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Classroom Practice of Analog and Digital Electronic Technology under the Collaborative Teaching Mode of AI and Teachers

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Abstract: To address the common pain points in conventional classrooms of Analog and Digital Electronic Technology, namely insufficient personalized support, disconnection between theory and practice, and low student engagement, this study constructs an AI-teacher collaborative teaching model. Centered on a three-dimensional collaborative system covering personalized learning, virtual-reality integrated practice and interactive motivation, the model generates accurate learning profiles of students through the combination of AI learning analytics systems and teachers' empirical calibration, and meets personalized learning needs via stratified teaching and dynamic learning plans. It also reshapes the classroom interaction ecosystem with the support of AI-intelligent Q&A, interesting interactive tools, as well as teachers' guidance and incentives. The core innovation lies in defining the complementary roles: AI undertakes data processing, real-time guidance and interactive support, while teachers are responsible for objective setting, professional tutoring and classroom atmosphere building, thereby forming a full-process teaching closed loop. Practical results show that the proposed model can effectively improve students' knowledge mastery efficiency and engineering practical competence, and provide a feasible reference for the teaching reform of Analog and Digital Electronic Technology and other similar engineering courses.

Keywords: AI and teachers; Collaborative teaching; Analog and digital electronic technology

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1. Introduction

Analog and Digital Electronic Technology is a core course for majors such as Computer Science and Electronic Information. It directly affects students' logical thinking, circuit design capabilities and adaptability to learning in cutting-edge fields. As the Emerging Engineering Education places higher requirements on engineering practical ability and innovative literacy, drawbacks of traditional teaching have gradually emerged. Teacher-centered theoretical teaching fails to accommodate differences in students' prior knowledge. Restricted by hardware facilities and dominated by confirmatory experiments, practical training leads to a disconnection between theory and practice [1,2].

Artificial intelligence offers a viable solution to the above challenges. AI learning analytics systems enable learning status diagnosis and learning path prediction, while simulation tools such as Multisim reduce reliance on physical experimental equipment. Nevertheless, current AI applications still have limitations: AI technologies are adopted in a fragmented manner and only serve individual teaching links. The division of responsibilities between AI tools and teachers remains ambiguous, which prevents in-depth integration and personalized teaching [3].

This study aims to establish an innovative teaching model for Analog and Digital Electronic Technology based on AI-teacher collaboration. By integrating intelligent tools and collaborative platforms, it improves students' in-depth understanding of professional knowledge and engineering practical abilities, and provides a reference for the teaching reform of electronics-related courses. The core innovation lies in upgrading AI from an auxiliary tool to an equal collaborative participant, and constructing a closed-loop system featuring data-driven analysis, teacher empowerment and student orientation. The main implementations are presented as follows:

(1) Restructure the personalized learning system. AI collects multi-dimensional data throughout pre-class, in-class and after-class stages to generate student learning profiles. On this basis, teachers work with students to formulate dynamic learning plans and implement stratified teaching, so as to abandon the one-size-fits-all teaching mode.

(2) Innovate the practice mode by combining virtual and physical experiments. A dedicated AI virtual experiment platform with real-time guidance modules has been developed. Combined with physical laboratories, it forms a complete learning chain covering theory learning, virtual simulation, physical innovation and engineering application, addressing the difficulties in practical teaching.

(3) Build an interactive classroom ecosystem. AI-powered intelligent Q&A systems and online discussion communities are introduced to create a teaching framework of teacher guidance, AI-enabled motivation and student participation. A diversified evaluation system combining AI statistical results and teacher assessments is adopted to stimulate students' learning initiative.

2. Problems existing in conventional classroom teaching

Analog and Digital Electronic Technology features abstract theories and strong engineering practicality, which requires a balance between knowledge delivery and competency cultivation. Restricted by teaching resources, methods and technologies, traditional teaching is confronted with three major structural problems that hinder the development of students' core competencies.

2.1. Lack of support system for personalized learning

Traditional classrooms adopt relatively fixed and standardized teaching procedures throughout the whole teaching process. In conventional teaching settings with 30 to 50 students per class, teachers usually design and arrange teaching content, learning pace and knowledge difficulty mainly to fit the learning ability of students at the intermediate proficiency level. This rigid arrangement inevitably leaves two distinct groups of learners neglected and unable to receive targeted guidance. Students with weak academic foundations often struggle to keep up with the overall progress. When tackling key points and difficult knowledge modules such as amplifier circuit analysis and logic circuit design, they gradually accumulate continuous knowledge gaps that are hard to make up for in time. By contrast, high-achieving students with solid expertise frequently encounter repetitive and basic learning content in class. This monotonous learning fails to challenge their potential and deprives them of valuable opportunities to explore in-depth and extended technical topics, including professional research on circuit noise suppression.

The current diagnosis of students' real-time learning situation mainly relies on two traditional means: routine homework review and random in-class questioning. However, teachers generally only grade homework by judging whether the final answers are right or wrong, without carrying out systematic and in-depth analysis of the root causes of students' mistakes and knowledge misunderstandings. Meanwhile, in-class questioning can involve a small portion of the whole class, covering 10% to 15% of students on average. As a result, teachers cannot fully and accurately figure out the specific knowledge deficiencies and learning difficulties of every individual student. This rigid one-size-fits-all teaching model eventually creates a vicious cycle in daily teaching: underachieving students always receive inadequate personalized attention and tutoring, while top students lack sufficient room and opportunities for independent thinking and technological innovation. This phenomenon clearly runs counter to the core requirement of personalized and differentiated teaching proposed by Emerging Engineering Education [4].

2.2. Disconnection between theoretical and practical teaching

The separation of theory and practice is a prominent drawback existing in traditional engineering teaching, which greatly weakens students' comprehensive capability to flexibly apply professional theories to analyze and solve practical engineering problems. This undesirable situation is mainly reflected in the following three aspects:

(1) Obvious time lag between theoretical learning and practical training. Under the conventional teaching schedule, theoretical courses are arranged ahead of corresponding practical experiments, with an interval of one to two weeks between them. During this period, students gradually fail to consolidate what they have learned and easily forget key theoretical knowledge. When carrying out experiments later, they mostly follow fixed operating instructions to finish simple confirmatory tasks mechanically, and are unable to establish effective links between abstract theoretical knowledge and real experimental phenomena.

(2) Overly rigid and monotonous practical content. Restricted by the total number and performance of on-campus physical experimental equipment, most practical activities can only focus on basic and repetitive operations, such as simply verifying the basic functions of AND-NOT gates. Students have very few chances to participate in exploratory and innovative experiments, such as the independent design of temperature alarm circuits. As a result, their ability to integrate innovative design thinking with real engineering practice cannot be fully trained and improved.

(3) Superficial use of circuit simulation tools. Professional simulation software such as Multisim is merely regarded as a simple alternative to physical experiments, instead of being deeply integrated into the whole process of theoretical teaching. For example, teachers rarely guide students to explore and analyze how the adjustment of different parameters will influence the overall operating performance of circuits. In this case, students can only master basic software operations, but remain incompetent in independent circuit design. A complete closed loop covering theoretical cognition, practical operation and knowledge internalization can never be formed [5].

2.3. Deficient classroom interaction and low student engagement

The traditional teaching mode is predominantly dominated by teacher-centered, cramming lecturing, where teachers occupy the dominant position throughout the whole classroom teaching process, while students passively receive knowledge. This single teaching method leads to serious insufficient classroom interaction and communication between teachers and students, which greatly suppresses students' subjective consciousness and weakens their autonomous initiative in professional learning. The main reasons for the lack of active student participation in classroom teaching are summarized as follows:

(1) Oversimplified and single classroom interaction forms. The limited interactive links in class are merely confined to basic teacher questioning and voluntary student answering. Most of the designed classroom questions focus on mechanical memorization and inspection of theoretical knowledge, such as the derivation and application of the characteristic equation of JK flip-flops. There is a serious lack of open-ended, exploratory and expandable questions closely combined with engineering practice, such as the optimization design and performance improvement of amplifier circuits. In such a rigid interactive environment, only a small number of active students can participate in classroom interaction, while the majority of students stay in a passive listening state with low participation and low learning engagement.

(2) Disconnection between abstract professional knowledge and classroom interactive activities. Electronic engineering courses involve a large number of abstract, obscure and difficult-to-understand professional concepts, including the phase compensation principle and the timing race phenomenon. In traditional classes, these complex knowledge points are only displayed and explained statically through blackboard writing and PPT slides. Students are unable to conduct dynamic parameter adjustment, simulation verification and experimental exploration in the classroom. Therefore, their cognition of professional knowledge only stays at the superficial theoretical level, lacking in-depth understanding and practical perception, which makes them prone to learning fatigue and classroom distraction.

The long-term low student engagement and insufficient effective interaction further trigger a vicious cycle of classroom teaching. The single teaching form makes the overall classroom atmosphere dull and rigid, which greatly reduces students' learning interest and knowledge absorption efficiency. Relevant teaching survey data shows that students' effective in-class concentration rate of this electronic technology course is less than 60%. Meanwhile, the students' comprehensive mastery rate of core knowledge points, such as sequential logic circuit design, only ranges from 45% to 55%, which is significantly lower than the curriculum teaching quality and talent training expected standards.

3. Construction of a classroom under the AI-teacher collaborative teaching model

Targeting three prominent problems in conventional classrooms of Analog and Digital Electronic Technology, namely insufficient personalized support, disconnection between theory and practice, and low student engagement, this model follows the principles of AI as a collaborative participant, teachers as the guiding core, and students as the learning center. A three-dimensional collaborative system covering learning support, integrated practice and interactive motivation is established to restructure the entire teaching process.

3.1. Collaborative system for personalized learning: Two-way interaction between AI learning profiles and teacher empowerment

Aiming to eliminate the drawbacks of the traditional one-size-fits-all teaching approach in electronic courses, this system integrates AI data mining technology with teachers' practical teaching experience to form a complete closed loop of accurate learning diagnosis, dynamic teaching adaptation and tiered personalized guidance. It effectively solves the problem of rigid and unified teaching in traditional classrooms, and the detailed implementation procedures of the system are as follows.

(1) Development of the Intelligent Learning Analytics System

The AI system connects to multi-dimensional data from educational administration platforms, online learning systems and intelligent classroom terminals. It adopts scientific evaluation algorithms to comprehensively quantify students' knowledge mastery, learning habits and practical competency characteristics, and generates objective individual learning profiles for each student. Teachers calibrate the weight of each profile dimension according to curriculum teaching requirements (e.g., assigning a 25% weight to standardization of experimental operations) and carefully verify abnormal data samples to effectively avoid algorithm bias and guarantee profile accuracy and authenticity.

(2) Customization of Personalized Learning Plans

This study adopts a reliable working mechanism of AI preliminary recommendation, teacher revision and student confirmation to ensure the rationality of personalized teaching. Based on systematic learning profiles, AI recommends targeted learning resources for students at different levels: basic micro-lessons and knowledge supplements for underachieving students, and innovative competition projects for high-achieving students. Teachers appropriately revise the plans according to real in-class observations and actual learning performance, such as adjusting the delivery time of resources and adding targeted virtual experiments. After learning objectives are jointly confirmed by teachers and students, the system tracks the whole learning progress in real time to ensure effective learning outcomes.

(3) Implementation of Tiered Teaching Activities

AI classifies students into three groups via scientific clustering algorithms based on their real-time learning data: the basic group (knowledge mastery rate below 60%), the intermediate group (60%–85%) and the advanced group (no less than 85%), and continuously monitors their daily learning engagement and task completion status. Teachers design completely differentiated learning tasks for different groups: the basic group focuses on principle learning and standardized basic operations, the intermediate group conducts circuit debugging and optimization practice, and the advanced group carries out interdisciplinary innovative design. During class, teachers provide on-site roaming guidance for individual problems. Meanwhile, AI collects real-time progress data and timely reports abnormal learning situations to help teachers prioritize guidance arrangements and achieve precise teaching.

3.2. Collaborative system for virtual-physical integrated practice: Deep integration of ai virtual platform and teacher guidance

To bridge the gap between theoretical knowledge and practical training, a complete practice chain consisting of virtual rehearsal, physical verification and project implementation is constructed to facilitate the transformation from knowledge into practical abilities [6].

(1) Development of the AI virtual experiment platform

The platform is equipped with dedicated functional modules and real-time guidance modules powered by AI. It can automatically identify circuit wiring errors such as short circuits and component misselection, and deliver hierarchical guidance accordingly. Teachers design progressive experimental tasks ranging from verification experiments to innovative design tasks, and embed practical engineering constraints, including parameter errors and temperature effects, to keep virtual practice consistent with real-world scenarios.

(2) Correlation between theoretical learning and experiments

AI embeds theoretical knowledge into virtual experiments, for example, clicking on circuit components will trigger playback of principle explanation videos. In theoretical courses, teachers project simulation scenarios (e.g., demonstrating race hazards in sequential circuits) and guide students to conduct comparative analysis. After class, AI assigns exercises combining theories and experiments. Teachers check completion results and give centralized explanations on common mistakes.

(3) Joint implementation of practical projects

AI recommends project topics according to students' learning profiles: digital clock design for the basic group and Bluetooth control circuit development for the advanced group, along with standard design templates. Teachers set up mixed-ability groups, clarify project requirements and organize result presentations, while offering guidance on engineering difficulties. At the evaluation stage, AI conducts quantitative scoring in terms of function realization, parameter performance and innovation. Teachers evaluate qualitative indicators, including teamwork and document compilation, and the final comprehensive score is generated accordingly.

3.3. Collaborative system for interactive motivation: Empowerment via AI tools and classroom atmosphere building led by teachers

This system thoroughly transforms the traditional teacher-centered indoctrination lecturing mode that dominates electronic technology courses, and innovatively builds a new classroom ecosystem featuring active student participation, real-time instant feedback and long-term sustained learning motivation. It effectively makes up for the defects of single interaction form and low student engagement in traditional classrooms, optimizing the overall classroom teaching atmosphere.

(1) Deployment of diversified AI interactive tools

The deployed AI-powered intelligent Q&A system can quickly respond to students' daily learning doubts, answering various common professional questions within 3 seconds and forwarding difficult and complex queries that cannot be automatically resolved to teachers for targeted guidance. The built-in online discussion community realizes autonomous interaction among students, which can automatically review published posts and intelligently screen and recommend high-quality exchange content. According to the curriculum teaching progress and learning focus, teachers design reasonable applicable scenarios for these intelligent tools, release targeted guiding topics regularly, and comment and summarize excellent student posts to drive in-class discussion.

(2) Design of interesting interactive activities

To solve the problem of dull classroom learning, AI supports the development of various knowledge-based competitive activities, including random question generation and real-time scoring functions, as well as interesting circuit jigsaw games that allow students to freely assemble split circuit modules. These vivid interactive forms turn abstract circuit knowledge into intuitive operational practice. Teachers accurately control the overall rhythm and progress of classroom activities, systematically analyze students' frequently occurring errors and typical misunderstandings, and further help students sort out and summarize core key knowledge points and practical skills.

(3) Implementation of instant feedback and incentive mechanisms

The AI system comprehensively records students' whole-process in-class learning behaviors and interaction data, and generates an intuitive real-time classroom engagement dashboard for teachers' reference.

Based on the objective statistical data, teachers deliver differentiated and tiered incentive measures, such as awarding academic extra points and electronic honor certificates for outstanding students. Meanwhile, teachers conduct targeted communication and guidance for students with low classroom participation, and recommend suitable interactive forms to mobilize their learning initiative. In addition, AI regularly generates personalized student growth reports. Teachers can dynamically adjust subsequent teaching strategies and interactive arrangements according to the report data, thus forming a complete closed loop of continuous optimization and sustained learning motivation.

4. Conclusion

Aiming at the three core pain points that have long plagued the conventional teaching of Analog and Digital Electronic Technology courses, namely insufficient personalized teaching support, serious disconnection between theoretical teaching and practical training, and low student classroom participation and learning initiative, this study innovatively constructs a novel AI-teacher collaborative integrated teaching model. Focusing on the actual teaching difficulties and talent training objectives of electronic engineering courses, this model relies on a three-dimensional collaborative teaching system covering personalized precision learning, virtual-physical integrated practical training, and intelligent interactive incentive teaching. It thoroughly restructures the traditional single teaching logic, transforming the indoctrination-oriented one-way knowledge transmission mode into a diversified two-way teacher-student collaborative interaction and intelligent tutoring teaching process, which fundamentally optimizes the overall teaching framework of the course.

The core educational value and practical advantages of the proposed teaching model are mainly reflected in three key dimensions. First, the organic linkage between the AI learning big data analytics system and teachers' empirical teaching calibration can realize full-process monitoring, accurate mining and scientific analysis of students' learning behavior, knowledge mastery status and learning difficulties, generating precise and visualized student learning profiles. On this basis, hierarchical differentiated teaching strategies and dynamic personalized learning plans can be formulated for students at different proficiency levels, which effectively solves the personalized learning dilemmas such as uneven learning foundation and inconsistent learning progress in traditional classrooms. Second, the whole-process practical teaching chain integrating virtual simulation training, physical offline experiments and comprehensive engineering projects perfectly makes up for the deficiencies of single traditional practical teaching. Combined with real-time intelligent guidance provided by AI tools and in-depth theoretical summary and verification conducted by professional teachers, the model completely resolves the common dilemmas of disjointed theory and practice and rigid practical content in traditional teaching, and effectively promotes the systematic cultivation and practical transformation of students' comprehensive engineering application capabilities and innovative thinking. Third, the organic combination of diversified AI interactive tools, including intelligent real-time Q&A systems and interesting educational interactive activities, together with teachers' manual regulation, classroom guidance and spiritual incentive mechanisms, completely reshapes the traditional rigid and single classroom interaction ecosystem.

This teaching mode significantly activates the classroom learning atmosphere, effectively improves students' in-class participation, learning enthusiasm and knowledge absorption efficiency, and solves the problem of low learning engagement caused by a single interactive form in traditional teaching. The key innovative breakthrough of this AI-teacher collaborative teaching model lies in the clear division of labor and complementary responsibilities between intelligent AI technology and professional teachers. Specifically, AI is responsible for efficient data processing, real-time online tutoring and omnidirectional interactive auxiliary support, while teachers focus on formulating scientific teaching objectives, providing professional academic guidance, designing high-quality teaching links and building a positive classroom atmosphere. This collaborative mechanism constructs a complete full-process closed-loop intelligent teaching system, which provides a feasible and innovative practical paradigm for the teaching reform of Analog and Digital Electronic Technology course and offers valuable reference for the teaching optimization of other similar engineering professional courses.

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References

[1] Che HJ, Yu SS, Zhao Y, et al., 2025, Research on the Interdisciplinary Talent Cultivation Model for Electronic Information-Related Majors from the Perspective of Large Artificial Intelligence (AI) Models. West Journal, 17: 96–100.

[2] Cai HY, Han B, Gu JN, et al., 2025, The Study on Optimization Strategies for Collaborative Knowledge Construction in AI-Supported Teachers Professional Development. Modern Distance Education, 2: 56–67.

[3] Zhou Q, Wen XY, 2020, The Practical Form of "AI+ Teacher" Collaborative Teaching in the Intelligent Era. Journal of Distance Education, 38(2): 37–45.

[4] Jia SY, Sun BG, Li HL, 2024, A Probe to Hybrid Teaching Mode of the Course of Digital Electronic Technology. Journal of Hubei University of Education, 41(2): 96–102.

[5] Chen Y, Tian J, Han X, et al., 2024, Multi-Platform Hybrid Teaching Mode of Electrical and Electronic Technology Based on Multisim. Agricultural Engineering, 41(2): 96–102.

[6] Yang CL, 2025, Optimization Research on Reform of Analog Electronic Technology Experimental Teaching under Application of Virtual Simulation Technology. Machine Building & Automation, 54(1): 163–165 + 186.