

Exploration of Teaching Reform in Electronic Technology Course Based on Outcome-Based Education

Yuan Fang*, Jie Zou, Zhihao Li

School of Information Science and Engineering, Xinjiang College of Science and Technology, Korla, Xinjiang, China

**Author to whom correspondence should be addressed.*

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Abstract: Motivated by the new demands for engineering talent posed by the latest technological revolution and industrial transformation, along with the guiding principles of engineering education accreditation, this study explores teaching reform based on outcome-based education using the Electronic Technology course as a case study. To address existing challenges in teaching content, instructional models, and assessment systems, this study defined course objectives aligned with graduation requirements. A multidimensional curriculum encompassing foundational theory, cutting-edge extensions, and regionally relevant case studies was restructured. A blended learning model featuring three deeply integrated phases—“pre-class inquiry, in-class progression, and post-class extension”—was implemented alongside a diversified assessment system. Practice demonstrates that this reform effectively promotes the coordinated development of students’ knowledge, abilities, and competencies, enhances the alignment of course content with industry frontiers and regional demands, and provides a referenceable pathway for the construction of engineering foundation courses in applied undergraduate institutions in western China.

Keywords: Outcome-based education; Electronic technology; Blended learning; Evaluation system; Teaching reform

Online publication: March 12, 2026

1. Introduction

Emerging technologies like artificial intelligence, the Internet of Things, and smart manufacturing are fundamentally transforming the global industrial landscape. This rapid change places new and significant demands on China’s engineering and technical professionals to enhance their innovation, practical skills, and overall competency^[1]. Guided by the principle of accreditation^[1], the Chinese Ministry of Education has launched the “Emerging Engineering Education” initiative as a strategic response. This reform is fundamentally redirecting higher engineering education to a student-centered, outcome-focused, and quality-sustained paradigm. Such a transformation is pivotal, as it facilitates the dual objectives of elevating the caliber of engineering graduates and establishing internationally equivalent standards of educational quality^[2].

As the core region of the Silk Road Economic Belt, Xinjiang faces an increasingly urgent demand for high-caliber applied electronics and information technology professionals to support industrial upgrading and economic development. Local institutions have a vital role in serving regional strategic needs. The Electronics Technology course offered by the School of Information Science and Engineering at Xinjiang College of Science and Technology serves as a foundational core discipline for majors in electronics, information technology, and computer science. It plays an important role in cultivating students' circuit analysis and design capabilities while bridging theoretical knowledge with engineering practice.

2. Current state of course instruction

2.1. Relatively rigid curriculum content disconnected from industry frontiers and new engineering requirements

The Electronic Technology curriculum is a core course for disciplines such as Electronic Information Engineering, Communication Engineering, and Automation. It consists of three main modules: circuit analysis, analogue electronics, and digital electronics. This course aims to give students a basic understanding and practical skills in electronic systems. As a result, it forms a central pillar of the broader engineering knowledge framework^[3]. However, the course content focuses mainly on classical theories and established circuits. Textbooks are updated infrequently, so the course covers little about recent advances in the field. Technologies such as novel integrated circuit design, advanced power semiconductor devices, hardware description languages (HDL), and AI or IoT-specific chips are rarely addressed. This gap between classical and modern knowledge creates a disconnect between academic learning and industry progress. As a result, the curriculum does not motivate students to explore emerging technologies. It also does not meet the current knowledge requirements of the new engineering paradigm^[4]. In addition, the course does not clearly show electronics as the underlying hardware for fields such as computing, AI, and big data. It also lacks meaningful integration with the trend toward interdisciplinary convergence.

2.2. Teacher-centered teaching models with weak cultivation of students' practical and innovative abilities

Teaching methods often perpetuate an indoctrination model of "teacher lectures, students listen," with insufficient interaction. This approach encourages passive knowledge absorption. As a result, student initiative and innovative thinking remain underdeveloped^[5]. A key issue is the severe lag in practical teaching components, which has historically been tied to the development of laboratory infrastructure. The chronic overemphasis on theory leads to either scant lab hours or excessive dependence on simulations. Students rarely gain hands-on experience with real equipment, practical circuit soldering, or debugging. This disconnect between theory and practice entrenches a pattern of "armchair theorizing" and fails to develop the engineering thinking and complex problem-solving skills modern engineers need.

2.3. Significant variations in students' mathematical and physical foundations, coupled with generally low group learning motivation

The student cohort has heterogeneous backgrounds, leading to pronounced divergence in their foundational knowledge and understanding of prerequisites such as Advanced Mathematics and University Physics. Students with weaker preparation often struggle to grasp fundamental laws and concepts, experiencing frustration, while their well-prepared peers may become disengaged due to insufficient intellectual challenge. Consequently, a

uniform pedagogical pace and difficulty level prove inadequate to address this diversity, thereby compromising overall instructional effectiveness. Furthermore, the course content's abstract and theory-dense nature, which is poorly aligned with students' prior learning experiences, contributes to low initial engagement. Traditional didactic methods, reliant on rote memorization and decontextualized theoretical explanations, fail to render abstract knowledge tangible or to connect it meaningfully to engineering practice. This approach struggles to ignite student curiosity or a genuine desire for inquiry. The resulting lack of intrinsic motivation directly manifests as low classroom participation, limited independent study, and difficulties in knowledge internalization—creating a significant barrier to the development of higher-order, innovative capacities.

2.4. Insufficient implementation of engineering education principles, with evaluation systems failing to guide competency outcomes effectively

Traditional assessment methods overemphasize closed-book final exams, focusing on discrete knowledge points and computational skills. This approach fails to comprehensively and objectively evaluate students' integrated competencies and competencies in system design, engineering practice, teamwork, and innovation^[6]. This evaluation orientation directly leads students to adopt learning strategies focused on solving problems rather than addressing real-world challenges, running counter to the complex engineering problem-solving competency emphasized by engineering accreditation. Furthermore, the relationship between course learning objectives and program graduation requirements is unclear, and the absence of a continuous improvement mechanism based on student learning outcomes results in a lack of scientific basis and effective closed-loop feedback for enhancing teaching quality.

3. Teaching reform approach and practice

3.1. Course learning objective design based on OBE principles

Outcome-based education (OBE), a systematic educational philosophy, organizes, implements, and evaluates the entire educational process around students' ultimate learning outcomes^[7]. First articulated by Spady et al. in the 1980s, OBE has gained widespread recognition and has rapidly evolved into a core principle of international engineering accreditation, primarily due to its explicit focus on the demonstrable attainment of student competencies^[8].

The core principles of OBE can be distilled into three key tenets: (1) Outcome-oriented design: Emphasizing a “backward design” approach, where instructional systems are constructed starting from a clear definition of the competencies (outcomes) students must possess upon graduation. (2) Student-centered focus: Requiring that all instructional activities be designed and implemented with the fundamental purpose of facilitating students' achievement of these defined learning outcomes. (3) Continuous quality improvement: Achieved through establishing dynamic evaluation, feedback, and revision mechanisms based on outcome attainment data, thereby enabling a cyclical process of educational enhancement^[9].

Within the dual context of advancing engineering education accreditation and developing emerging engineering disciplines, Electronic Technology courses serving as foundational core subjects for majors in electrical engineering, information technology, and related fields must undergo reform guided by the OBE philosophy. Aligning course instructional objectives with OBE principles is essential to ensure these courses effectively contribute to fulfilling program-level graduation requirements and overarching talent development goals. To this end, the specific learning outcomes for the Electronic Technology course must be meticulously derived from and integrated with the institution's educational mission, program-specific talent development

objectives, and the stipulated graduation requirements of engineering accreditation. Given that Electronic Technology encompasses fundamental theories and analytical methods for analogue, digital, and integrated circuits, it is imperative to systematically map course content and activities onto the key competency indicators outlined in the program’s graduation requirements.

In line with the generic standards of engineering education accreditation, electronic technology courses can primarily support graduation requirement indicators such as “Engineering Knowledge,” “Problem Analysis,” “Design/Development of Solutions,” and “Use of Modern Tools.” Course learning outcomes should embody the new engineering education orientation of “strong foundation, robust practice, and emphasis on innovation.” They should cultivate students’ mastery of fundamental electronic technology theories and analytical methods, equip them with circuit analysis, design, and debugging capabilities, enable them to solve complex engineering problems using modern EDA tools, and simultaneously strengthen their awareness of engineering ethics, teamwork skills, and lifelong learning abilities.

Based on the positioning of electronic technology courses within the professional curriculum and the graduation requirements they support, a backward design approach is adopted. Starting from the expected learning outcomes, the course teaching objectives are refined in reverse order. Course objectives should be specific, measurable, and clearly aligned with graduation requirements, reflecting the integration of knowledge, skills, and competencies. **Table 1** presents an example of teaching objective design for electronic technology courses:

Table 1. Correspondence between Electronic Technology course learning objectives and graduation requirements

Learning objectives		Graduation requirements
1. Master fundamental concepts, circuit structures, and operating principles of electronic technology; apply foundational engineering knowledge to analyze typical electronic circuit structures.	Engineering knowledge	Focus on fundamental theories and analytical methods, including circuit modelling, semiconductor devices, amplifier circuits, and digital logic.
2. Identify and articulate engineering problems within complex electronic systems, and conduct rational analysis and verification through modelling, computation, and simulation.	Problem analysis	Emphasizes problem decomposition, circuit modelling, performance calculation, and auxiliary analysis capabilities using software simulation tools.
3. Design, debug, and optimize analogue or digital circuit units to meet specific functional requirements, proposing viable solutions.	Design/Development solutions	Comprehensive training covering the entire process from functional analysis, circuit selection, parameter design, to physical prototyping or simulation verification.
4. Proficient in circuit simulation software, experimental instruments, and development tools, with the ability to design and test electronic systems using modern technological methods.	Utilizing modern tools	Emphasizes practical proficiency with EDA tools (e.g., Multisim, PSpice, FPGA development platforms) and standard instruments.
5. Understanding of engineering ethics, environmental impact, and economic factors in experiments and projects, with teamwork and communication skills.	Engineering and society/individual and team/communication	Cultivates professional ethics and collaborative spirit through group experiments, course projects, and similar formats.

3.2. Reconstruction and optimization of teaching content

To achieve seamless alignment among course instruction, industry demands, and student development outcomes, the instructional content of electronic technology courses has undergone systematic deconstruction and reorganization in line with the OBE “backward design” principle. The core objective of this restructuring

is to break away from the linear, discipline-logic-driven organization of traditional textbooks, constructing instead a multi-layered knowledge system that is clearly structured, dynamically updated, and closely integrated with regional development. At the foundational theory level, classic content was refined by eliminating outdated circuit examples and overly complex theoretical derivations. Instead, the curriculum focused on in-depth exploration of key concepts such as semiconductor physics fundamentals, amplifiers, stability analysis of feedback systems, and combinational/sequential logic design, ensuring students build a robust and coherent knowledge framework. The Frontier Expansion Layer introduces a dedicated “Modern Electronics Technology Guide” module. Delivered as a series of micro-lectures (4–6 hours per semester), it systematically covers: fundamentals of hardware description languages; basic integrated circuit design workflows using EDA tools; and hardware architecture overviews of AI accelerators (e.g., NPUs) and IoT edge computing nodes (e.g., Cortex-M series MCUs). The Regional Integration Layer incorporates localized case studies. For instance, in teaching power electronics, the course analyzes the topologies and control strategies of wind turbine converters at Xinjiang’s Dabancheng Wind Farm. When covering sensors and signal conditioning circuits, it examines interface circuit design and anti-interference processing for soil moisture sensors within Xinjiang’s innovative drip irrigation systems for cotton fields. These case studies serve as anchors for theoretical instruction, effectively enhancing the course’s real-world relevance and students’ engineering immersion. They render abstract electronic principles vivid and accessible within concrete contexts of regional development.

3.3. Implementation pathway for deeply integrated online-offline teaching model

Guided by cognitive learning principles and OBE philosophy, a three-stage blended teaching model, termed “pre-class exploration, in-class progression, post-class extension,” is constructed around the objectives of the electronic technology course. This model progressively guides students from knowledge comprehension to comprehensive application and engineering innovation.

3.3.1. Pre-class inquiry-based learning: Stimulating intrinsic motivation and knowledge construction

Aimed at addressing foundational knowledge gaps, this phase focuses on enabling students to grasp core electronic concepts and typical circuit principles. Pre-class learning is facilitated through a combination of cutting-edge application introductions, online self-study of fundamental theories, and guided problem chains. First, instructors stimulate inquiry by presenting videos or scenarios that highlight advanced applications (e.g., innovative hardware, IoT terminals, new-energy vehicle electronics). Students then complete theoretical study of assigned chapters on the Yuke Classroom platform and engage with guided exercises and brief simulations centered on pivotal knowledge points, such as transistor amplification principles and logic gate functions. This process cultivates students’ independent information acquisition and knowledge-building, establishing an essential foundation for deeper in-class learning^[10].

3.3.2. Classroom progressive learning: Deepening critical thinking and applied analysis skills

Focused on the application of theory to circuit analysis and preliminary design, this phase aims for students to master analysis methods, understand parameter-performance relationships, and accomplish basic circuit design and verification. Implementation follows an integrated approach that combines focused instruction on key/difficult points, Pair-and-Discuss (PAD) seminars, and simulation/experiment case studies. This is realized by instructors first providing concentrated lectures on pivotal topics like frequency response and sequential logic

design. Students then tackle engineering cases (e.g., op-amp circuit design) through self-study and structured group discussion within PAD seminars, utilizing Multisim tools for immediate simulation and optimization. The phase thereby emphasizes cultivating an engineering mindset, analytical rigor, and collaborative problem-solving skills.

3.3.3. Post-class extension learning: Developing comprehensive design and engineering practice capabilities

This phase focuses on integrating knowledge and solving complex problems. Students synthesize knowledge to design electronic system modules. Using a project-based approach and a virtual simulation platform, students complete a team project, such as designing an audio power amplifier or a digital temperature acquisition system. The project covers the full cycle: proposal, design, simulation, debugging, and reporting. Students must also consider factors like cost and societal impact. This process develops practical problem-solving skills, project management, and innovative thinking, building an engineering mindset and a systems perspective.

The entire teaching process achieves a fundamental shift from uniform instruction to precision empowerment and from knowledge transmission to competency development through seamless online-offline integration and data-driven feedback loops.

3.4. Building a diversified assessment system and continuous improvement mechanism

To counterbalance traditional assessment tendencies, which often overemphasize final examinations at the expense of learning processes and prioritize theoretical knowledge over practical skills, the teaching team has systematically reformed the course evaluation system. The reform aims to establish an integrated, multidimensional framework that combines summative and formative assessments, balances theoretical understanding with applied innovation, and accommodates both standardized benchmarks and individual growth. This approach enables more comprehensive, objective measurement of student learning outcomes, thereby effectively supporting the attainment of both course objectives and the overarching program graduation requirements.

3.4.1. Reconstructing the assessment structure: From static to dynamic

Driven by the need to move beyond the limitations of a single high-stakes exam, the course assessment has been fundamentally restructured into a comprehensive framework. This model integrates continuous formative evaluation with summative judgment through three deliberately weighted components: classroom performance (25%), applied practical outcomes (25%), and a final theoretical assessment (50%).

The classroom performance rewards the completion of the learning process, assessing preparatory work, participation, assignments, and collaboration to incentivize daily engagement. The applied practice segment evaluates comprehensive project-based work and simulations, specifically targeting the competency to employ modern tools for solving complex engineering problems like circuit design. The final exam provides a rigorous, systematic evaluation of integrated conceptual understanding and analytical skill.

Thus, the reformed system operationalizes an educational philosophy that values robust foundational knowledge and applied competence equally. It mitigates the drawbacks of both a deterministic final-exam model and an unstructured multiplicity of small assessments. The result is a standardized yet pedagogically clear and practical method that yields a more valid, reliable, and holistic measure of student learning outcomes, thereby directly supporting the attainment of defined course and program objectives.

3.4.2. Deepening evaluation specifications: Aligning objectives with quantified competencies

To ensure each assessment precisely supports specific course learning objectives and graduation requirements, the course establishes detailed quantitative evaluation standards. Assessment items are closely aligned with five core competencies:

- (1) Assessment of engineering knowledge: Conducted primarily through chapter assignments and pre-class quizzes. An excellent grade requires accurate mastery of fundamental concepts and principles, demonstrated through standardized problem-solving processes that effectively transfer knowledge. A failing grade indicates significant conceptual confusion or fundamental methodological errors.
- (2) Assessment of problem analysis competency: Evaluated through simulation analysis reports (e.g., amplifier distortion analysis, timing circuit verification). An excellent evaluation demands not only correct circuit modeling, parameter setting, and result acquisition but also emphasizes in-depth data analysis and rational interpretation of phenomena to draw rigorous engineering conclusions.
- (3) Assessment of design and development solution capability: This constitutes the core of the capability assessment for project deliverables (e.g., functional analogue or digital subsystems). Evaluation criteria include solution rationality, innovation, functional completeness, performance metrics, and documentation standards. Outstanding designs demonstrate clear engineering logic and a comprehensive approach to solving complex problems.
- (4) Assessment of modern tool usage competency: Integrated throughout experimental procedures and EDA tool operations. High evaluations require the proficient, accurate, and efficient application of tools such as Multisim, oscilloscopes, and signal generators to complete design, simulation, and debugging tasks.
- (5) Assessment of individual, teamwork, and communication competencies: Implemented via group project presentations and structured peer evaluation. The focus is on evaluating a student's contribution to team roles, collaborative efficiency, and communication clarity—including the ability to articulate design concepts and respond effectively to questions.

3.4.3. Implementation effectiveness of the system: Driving continuous improvement and competency development

Through these reforms, a precise and tiered quantitative evaluation mechanism has been established for the course. This system embeds assessments throughout the entire learning cycle (pre-class, in-class, post-class), using blended platforms to record traceable process data. It culminates in a comprehensive evaluation report detailing each student's multidimensional development in knowledge, skills, and competencies. This report, in turn, serves two key purposes: it provides instructors with objective evidence for diagnosing effectiveness and implementing interventions, thus supporting Continuous Quality Improvement (CQI); and it empowers students to clearly identify their strengths and weaknesses. Armed with this insight, students can proactively plan their learning, transitioning from an exam-focused to a competency-driven mindset. In this way, assessment ceases to be a mere endpoint and becomes a vital catalyst for driving student achievement and cultivating high-caliber, innovative engineers.

4. Conclusion

This study conducted a systematic reform practice based on OBE principles to address critical issues in the instruction of the Electronic Technology course. By integrating the “student-centered, outcome-oriented”

philosophy throughout course goal setting, content restructuring, model innovation, and assessment reform, it has preliminarily established a new teaching system characterized by clear objectives, cutting-edge content, diverse methodologies, and scientific evaluation. The integration of local Xinjiang industry case studies not only enhances the relevance and engineering realism of teaching content but also deepens the course's value in serving regional development. The assessment structure, designed to emphasize “strong foundations and robust practice,” provides stable institutional support for cultivating students' comprehensive competencies. Reform practices have yielded positive outcomes, including increased student initiative and strengthened engineering thinking and innovation capabilities. To precisely align with frontier region industrial needs, the course team is committed to continuous improvement: optimizing teaching resources and project design based on learning outcomes and feedback, deepening university-industry collaboration, and solidifying the foundation for cultivating high-caliber applied engineering talent.

Funding

This work was supported by the 2023 Teaching Reform Project of Xinjiang College of Science and Technology, China, “OBE-Based Teaching Reform in Electronic Technology Course” (JGPT-23-15).

Disclosure statement

The authors declare no conflict of interest.

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