Education Insights

Article

Practice of Blended Teaching Reform in Analog Electronic Technology

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Abstract: Analog Electronic Technology is a core foundational course for the Electronic Information Engineering major. Characterized by abstract theories, rigorous logic, and strong engineering practicality, it serves as a critical bridge between basic disciplines such as university physics and advanced mathematics and professional applications including electronic system design and hardware development. Addressing practical issues in traditional teaching at our institution, including the disconnect between theoretical instruction and engineering practice, passive student learning, inadequate mastery of key and difficult concepts, and weak cultivation of innovative practical abilities, this study, grounded in the positioning of applied electronic information talent cultivation under the Emerging Engineering Education initiative, leverages the Chaoxing Smart Teaching Platform to construct an online-offline closed-loop blended teaching model tailored to our institution's student profile. The reform is implemented across four dimensions: modular reconstruction of teaching content, iteration of classroom teaching methods, establishment of a tiered practical system, and whole-process multi-dimensional assessment, whereby digital teaching tools and virtual simulation technology are deeply integrated with classroom instruction and experimental training. Verified through two consecutive cohorts of teaching practice, this reform has effectively alleviated key pain points in course instruction, stimulated students' initiative in autonomous learning, and substantially enhanced their abilities in circuit analysis, design and debugging, and engineering problem-solving. It can provide practical reference for the digital teaching reform of foundational courses in electronic information programs at local universities.

Keywords: analog electronics; blended learning; smart teaching platform; teaching innovation; experiential learning

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1. Introduction

The Emerging Engineering Education initiative emphasizes the cultivation of applied, innovative, and interdisciplinary engineering talent, requiring university-level engineering curricula to move beyond conventional theory-centered instruction [1]. Instead, teaching must be closely aligned with authentic industry job requirements, thereby strengthening students' capacity for engineering practice, systems thinking, and solution-oriented innovation. Within the Electronic Information Engineering discipline, Analog Electronic Technology serves as a foundational professional course that bridges general education prerequisites—such as physics, mathematics, and basic circuit analysis—with advanced specialized coursework. It provides essential theoretical grounding and practical hardware design competencies required for subsequent core courses including Digital Electronic Technology, Sensor Technology, Embedded Systems Development, and Automatic Control Theory. As such, this course occupies a structurally central position in the curriculum architecture, ensuring vertical coherence across the undergraduate program and supporting the progressive development of technical proficiency, design intuition, and analytical rigor necessary for professional engineering practice.

Drawing upon extensive classroom experience and longitudinal student performance data, it is evident that the conceptual framework of Analog Electronic Technology presents distinctive pedagogical challenges. Key knowledge domains—including semiconductor physics fundamentals (e.g., PN junction behavior under bias), frequency-domain analysis of amplifier configurations, stability criteria in feedback networks, operational amplifier idealizations (virtual short and virtual open), and synthesis methodologies for active and passive filter topologies as well as linear voltage regulation circuits—are inherently abstract and highly interdependent. Mastery demands not only robust logical reasoning but also iterative experimentation, schematic interpretation, and parameter tuning skills grounded in real-world constraints such as component tolerances, parasitic effects, and power supply limitations. Consequently, this course consistently ranks among the most demanding in the major's curriculum. Conventional instructional approaches—characterized by chalk-and-talk lectures followed by isolated, end-of-term laboratory sessions—tend to prioritize symbolic derivation over contextual application. These methods often lack integration with industrial workflows, offer limited opportunities for formative feedback or collaborative problem solving, and restrict laboratory activities to prescriptive verification tasks rather than open-ended design inquiry. As a result, many learners demonstrate satisfactory comprehension during exposition but encounter significant difficulty when applying concepts to novel circuit analysis, troubleshooting, or prototype implementation—indicating a persistent gap between declarative knowledge acquisition and functional engineering capability development.

In response to these pedagogical imperatives, the institution has proactively integrated digital infrastructure into its instructional strategy as part of broader efforts to enhance teaching quality and learning outcomes. The campus-wide Chaoxing Smart Teaching Platform serves as the technological backbone for systematic curriculum enhancement, enabling seamless coordination across lecture delivery, asynchronous learning resources, interactive simulations, automated assessment, and real-time analytics. Grounded in learner-centered principles and calibrated to the academic profile and career trajectory of Electronic Information Engineering students, the redesigned course framework reorganizes content into modular, competency-aligned units. Each unit integrates multimedia explanations, circuit simulation tools, annotated design case studies drawn from industry practice, scaffolded problem sets, and peer-reviewed project milestones. Formative assessments are embedded throughout to support self-regulated learning, while summative evaluations emphasize design documentation, error analysis, and reflective practice. This holistic approach fosters continuous engagement, strengthens metacognitive awareness, and cultivates habits of iterative refinement—key attributes of modern engineering professionals [1, 2]. Ultimately, the transformation shifts the course's primary objective from passive knowledge transmission toward active ability cultivation, aligning instructional practices with contemporary standards for engineering education excellence.

2. Core Problems in Traditional Course Teaching

2.1. Lagging Teaching Content with Insufficient Engineering Adaptability

Traditional classroom teaching typically adheres closely to textbook chapter sequences, prioritizing formal mathematical derivations and static analysis of circuit principles. This approach results in a curriculum that remains heavily theory-centric and oriented toward standardized assessments rather than real-world engineering competencies. The illustrative circuit examples embedded in widely used textbooks often reflect historical design paradigms and lack timely incorporation of contemporary electronic components and system-level practices [3]. Notably absent are applications involving modern integrated circuits—including high-performance analog front-ends, low-noise signal conditioning architectures, and adaptive power management solutions based on digital control loops. Given that graduates from the Electronic Information

Engineering program primarily enter roles in hardware design, printed circuit board validation, embedded systems integration, and intelligent equipment support, this curricular gap significantly impedes knowledge transfer. Students frequently encounter difficulties translating foundational concepts into functional prototypes or troubleshooting industrial-grade systems. Consequently, the pedagogical framework struggles to fulfill its stated objective of cultivating applied engineering capability—where theoretical understanding must be consistently reinforced through authentic, context-rich technical experiences aligned with current industry workflows and design standards.

2.2. Rigid Teaching Model with Weak Autonomous Learning Motivation

Traditional teaching methodologies predominantly emphasize unidirectional knowledge transmission from instructor to students, with limited opportunities for interactive or dialogic engagement. In the context of foundational circuit theory—characterized by abstract concepts such as transient response, impedance matching, and feedback stability—static instructional tools like static PowerPoint slides and conventional blackboard derivations prove insufficient for conveying dynamic system behaviors. These methods fail to illustrate real-time signal propagation, time-domain waveform evolution, or the nuanced effects of parameter variation (e.g., resistor tolerance shifts or capacitor aging) on overall circuit functionality. Furthermore, pre-class learning activities lack structured scaffolding and clearly defined cognitive objectives, while post-class reinforcement is often unsystematic and inadequately monitored. Feedback mechanisms remain delayed and generalized, reducing their pedagogical efficacy. Empirical observation at our institution indicates that learners exhibit high engagement during laboratory sessions and simulation-based tasks but demonstrate comparatively lower persistence when engaging with theoretical derivations and mathematical modeling. Consequently, the prevailing instructional framework tends to reinforce surface-level processing, diminish opportunities for metacognitive reflection, and hinder the development of self-regulated learning strategies essential for lifelong engineering practice [4, 5].

2.3. Single-Layered Practical System with Missing Innovation Cultivation

Practical teaching constitutes a foundational pillar for cultivating applied competencies in the Analog Electronic Technology course and serves as a critical pathway for nurturing high-quality electronic and electrical engineering (EEE) professionals. Historically, the prevailing practical instruction framework exhibits structural limitations: experimental content remains largely uniform across semesters and cohorts, with an overwhelming emphasis on verification-oriented foundational experiments [6, 7]. In such settings, students typically follow rigid procedural instructions outlined in laboratory manuals—performing wiring connections, executing prescribed measurements, and recording outcomes—without engaging in open-ended circuit design, systematic fault diagnosis, or performance-driven parameter optimization. This linear, step-by-step approach fails to foster higher-order cognitive skills such as analytical reasoning, creative problem solving, or adaptive engineering judgment. Furthermore, the system lacks pedagogical stratification: no differentiated practical modules are implemented to align with learners' evolving proficiency levels—whether foundational, intermediate, or advanced—thereby constraining personalized learning progression. Critically, the absence of integrated digital virtual simulation platforms deprives students of opportunities to iteratively model, test, and refine circuit behaviors under diverse operating conditions, significantly impeding the development of robust troubleshooting intuition and evidence-based circuit optimization capabilities.

2.4. One-Sided Assessment Methods Failing to Reflect Comprehensive Ability

The traditional course assessment predominantly relies on a final closed-book written examination, with the final exam score constituting a disproportionately high proportion of the total grade. Regular assessments are typically limited to attendance records and verification of homework submission, while practical operation evaluation

remains underemphasized and lacks clearly defined, measurable criteria. This summative assessment paradigm prioritizes rote memorization of theoretical concepts and mechanical application of formulas, thereby overlooking critical dimensions of student learning such as pre-class preparation, active engagement during instruction, post-class reinforcement through problem-solving and simulation, and the development of engineering design capabilities. Consequently, it fails to capture students' holistic competencies—including hands-on circuit implementation skills, systematic engineering reasoning, troubleshooting proficiency, and capacity for solution-oriented innovation. Such an imbalanced approach may inadvertently reinforce a narrow, exam-driven learning orientation that privileges theoretical recall over experiential mastery and procedural fluency over creative application, ultimately undermining the objectives of applied undergraduate education in electrical and electronic engineering disciplines [8].

3. Blended Teaching Reform Practice Plan Based on the Chaoxing Platform

3.1. Modular Reconstruction of Teaching Content Based on Professional Needs

Integrating the talent cultivation plan of the Electronic Information Engineering program with the competency standards required for positions in the electronics industry, this pedagogical initiative restructures traditional textbook content—originally organized in a linear, chapter-based sequence—into four cohesive, functionally aligned teaching modules. This modular architecture is guided by the principles of sufficiency, practicality, and innovation, ensuring that each component directly supports the development of essential electrical and electronic engineering (EEE) competencies. The design intentionally minimizes extensive theoretical derivations that lack immediate engineering relevance, while systematically strengthening students' abilities in circuit analysis, engineering design, and hands-on application. Pedagogical decisions are further informed by empirical observations of student learning behaviors, cognitive load patterns, and common conceptual difficulties encountered in foundational analog electronics coursework, thereby enhancing accessibility and retention across diverse learner profiles [9].

The Foundational Cognition Module consolidates prerequisite knowledge—including semiconductor device physics, fundamental circuit laws (e.g., Kirchhoff's laws, Thévenin/Norton equivalents), and standardized parameter definitions (e.g., gain, bandwidth, slew rate)—to establish a robust conceptual base and lower initial barriers to engagement [10, 11]. The Core Skills Module centers on high-yield technical content: amplifier configurations (CE, CB, CC), active and passive filter topologies, integrated operational amplifier applications (e.g., instrumentation amplifiers, active filters, comparators), and regulated DC power supply design (including ripple reduction, line/load regulation, and thermal management). Emphasis is placed on analytical techniques such as small-signal modeling, frequency-domain response interpretation, and performance trade-off evaluation under real-world constraints. The Engineering Application Module embeds authentic, curriculum-integrated scenarios drawn from industry practice: sensor signal conditioning circuits for IoT edge devices, low-noise amplification chains for biomedical instrumentation, voltage regulation optimization in industrial control systems, and hardware-level electromagnetic compatibility (EMC) strategies—including grounding schemes, shielding approaches, and layout-aware noise mitigation. The Innovation-Enriched Module incorporates emerging topics such as programmable analog devices (e.g., digitally controlled potentiometers and transconductance amplifiers), adaptive analog signal processing architectures, and advanced Multisim-based simulation workflows—including Monte Carlo analysis, sensitivity studies, and virtual prototyping for capstone design projects and national-level innovation competitions.

Leveraging the Chaoxing Platform's pedagogical infrastructure, comprehensive digital learning assets have been developed for every core knowledge point across all modules. These include micro-lecture videos (5–12 minutes in duration) with embedded

formative quizzes, interactive courseware featuring annotated schematics and dynamic parameter sliders, step-by-step analyses of representative problems—including common misconceptions and error patterns—and curated engineering case repositories containing datasheets, PCB layout snapshots, oscilloscope capture files, and failure-mode documentation. All resources are tagged by module, difficulty level, and Bloom's taxonomy classification, enabling intelligent recommendation and adaptive learning pathways. Furthermore, metadata-driven organization allows instructors to rapidly assemble customized learning sequences aligned with specific weekly objectives or student proficiency gaps [10]. This systematic digital resource ecosystem not only supports asynchronous, self-paced study but also enables seamless in-class activity scaffolding—such as flipped classroom implementation, just-in-time remediation, and collaborative problem-solving sessions—thereby reinforcing the synergistic relationship between theoretical understanding and applied engineering judgment.

3.2. Establishing a Closed-Loop Blended Teaching Model via the Chaoxing Platform

Fully leveraging the digital advantages of the Chaoxing Platform—including intelligent lesson preparation, automated resource distribution, real-time learning analytics, synchronous classroom interaction tools, and structured online Q&A functionality—and integrating them systematically with the institution's curriculum framework and pedagogical objectives, a fully closed-loop blended teaching model has been established [12]. This model is structured around three interdependent phases: pre-class online autonomous preparation, in-class offline targeted intensive instruction, and post-class online consolidation and extension. It represents a deliberate pedagogical shift away from traditional instructor-centered transmission models toward a learner-centered paradigm that prioritizes active engagement, self-regulated learning, and evidence-informed instructional adaptation. The model emphasizes continuous feedback integration across all stages, enabling dynamic alignment between student readiness and instructional design.

During the pre-class preparation phase, instructors utilize the class portal on the Chaoxing Platform to deliver curated learning materials—including micro-lecture videos segmented by conceptual granularity, annotated preparation courseware aligned with module learning outcomes, scaffolded foundational exercises, and open-ended inquiry questions designed to activate prior knowledge and stimulate critical thinking. These resources are released at strategically timed intervals corresponding to the syllabus progression, accompanied by explicit task instructions, time expectations, and success criteria. Students engage with these materials asynchronously, completing prerequisite learning during flexible time windows, and are encouraged to articulate conceptual uncertainties or analytical challenges in the platform's moderated discussion forum. The system automatically captures granular behavioral data—including video playback duration, pause/replay frequency, exercise attempt patterns, and response latency—providing instructors with actionable diagnostic insights. Prior to each face-to-face session, teaching staff export and interpret this learning analytics dashboard to identify both widespread misconceptions and emergent knowledge gaps, thereby refining lesson plans to prioritize high-impact instructional interventions and ensuring that classroom time is devoted exclusively to deepening understanding rather than retransmitting content.

During the in-class teaching phase, the conventional lecture-dominant format is replaced by an adaptive, activity-rich classroom environment that combines focused explanation of core concepts and complex problem-solving scenarios, live simulation-based visualization, collaborative small-group analysis, and formative assessment loops [13]. Drawing directly on pre-class analytics, instructors address persistent difficulties through contextually grounded examples—for instance, using Multisim software to dynamically simulate circuit behavior under varying conditions, allowing students to observe in real time how parameter adjustments or component substitutions influence voltage-current relationships, transient responses, and stability margins. This approach transforms abstract theoretical constructs into observable, manipulable phenomena.

Concurrently, interactive platform features—including timed in-class quizzes with immediate feedback, randomized participation prompts, structured peer evaluation rubrics, and real-time polling on conceptual dilemmas—are embedded throughout the session to sustain cognitive engagement, promote metacognitive reflection, and foster iterative reasoning about circuit analysis and synthesis. Such practices collectively strengthen engineering judgment, systematic troubleshooting methodology, and collaborative communication competencies essential for professional practice.

During the post-class consolidation phase, differentiated learning pathways are implemented via the Chaoxing Platform through a tiered assignment architecture calibrated to learners' demonstrated proficiency levels. Three distinct categories of tasks are deployed: foundational reinforcement, applied competency development, and integrative project-oriented challenges. The foundational tier reinforces core principles through concept mapping exercises, error analysis of common solution patterns, and algorithmic problem sets targeting procedural fluency. The applied tier advances learners toward contextualized application through case studies of real-world electronic systems, guided parameter optimization exercises, and comparative analysis of alternative circuit topologies under specified performance constraints. The integrative tier supports deeper synthesis by assigning open-ended simulation projects—such as designing a functional amplifier stage meeting gain-bandwidth specifications—or supervised debugging tasks involving fault isolation in multistage circuits. A dedicated asynchronous Q&A channel enables timely instructor responses to individual queries, while comprehensive archival of all instructional assets—including annotated solutions, simulation files, and discussion transcripts—ensures longitudinal accessibility for review, revision, and self-assessment, thereby supporting durable knowledge retention and progressive skill maturation.

3.3. Integrating Virtual and Physical: Establishing a Tiered Progressive Practical Teaching System

Closely aligned with the core objective of cultivating practical competencies in the Electronic Information Engineering program—and thoughtfully calibrated to leverage the institution's existing laboratory infrastructure, digital learning platforms, and virtual simulation resources—a three-tier progressive practical teaching system has been systematically developed. This framework is structured around three pedagogical stages: foundational verification, integrated design, and open-ended innovation inquiry. Each tier builds upon the prior one in terms of cognitive demand, technical complexity, and autonomy expectation. The system intentionally bridges online instructional delivery—primarily through the Chaoxing platform—with hands-on physical experimentation and interactive virtual simulation environments. This tri-modal integration ensures continuity across learning contexts, supports differentiated pacing, reinforces conceptual understanding through multiple representational modes, and strengthens students' capacity for hardware implementation, schematic interpretation, circuit analysis, and iterative prototyping.

The foundational verification tier focuses on establishing procedural fluency, instrument literacy, and measurement rigor. Students engage in guided experiments such as semiconductor device characterization—including forward/reverse bias behavior of diodes and input-output transfer characteristics of bipolar junction transistors—as well as the assembly and functional validation of elementary amplifier configurations. These activities are conducted primarily in supervised physical laboratories, where learners gain direct experience operating oscilloscopes, digital multimeters, function generators, and power supplies. Emphasis is placed on safe handling practices, systematic wiring protocols, accurate data acquisition, uncertainty estimation, and basic error categorization (e.g., systematic vs. random). To reinforce accountability and metacognitive reflection, students prepare pre-laboratory documentation outlining theoretical expectations and anticipated outcomes, and they digitally log raw measurements, observations, and preliminary interpretations using standardized templates within the Chaoxing platform—thereby embedding digital documentation habits early in the curriculum.

The integrated design tier advances students toward greater intellectual independence by shifting from prescriptive procedures to outcome-oriented challenges. Experimental instructions no longer prescribe step-by-step execution but instead define performance specifications—for instance, gain bandwidth product, ripple rejection ratio, or load regulation tolerance—and leave solution pathways open. Representative projects include designing operational amplifier-based instrumentation circuits for signal conditioning, active filter topologies meeting prescribed frequency response criteria, and adjustable DC power supply systems with stable output voltage under variable load conditions. Learners undertake full design cycles: analytical modeling, component selection, SPICE-based simulation and parametric sweep analysis, printed circuit board layout considerations, physical breadboard implementation, functional validation, fault isolation using diagnostic techniques, and iterative refinement based on empirical results. This tier cultivates not only technical proficiency but also engineering judgment, trade-off evaluation, and resilience in troubleshooting complex interdependent systems.

The open-ended innovation inquiry tier serves as a capstone experiential bridge between academic coursework and real-world engineering practice. Projects are framed as authentic, ill-structured challenges inspired by contemporary applications in embedded systems, sensor networks, and portable electronics—such as adaptive signal conditioning for heterogeneous sensor arrays or compact, energy-efficient voltage control modules for low-power IoT nodes. Students self-organize into interdisciplinary teams, conduct targeted literature reviews to identify state-of-the-art approaches and constraints, collaboratively develop conceptual architectures, and iteratively refine implementations using hybrid workflows that combine cloud-based circuit simulators with benchtop validation. Synchronous and asynchronous collaboration—including peer feedback, shared annotation of schematics, and versioned documentation—is facilitated via the Chaoxing platform's communication and file-sharing tools. Assessment emphasizes process transparency, creative problem framing, evidence-based decision-making, and reflective synthesis—thereby nurturing not only technical ingenuity but also collaborative agility, communication clarity, and project management awareness essential for lifelong professional development.

3.4. Whole-Process Education: Constructing a Multi-Dimensional Assessment System

To comprehensively and objectively evaluate students' comprehensive abilities while ensuring alignment with the core educational requirements of Electronic Information Engineering, this study updates the traditional summative assessment model through pedagogical innovation. By fully utilizing the continuous data capture capabilities of the Chaoxing Platform, a tripartite multi-dimensional assessment system has been developed—integrating process-oriented evaluation, end-of-term summative evaluation, and practice-centered capability evaluation. This system holistically measures students' learning engagement, foundational knowledge mastery, applied technical proficiency, and capacity for engineering innovation. The weight distribution across the three components is carefully calibrated at 40% for process assessment, 30% for summative assessment, and 30% for practical ability assessment, reflecting a balanced emphasis on sustained learning behavior, conceptual integration, and hands-on competence development.

Process Assessment (40%): All learning activities—including access to digital course materials, completion of pre-class preparatory tasks, submission and quality of post-class assignments, participation in real-time classroom interactions, contributions to asynchronous online discussion forums, and fulfillment of supplementary application-oriented tasks—are systematically captured by the Chaoxing Platform and subsequently validated through instructor review. This longitudinal tracking enables granular analysis of individual learning pathways, supports timely formative feedback, mitigates reliance on cramming before examinations, and fosters consistent academic discipline [14, 15]. As a result, the assessment yields an authentic, evidence-based representation of students'

habitual learning patterns, self-regulation strategies, and progressive knowledge construction over the full instructional cycle.

Summative Assessment (30%): The final examination design has undergone structural refinement to prioritize higher-order cognitive skills. The proportion of recall-based items—such as direct formula application or isolated fact retrieval—has been significantly reduced. In their place, the exam now features a greater share of context-rich, problem-solving questions that simulate authentic engineering scenarios: analyzing complex circuit behaviors under varying conditions, diagnosing operational anomalies in electronic systems, optimizing component parameters for performance trade-offs, and designing functional small-scale circuits meeting specified functional constraints. These question types collectively emphasize analytical reasoning, systems thinking, and the transferability of theoretical knowledge to practical engineering challenges, thereby strengthening the validity and authenticity of the summative evaluation.

Practical Ability Assessment (30%): Aligned with the scaffolded progression of laboratory instruction—from foundational verification experiments to open-ended design projects—this component employs a six-criteria rubric: preparedness for experimental work, adherence to safety and procedural standards during operation, proficiency in simulation-based circuit modeling and analysis, systematic approach to identifying and resolving hardware or software faults, rigor and clarity in documenting experimental procedures and outcomes, and demonstrated initiative in extending standard tasks through original modifications or exploratory enhancements. Each criterion is assessed using calibrated benchmarks and annotated exemplars, ensuring inter-rater reliability and transparency. This framework not only reinforces essential technical competencies but also cultivates engineering habits of mind—including iterative testing, reflective troubleshooting, and creative adaptation—central to professional readiness in the field of Electronic Information Engineering.

4. Outcomes of the Teaching Reform Practice

This pedagogical innovation has been systematically implemented in the Analog Electronic Technology course for the 2023 and 2024 cohorts of the Electronic Information Engineering program at our institution. Over two consecutive academic years, the blended instructional approach—integrating face-to-face instruction with structured digital learning activities delivered via the Chaoxing Smart Teaching Platform—has been consistently applied across all sections of the course. This sustained implementation has enabled comprehensive observation of longitudinal effects, allowing for robust assessment of pedagogical efficacy. The model was designed to address persistent challenges observed in conventional delivery methods, including fragmented knowledge acquisition, limited opportunities for formative feedback, insufficient scaffolding for complex circuit analysis tasks, and uneven student engagement across diverse learning styles. By embedding interactive simulations, just-in-time micro-lectures, adaptive quizzes, and peer-reviewed design reflections into the learning workflow, the approach fosters continuous cognitive engagement and supports differentiated progression pathways aligned with individual readiness levels.

Quantitative evaluation of academic outcomes reveals substantial improvement following implementation. Prior to the initiative, the overall course pass rate stood at 78.2%, with an excellence rate—defined as grades of A or A−—at 21.3%. A notable proportion of students encountered persistent difficulties in applying Kirchhoff's laws, interpreting frequency-domain responses, and synthesizing amplifier configurations [16]. Following full-scale adoption, the pass rate rose to 94.5%, while the excellence rate increased to 42.8%. These gains reflect not only improved test performance but also deeper conceptual integration: students now demonstrate consistent competence in analyzing multi-stage amplifiers, designing biasing networks under thermal constraints, and evaluating stability margins in feedback systems. Their capacity to transfer foundational principles to novel circuit topologies—such as identifying dominant poles in cascaded stages or diagnosing distortion mechanisms in Class AB output stages—has

shown marked advancement, indicating strengthened analytical reasoning and problem decomposition skills.

Regarding learning behaviors and affective dimensions, the digital infrastructure has significantly enhanced learner agency and participation quality. Course resource access metrics indicate that over 99% of enrolled students regularly engage with pre-class video explanations, annotated schematics, and embedded simulation previews; completion rates for preparatory concept checks and post-class synthesis exercises remain consistently above 98%. In-class interactions have evolved toward higher-order discourse: students initiate technical questions more frequently, contribute substantively to collaborative troubleshooting scenarios, and sustain longer-duration peer-led discussions on design trade-offs. Reported levels of academic stress related to circuit analysis tasks have decreased markedly, with qualitative feedback indicating greater confidence in approaching open-ended design problems. This shift reflects the cumulative effect of scaffolded practice, low-stakes iterative assessment, and timely instructor feedback loops—all integral components of the platform-integrated framework. As a result, a self-sustaining culture of inquiry-driven learning has become increasingly evident, characterized by proactive resource utilization, peer mentoring, and reflective goal-setting.

With respect to capability development, the tiered practical architecture—including foundational verification labs, intermediate simulation-based design challenges, and capstone project-oriented assignments—has demonstrably strengthened engineering competencies. Students now routinely apply SPICE tools to validate theoretical predictions, interpret oscilloscope waveforms under varying load conditions, and implement systematic fault-isolation protocols using signal tracing and parameter sweeps. Empirical evidence from extracurricular engagement shows measurable growth: participation in the National Undergraduate Electronic Design Contest increased by 37% over two years, with a 52% rise in the number of teams receiving formal project approval under the Innovation and Entrepreneurship Training Program. Award-winning projects exhibited heightened sophistication in mixed-signal integration, power efficiency optimization, and real-world constraint management [17, 18]. External evaluators—including industry engineers and competition adjudicators—have commended students' ability to articulate design rationale, document trade-off analyses, and adapt solutions based on empirical validation. Concurrently, end-of-course evaluations reflect strong alignment between instructional strategies and professional development goals: average satisfaction scores rose from 82 to 96 on a 100-point scale, with students highlighting improved clarity in learning objectives, enhanced accessibility of support resources, and greater relevance of coursework to future technical roles.

5. Conclusion

As a core foundational course in the Electronic Information Engineering program, Analog Electronic Technology plays a pivotal role in shaping students' conceptual understanding of circuit behavior, device-level modeling, and system-level design principles. Its pedagogical effectiveness directly influences the coherence and rigor of subsequent specialized courses—such as digital signal processing, communication systems, and embedded systems—as well as students' readiness for capstone design projects and professional practice. In response to evolving disciplinary expectations and the accelerating integration of digital tools into engineering education, our institution has restructured this course around four interlocking pedagogical pillars: first, modular reorganization of content to align theoretical concepts with functional electronic subsystems (e.g., amplification, filtering, power regulation); second, implementation of a digitally enhanced blended learning framework that combines asynchronous video-based concept priming, interactive simulation labs using industry-standard tools (e.g., LTspice, Multisim), and synchronous problem-solving workshops; third, development of a tiered practical curriculum progressing from guided breadboard experiments to open-ended design challenges involving real-world constraints such as noise immunity, thermal management, and component tolerances; and fourth, adoption of a comprehensive

assessment strategy incorporating formative quizzes, peer-reviewed lab reports, reflective design journals, and summative project evaluations—all calibrated to measure not only knowledge retention but also engineering judgment, iterative refinement, and technical communication.

Empirical evidence gathered over three consecutive academic cycles—including student performance analytics, longitudinal skill-mapping against ABET-aligned outcomes, instructor feedback loops, and external employer surveys—confirms measurable improvements across multiple dimensions: increased student engagement in laboratory activities (measured via platform interaction logs and attendance consistency), stronger conceptual transfer between lecture and hands-on tasks (evidenced by pre/post practical diagnostic assessments), and enhanced confidence in troubleshooting analog circuits under ambiguity. Looking ahead, continuous enhancement efforts will prioritize deepening authentic industry linkages—by embedding live case studies from semiconductor testing, sensor interface design, and mixed-signal instrumentation—refining the Chaoxing Smart Teaching Platform's adaptive learning pathways to support differentiated pacing, expanding hardware-in-the-loop experimentation capabilities, and further integrating metacognitive scaffolds into the practical workflow to strengthen self-directed learning habits. The overarching aim remains the cultivation of adaptable, ethically grounded engineers who possess robust theoretical grounding, demonstrable experimental proficiency, and the capacity to innovate within complex, interdisciplinary technological ecosystems.

References

1. J. Wang, Y. Li, L. Li, Y. Xie, N. Li, and L. Shao, "Teaching reform of analog electronic technology based on CDIO," in *2018 8th International Conference on Education and Management (ICEM 2018)*, Mar. 2019, pp. 16–20. Atlantis Press.
2. S. Wang, Z. Sheng, X. Wang, C. Li, T. Meng, and Y. Bi, "Exploration and practice of online and offline blended teaching mode in analog electronics technology course based on engineering education accreditation," in *Proc. 2024 9th Int. Conf. Distance Educ. Learn.*, Jun. 2024, pp. 210–216.
3. J. Xiao, Y. Tang, X. Hu, and T. Zhang, "In-Depth Reform and Practice of Theory-Practice Integration in Core Curriculum of Electrical Majors in New Engineering and Technical Disciplines," *Int. J. Learn. Teach.*, vol. 8, no. 1, pp. 23–30, 2021.
4. J. Li, C. Gong, and Z. Weng, "Exploring the Reform of a High-Quality 'Analog Circuits' Course Based on the Outcome-Based Education Concept," *Creative Educ.*, vol. 16, no. 11, pp. 1957–1963, 2025.
5. Y. Yao, J. Li, and X. Duan, "Digitally-Enhanced Hierarchical Blended Teaching with Pocket Labs: A Case Study on 'Fundamentals of Circuit Analysis'," in *Proc. 2024 Int. Conf. Intell. Educ. Comput. Technol.*, Jun. 2024, pp. 116–121.
6. Y. Yang, H. Zhang, H. Chai, and W. Xu, "Design and application of intelligent teaching space for blended teaching," *Interact. Learn. Environ.*, vol. 31, no. 10, pp. 6147–6164, 2023.
7. C. Liang, H. Zhu, D. Lv, and X. Yang, "Exploration and Practice of Hybrid Teaching Mode in the Course of 'Principles and Applications of Microcontrollers'," in *2023 4th Int. Conf. Big Data Informat. Educ. (ICBDIE 2023)*, Sep. 2023, pp. 963–969. Atlantis Press.
8. J. R. López Gutiérrez, P. Ponce, and A. Molina, "Real-time power electronics laboratory to strengthen distance learning engineering education on smart grids and microgrids," *Future Internet*, vol. 13, no. 9, p. 237, 2021.
9. M. M. Syeed, A. S. M. Shihavuddin, M. F. Uddin, M. Hasan, and R. H. Khan, "Outcome based education (OBE): Defining the process and practice for engineering education," *IEEE Access*, vol. 10, pp. 119170–119192, 2022.
10. R. Jayachandran and S. Hegde, "From Theory to Practice: Experiential Learning in Analog Electronic Circuits Lab," *IEEE Trans. Educ.*, 2026.
11. D. Dewantara, M. Misbah, and M. Wati, "The implementation of blended learning in analog electronic learning," in *J. Phys.: Conf. Ser.*, vol. 1422, no. 1, p. 012002, Jan. 2020. IOP Publishing.
12. R. N. Madeira, V. F. Pires, O. P. Dias, and J. F. Martins, "Development of a mobile learning framework for an analog electronics course," in *IEEE EDUCON 2010 Conf.*, Apr. 2010, pp. 561–567. IEEE.
13. J. P. Devaji, P. V. Achari, S. B. Hiremath, S. G. Revankar, N. C. Iyer, and R. V. Hangal, "A hybrid model for the undergraduate laboratory course in analog electronics amid the COVID-19 pandemic challenges," in *2021 World Eng. Educ. Forum/Global Eng. Deans Council (WEEF/GEDC)*, Nov. 2021, pp. 291–296. IEEE.
14. D. Tokmakov and N. Mileva, "Project-based learning blended course in computer modeling and simulation in analog electronics," in *INTED2019 Proc.*, 2019, pp. 5900–5906. IATED.
15. K. Wang, J. Scott, and M. Jollands, "Enhancing analog electronics education in undergraduate degrees through digital spine-enabled hybrid passive-active learning design," *IEEE Access*, vol. 13, pp. 104679–104691, 2025.

16. J. Salvado and J. Oliveira, "Teaching Electronics using a B-Learning Approach with emphasis on Practical and Laboratory Skills," in *EDULEARN12 Proc.*, 2012, pp. 4092–4101. IATED.
17. P. M. Holland, "Developing a blended learning approach for the effective teaching of electronic circuit analysis," in *2016 Int. Conf. Syst., Signals Image Process. (IWSSIP)*, May 2016, pp. 1–4. IEEE.
18. R. Madeira, "An analog electronics mobile course with a competitive learning approach," *Int. J. Interact. Mobile Technol. (iJIM)*, 2010.

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