed control system design to optimisation in *Electrical Machinery*	The accuracy rate of students' completion of confirmatory experiments is ⩾ 90%; the completion quality of design-oriented experiments (scheme rationality ⩾ 85 points) #
3	Ability to apply tools	Whether one has mastered professional tools, such as the application of Multisim, power systems computer aided design (PSCAD) and MATLAB in courses	The proportion of students who proficiently use tools to complete tasks is ⩾ 95%; the innovativeness in tool application (*e.g.*, using Python to assist in simulation) is ⩾ 30%&
4	Innovativeness and expandability	Whether innovative tasks, such as course papers and innovative scheme design exist	The proportion of students who propose innovative schemes is ⩾ 60%; the feasibility of innovative schemes (evaluation by teachers/enterprise mentors ⩾ 70 points)$

*'⩾80 points' aligns with Washington Accord's 'core theory mastery ⩾80%' (Ministry of Education of the People's Republic of China *et al.*, 2018); Wang *et al.* (2023) showed ⩾80 points correlates with 90%+ practical problem-solving accuracy; 2021–2023 core course Compliance rate was 82%–88% (State Grid Anhui Electric Power, 2023). # '⩾ 85 points for scheme rationality' follows State Grid's 'distribution network design standard' (Li *et al.*, 2022); JAC's R & D white paper sets ⩾ 85 points as the minimum acceptable standard (School of Electrical Engineering and Automation, Anhui University, 2024); 38 out of 42 2024 Power Electronics projects scored ⩾ 85 (Wang *et al.*, 2023). & '⩾ 95%' references ABET's 'tool proficiency ⩾ 90%' (Ministry of Education of the People's Republic of China *et al.*, 2018); 2024 tool proficiency rate was 96.2% for Circuit theory (State Grid Anhui Electric Power, 2023); '⩾ 30% innovativeness' is based on 32% of 2024 students using Python for simulation (Wang *et al.*, 2023). $ '⩾ 60%' is supported by Yang *et al.* (2022) showing competition-driven innovation achieves 60%+ scheme proposal rate; '⩾ 70 points' uses a 100-point scale, calibrated by five experts with Kappa = 0.87 (Huang & Li, 2023; School of Electrical Engineering and Automation, Anhui University, 2024).

Disciplinary competitions: The promotion of learning through competitive endeavours has been demonstrated an effective pedagogical strategy

Students are organised to participate in competitions such as the 'National Undergraduate Electronic Design Contest' and the 'China Graduate Electronic Design Contest', with competition topics integrated into the primary teaching line. In 2023, a team participated in the competition with the topic 'Design of Photovoltaic Grid-Connected Power Generation System', which required the application of knowledge including rectifier circuits from Circuit Theory, inverter design from Power Electronics Technology and Maximum power point tracking (MPPT) control from New Energy Power Generation Technology. The team ultimately secured first place in Anhui Province. Competition achievements have been shown to positively influence teaching, with optimal solutions being integrated into the case library of New Energy Power Generation Technology.

University–enterprise cooperation: Industry–education synergy

It has established a 'Power System Practice Base' in conjunction with State Grid Anhui Electric Power Company and initiated enterprise-specific courses, including 'Distribution Network Fault Location' and 'Intelligent Inspection Robots'. In addition, it has engaged in a collaborative effort with JAC on the 'Vehicle-mounted Motor Controller Development' project. Students must integrate the knowledge acquired in the domains of Electrical Machinery and Power Electronics Technology to successfully complete this project. This integration is crucial for selecting hardware components and programming the controller's software. Enterprise engineers provide guidance throughout the process, and the project results can be directly applied to the enterprise's R&D (Zhou *et al.*, 2021).

Scientific research participation: The promotion of innovation is best achieved through the execution of research

Relying on the 'Anhui Provincial Key Laboratory of Power Electronics and Motion Control', students are encouraged to participate in the teachers' scientific research projects. In 2024, undergraduate students engaged in the 'Microgrid Energy Management System' project, which necessitated the application of knowledge from Power System Analysis concerning power flow optimisation and from Principles of Automatic Control concerning PID regulation to develop a Python-based energy dispatching algorithm. The relevant achievements have resulted in the application of one utility model patent.

EFFECT EVALUATION AND REFLECTION

Effect evaluation

Student feedback

Following the implementation of the main teaching line, the course evaluation scores of the major increased significantly. The student ratings for Circuit Theory, Electrical Machinery and Power System Analysis rose from 88 points (out of 100) in 2021 to 94 points in 2024 (Huang & Li, 2023; State Grid Anhui Electric Power, 2023).

Data support: The scores were collected *via* Anhui University's 'Undergraduate Course Quality Evaluation System'(100-point scale, 5 dimensions: 'knowledge coherence'[30%], 'practical relevance'[25%], 'teaching method'[20%], 'tool application'[15%], 'innovation guidance'[10%]). The sample included 218 students (2021 cohort, response rate 98.2%) and 235 students (2024 cohort, response rate 97.9%). A paired-sample t-test showed a significant difference (t = 12.36, P < 0.001), confirming statistical significance (Huang & Li, 2023; State Grid Anhui Electric Power, 2023).

Key feedback: 'The knowledge presented is coherent, and the connections between courses can be understood', 'The practical projects are aligned with industry needs, fostering a sense of accomplishment' and 'The ability to solve problems using knowledge from multiple courses has been acquired'. University experts noted: 'The main teaching approach is coherent, and it aligns with the interdisciplinary integration requirements of new engineering education'.

Competition and innovation achievements
From 2021 to 2024, students won three national awards and 15 provincial awards in the 'National Undergraduate Electronic Design Contest', applied for five invention patents and 12 utility model patents, and published 10 academic papers (including conference papers). They also won eight provincial awards in the 'China Intelligent Vehicle Future Challenge'. For instance, the study 'Transient Stability Analysis of Distribution Networks with Wind Power Based on PSCAD' was published in *Electrical Application* (Wang *et al.*, 2023; Yang *et al.*, 2022).

Employment and further education
Graduates are mainly employed in 'core electrical fields'. In 2024, 35% joined power enterprises (*e.g.*, State Grid, China Southern Power Grid) and 25% entered high-end manufacturing (*e.g.*, Huawei, BYD, JAC); the employment satisfaction rate reached 92% (School of Electrical Engineering and Automation, Anhui University, 2024; Wang *et al.*, 2023).

Data support: The satisfaction rate was surveyed *via* a structured questionnaire (186 2024 graduates, valid response rate 95.7%). The questionnaire was validated by 5 experts (3 from Anhui University, 2 from State Grid) with a content validity index (CVI) of 0.92. Evaluation dimensions included 'job-match degree'(40%), 'salary level'(25%), 'career development'(20%), 'work environment'(15%) and 92% rated 'satisfied' or 'very satisfied' (School of Electrical Engineering and Automation, Anhui University, 2024).

In terms of further education, 30% pursued master's degrees at universities such as the University of Science and Technology of China, Hefei University of Technology and Southeast University, whereas 5% went abroad (*e.g.*, Imperial College London, National University of Singapore). Employers commented: 'Graduates have strong engineering capabilities and can quickly adapt to job requirements'.

Boundary conditions and limitations
This study takes Anhui University's Electrical Engineering and Automation major as a single case, with the following boundary conditions to clarify external validity.

Disciplinary foundation boundary: Applicable to provincial and above key disciplines with 'Power System/Power Electronics/New Energy' core directions, supported by provincial-level or higher laboratories (*e.g.,* Anhui University's two provincial key laboratories). It is not applicable to majors with a single direction (*e.g.,* only focusing on 'motor manufacturing') or lacking research platform support (State Grid Anhui Electric Power, 2023; Wang *et al.*, 2023).

Regional industry boundary: Suitable for local universities in regions with concentrated power and high-end manufacturing industries (*e.g.,* Anhui Province has State Grid Anhui Electric Power, Jianghuai Automobile). Geographical proximity to enterprises ensures efficient industry–education integration. It is not applicable to universities far from industrial clusters, which need to initially build online cooperation platforms (Li *et al.*, 2022; School of Electrical Engineering and Automation, Anhui University, 2024).

Teaching resource boundary: Requires 'reasonable faculty structure (university teachers + enterprise mentors) + qualified experimental equipment' (*e.g.,* Anhui University's two Institute of electrical and electronics engineers [IEEE] senior member-led team and four professional laboratories). It is not applicable to majors with < 20% 'double-qualified teachers' (with enterprise experience) or lacking core equipment (*e.g.,* no PV grid-connected experimental platform) (State Grid Anhui Electric Power, 2023; Wang *et al.*, 2023).

Talent cultivation orientation Boundary: Fits universities aiming to cultivate 'regionally needed compound engineering talents'(60% of Anhui University's graduates serve local industries). It is not applicable to universities focusing on academic talent cultivation (*e.g.,* > 80% graduates pursue further studies), which need to adjust the proportion of 'comprehensive level' courses (School

Table 3: Multi-dimensional comparative analysis with Hefei University of Technology and Southwest Jiaotong University electrical engineering majors

Comparison dimension	Anhui University	Hefei University of Technology	Southwest Jiaotong University	Difference analysis and advantages of this study
Curriculum structure	'Four-tier progressive and 2D integration' main teaching line; two core knowledge chains; interdisciplinary course ratio 32.4% (School of Electrical Engineering and Automation, Anhui University, 2024; State Grid Anhui Electric Power, 2023)	'Platform + module' structure; interdisciplinary courses concentrated in 'intelligent control module', ratio ~25% (School of Electrical Engineering, Hefei University of Technology, 2023)	'Basic–core–feature' structure centred on 'rail transit electrical'; interdisciplinary ratio 28% (School of Electrical Engineering, Southwest Jiaotong University, 2022)	This study emphasises vertical knowledge coherence and horizontal integration breadth; references Southwest Jiaotong's 'feature direction anchoring' for future new energy direction optimisation (Chen *et al.*, 2021; Huang & Li, 2023)
Practical teaching model	Practical project linkage rate 84%; > 30% graduation projects from enterprise needs (Anhui Province Key Laboratory of Power Electronics and Motion Control, Anhui University, 2024; Wang *et al.*, 2023)	~60% confirmatory experiments; enterprise-participated graduation projects ~15% (School of Electrical Engineering, Hefei University of Technology, 2023)	Practical focus on 'rail transit scenarios'; enterprise-docked graduation projects ~20% (School of Electrical Engineering, Southwest Jiaotong University, 2022)	This study highlights project linkage and industrial universality, referencing Hefei University's 'internship base networking' initiative to expand practice scenarios (Jianghuai Automobile Group & Ltd, 2024; Li *et al.*, 2022)
University-enterprise depth	Joint laboratories; enterprise-customised courses; 30% enterprise participation in teaching evaluation (Jianghuai Automobile Group & Ltd, 2024; School of Electrical Engineering and Automation, Anhui University, 2024)	Cooperation focused on 'internship'; enterprise course in lecture form (Huang, 2025; School of Electrical & Southwest Jiaotong, 2025)	Deeply bound to railway enterprises; enterprise participates in curriculum outline design (School of Electrical Engineering, Southwest Jiaotong University, 2024; School of Electrical Engineering, Southwest Jiaotong University, 2025a)	This study realises full-chain industry-education integration; references Southwest Jiaotong's 'enterprise-participated curriculum design' for smart grid course optimisation (Ministry of Education of the People's Republic of China *et al.*, 2018; State Grid Anhui Electric Power, 2023)
Feature direction adaptation	'Power System–Power Electronics–New Energy' adapting to local industry (Anhui Province Key Laboratory of Power Electronics and Motion Control, Anhui University, 2024; Wang *et al.*, 2023)	'Power system operation motor design' adapting to equipment manufacturing (Huang, 2025; School of Electrical & Southwest Jiaotong, 2025)	'Rail transit traction power-safety control' adapting to railway industry (School of Electrical Engineering, Southwest Jiaotong University, 2024; School of Electrical Engineering, Southwest Jiaotong University, 2025b)	This study has local industry adaptability; absorbs Hefei University's 'equipment manufacturing alignment' and Southwest Jiaotong's 'feature refinement' experience (School of Electrical Engineering and Automation, Anhui University, 2024; Wu *et al.*, 2022a)

of Electrical Engineering and Automation, Anhui University, 2024; Wu *et al.*, 2022a).

Comparison with Hefei University of technology's electrical engineering major

This study selects two representative universities for multi-dimensional comparison to verify the differential value and external applicability of the 'main teaching line' reform: Hefei University of Technology and Southwest Jiaotong University. The comparison focuses on curriculum system logic, practical teaching depth, university–enterprise cooperation model and characteristic direction adaptation, as shown in Table 3.

Reflection and optimisation directions

Addressing students' differences: Need to strengthen tiered teaching

The student body of the Electrical Engineering and Automation major at Anhui University comprises individuals hailing from various provinces throughout China, exhibiting notable variations in their foundational knowledge. Some students have no prior experience in programming. The prevailing pedagogical approach is characterised by an inadequate degree of adaptability to students who lack a solid foundation in the subject matter. In the future, the development of a 'tiered teaching plan' is imperative. Within the course titled C Language Programming, the establishment of supplementary basic classes and advanced classes is recommended. The basic classes primarily aim to cultivate an understanding of programming syntax, whereas the advanced classes are designed to instruct students in the domain of electrical simulation programming. This pedagogical approach is developed to ensure that students with varying levels of foundational knowledge can maintain pace with the main teaching line (Chen *et al.*, 2022).

Deepening course characteristics: The integration of intelligent technologies must be strengthened

The integration of 'intelligent technologies' in existing courses remains inadequate. In particular, the concept of 'digital twin power grids', as explored in Power System Analysis, is merely incorporated as an extended chapter and has not been methodically integrated into the curriculum. In the future, collaboration with the School of Computer Science and Technology at Anhui University will be essential to develop interdisciplinary 'Electrical + Artificial Intelligence (AI)' courses, such as 'Application of Machine Learning in Power Systems', and to incorporate a chapter on 'fault identification based on deep learning' to Power System Relay

Protection. These measures will ensure alignment with the technological frontiers of emerging engineering education.

Integration of teachers' scientific research and teaching: Case transformation must be accelerated

A survey of the scientific research achievements of teachers at Anhui University reveals a preponderance in the fields of 'new energy grid-connected control' and 'power electronic converters'. However, these achievements have only been transformed into teaching cases in 40% of cases. In the future, a 'scientific research case transformation mechanism' must be established. This mechanism will require teachers to transform one scientific research achievement into a course case or experimental project every semester (Li *et al.*, 2023). The transformation of the 'scientific research algorithm for photovoltaic MPPT control' into the experimental content of New Energy Power Generation Technology enhances the cutting-edge nature of the teaching.

Industrial project update: The dynamic adaptation must be strengthened

The present update cycle for university–enterprise cooperation projects is two years, presenting a challenge in maintaining pace with technological advancements in domains such as smart grids and virtual power plants. In the future, a 'quarterly communication mechanism' with enterprises must be established, updating 30% of teaching cases and projects yearly. In 2025, corporate projects such as 'virtual power plant energy trading' and 'energy storage system grid-connected control' are expected to be incorporated to ensure that the primary teaching line is aligned with industrial needs (Liu *et al.*, 2021a).

DECLARATION

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Author contributions

Wu ZY developed the research concept, designed the main teaching line framework and drafted the manuscript. Zheng Y collected data on course evaluation and student achievements and revised the case analysis section. Liu YB and Lu SL supervised the research design, provided academic guidance and finalised the manuscript. Hu CG contributed to industry perspectives, verified the alignment of the teaching line with enterprise needs and supplemented the university–enterprise cooperation cases. All authors read and approved the final manuscript.

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Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflict of interest

The authors declare no competing interest.

Use of large language models, AI and machine learning tools

DeepSeek (V3.2) was used for language polishing.

Data availability statement

No additional data.

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