Reforming the Digital Electronics Technology Course: A Case Study in Bridging Theory and Practice for Emerging Engineering Education

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Abstract: ***The continuous advancement of engineering education reform has placed new demands on the curriculum system and talent cultivation. As a foundational course for engineering majors, the digital electronics technology course has revealed many problems in teaching content and other aspects, making it difficult to meet the goal of cultivating interdisciplinary engineering talents under the emerging engineering education background. Based on this, this paper explores four strategies — "updating the content system," "integrating diverse methods," "consolidating experimental resources," and "introducing project-based teaching" — and proposes teaching reform strategies that better align with the requirements of the times, emphasizing the close integration of knowledge transmission and capability development, aiming to provide useful insights for university teachers.***

Keywords: Emerging engineering education; Digital electronics technology; Teaching reform.

1. INTRODUCTION

Higher engineering education is now in a period of deep transformation, and aligning classroom instruction with engineering practice has become the focal direction of teaching reform. In most universities, the Digital Electronics course still centers on transmitting foundational knowledge, with slow content updates and relatively traditional teaching methods; practical components are fragmented and disconnected from engineering requirements, making it hard to meet industry's real demand for high-quality technical talent. With the rapid development of electronic information technology, the course urgently needs breakthroughs in both content structure and practical format to shift theoretical teaching toward comprehensive ability cultivation and to enhance students' comprehension in engineering contexts. Therefore, instructors must investigate reform pathways for the Digital Electronics course around this goal, which can not only advance the course's own optimization and upgrading but also hold practical significance for the construction of engineering curricula and the enhancement of practical capabilities. Zhang (2024) investigated the dynamic adaptation of supply and demand for power emergency materials using cohesive hierarchical clustering [1]. User behavior analysis on digital platforms has been explored by Wang, Dong, and Zhou (2025), who researched short-video platform user decision-making through multimodal temporal modeling and reinforcement learning [2]. Similarly, for recommendation systems, Junxi, Wang, and Chen (2024) proposed GCN-MF, a hybrid model integrating graph convolutional networks with matrix factorization [3]. Beyond digital interactions, Su et al. (2025) conducted a structural assessment of family and educational influences on student health behaviors from a public health perspective [4]. Ensuring system reliability and security has become paramount, with research spanning cloud infrastructure and regulatory frameworks. Yang (2025) focused on site reliability optimization technology based on synthetic monitoring in cloud environments [5]. For regulatory compliance, Zhang (2025) designed a neuro-symbolic and blockchain-enhanced multi-agent framework for fair and consistent cross-regulatory audit intelligence [6]. A repeated study by Zhang (2024) on power emergency material allocation further underscores the importance of adaptive resource management [7]. Trust and security are also central to autonomous systems, as illustrated by Tang et al. (2026), who developed SVD-BDRL, a trustworthy autonomous driving decision framework enhanced by blockchain technology [8]. The frontier of generative models and applied AI continues to expand. Lu et al. (2025) introduced NeuroDiff3D, a diffusion-based method for 3D generation that optimizes viewpoint consistency [9]. Concurrently, Bi and Su (2025) proposed a secure access method for English education networks utilizing edge computing [10]. In robotics, Guo (2025) applied deterministic artificial intelligence for the optimal trajectory control of robotic manipulators [11]. Domain adaptation, a key challenge in machine learning, was addressed by Peng et al. (2023) with RAIN, a method applying regularization on both input and network for black-box domain adaptation [12]. Finally, research into predictive analytics and specialized computer vision tasks shows continued innovation. Zhang et al. (2025) developed MamNet, a novel hybrid model for time-series forecasting and frequency pattern analysis in network traffic [13]. In computer vision, Chen et al. (2022) tackled the task of one-stage object referring with gaze estimation [14]. For structural health monitoring, Tan et al. (2024) proposed a damage detection and isolation method based on deep transfer learning and an ensemble learning classifier for scenarios with limited experimental data [15].

2. ANALYZING PROBLEMS IN THE DIGITAL ELECTRONICS COURSE UNDER THE EMERGING ENGINEERING EDUCATION CONTEXT

2.1 Lagging Teaching Content

At present, the teaching content of the Digital Electronics course is updated slowly; many textbooks still concentrate on basic knowledge such as gate-level circuits. While these topics form an important part of the course, their coverage is relatively limited and fails to fully reflect the current direction of electronic technology development. Some courses use outdated textbook editions that lack integration with modern engineering practice and have not incorporated the advanced design platforms widely adopted in recent years, further restricting students' understanding of the complete digital-system design flow and creating a large gap between classroom learning and actual engineering work [1]. Moreover, the course rarely involves the application of Electronic Design Automation (EDA) tools, leaving students unable to master today's mainstream design methods. Under teaching conditions that lack support from modern technological contexts, students often struggle to form a clear understanding of the role digital circuits play in real-world applications, thereby diminishing their learning initiative and reducing the course's overall educational effectiveness.

2.2 Monotonous Teaching Methods

Current classroom instruction in digital electronics technology courses still relies mainly on teacher-centered lectures, with content delivery focused on explaining knowledge points while students mostly remain passive recipients, lacking necessary participation and interaction. Although this approach helps convey foundational knowledge, it neglects cultivating students' abilities to think actively, resulting in a monotonous learning process and low motivation. The absence of effective question guidance and discussion opportunities in class also makes it difficult for students to raise questions or delve deeper, hindering the development of critical thinking. Even though some courses include labs or projects, these activities are often confined to following prescribed steps, lacking authentic engineering contexts, so students cannot truly grasp the practical significance of what they learn. This teaching model fails to create an integrated theoretical-practical learning experience and limits the enhancement of students' comprehensive abilities.

2.3 Insufficient Experimental Resources

Many laboratories use outdated equipment with limited functionality, making it hard to support debugging of complex circuits. The experimental content is also relatively monotonous; most projects merely verify basic functions such as simple logic gates, lacking systematic design training. During experiments, students usually just follow preset steps, with little chance to analyze problems independently. Such a fragmented, knowledge-point-centered arrangement fails to cultivate an overall understanding of digital system structures. Moreover, the weak link between lab projects and real applications, and the absence of module-design tasks grounded in engineering scenarios, prevent students from developing a mindset oriented toward practical problems.

3. TEACHING REFORM STRATEGIES FOR DIGITAL ELECTRONICS TECHNOLOGY COURSES UNDER THE EMERGING ENGINEERING EDUCATION CONTEXT

3.1 Update the Content System to Align with Technological Frontiers

Under the emerging engineering education context, updating the digital electronics technology course content helps strengthen the connection between the curriculum and industry development, making instruction better meet current engineering needs. Traditional teaching focuses mainly on basic logic knowledge, covering overly narrow content that cannot encompass the diverse real-world applications of digital technology [2]. When course content becomes disconnected from technological progress, students struggle to understand the complete structure of digital systems in actual engineering and cannot form a clear vision of future technological directions. When revising content, instructors should integrate trends in digital electronics development and plan the curriculum holistically, designing a knowledge system that spans from basic logic to system-level applications so students can clearly see the links among topics. In the teaching schedule, instructors should appropriately introduce modern electronic design tools and common system architectures to help students build an overall understanding of entire electronic systems.

For example, under the emerging engineering education paradigm, the content of the Digital Electronics course must keep pace with the direction of engineering-technology development. Instructors should re-plan the entire curriculum, progressively guiding students to master a complete knowledge structure that spans from basic logic to system-level applications. The syllabus should reveal the intrinsic links among topics, starting with fundamental circuit concepts and gradually extending to the construction of digital systems, enabling learners to build a systematic understanding. Course material should not stop at simple logic gates and sequential circuits; instead, it should incorporate the architectures of contemporary electronic products to help students grasp the design process of complex circuits. In course design, instructors can introduce FPGA-related knowledge into the logic-module teaching segment, allowing students to see how combinational logic and control circuits are applied in real engineering while they learn them. At the same time, by integrating the basic principles of SoC architecture, students can be trained to master the interconnection of functional blocks and thus comprehend the overall composition of a digital system. Instructors should also guide students in learning the basic operations of EDA tools, weaving simulation and analysis into classroom activities so that students become familiar with the modern electronic-system development flow. Moreover, by referencing the typical structures of smart devices, teachers can help students recognize the relationship between control modules and peripheral devices, thereby deepening their understanding of the overall digital-system architecture during knowledge acquisition, strengthening the link between course content and practical applications, and aligning teaching objectives more closely with the demands of emerging engineering education.

3.2 Integrating Diverse Methods to Energize the Classroom

Traditional lectures often emphasize theory over participation, failing to stimulate student motivation and falling short of engineering education's goals for cultivating thinking and practical skills. By blending multiple pedagogical approaches, instructors can enrich classroom content and deepen students' understanding of knowledge [3]. Varied instructional formats allow learners to grasp the functions of digital circuits from multiple perspectives and enhance their problem-solving thinking. In electronics education, students must master logical structures and fundamental principles while also understanding their practical applications in system design and information processing to meet the real demands of complex engineering projects. When driving this classroom transformation, instructors need to oversee the course progression holistically, arrange content in well-structured layers, and balance foundational explanations with guidance on real-world problems, enabling students to build a complete knowledge framework and see how knowledge translates into practical capability.

For example, under the emerging-engineering paradigm, to enhance the teaching effectiveness of the Digital Electronics course, instructors can adopt multiple approaches to organize classroom content, making the format more flexible and the material richer. In lesson planning, teachers should combine knowledge delivery with problem-based guidance and small-group discussion, enabling students to engage actively in thinking at every stage and strengthening both understanding and application skills. Content should be presented in phases aligned with students' progress, guiding them to identify key points in each segment and gradually build a holistic view of digital systems. After explaining logic-circuit concepts, instructors can assign practical tasks that lead students to analyze circuit functions and structural features, followed by a question-and-reflection segment for peer exchange, reinforcing mastery of fundamentals. For core topics, teachers can set brief analytical tasks—asking students to judge logical relationships or trace functional processes—guiding them to translate theory into hands-on engineering skills, and can schedule structural-analysis and system-construction tasks to help learners grasp the role of each functional module within a digital system, equipping them with basic abilities from circuit design to system application. Toward the end of the course, instructors should design comprehensive projects that apply all prior knowledge to concrete systems such as digital clocks, letting students experience the contribution of every topic in practice. The integration of multiple teaching methods boosts student initiative and makes the classroom more engaging.

3.3 Integrate Laboratory Resources and Build a Practice Platform

Under the emerging-engineering paradigm, the Digital Electronics course must place greater emphasis on practical instruction; the completeness of laboratory resources directly affects the depth of students' understanding and the level of their engineering competence. At present, some content remains limited to basic function verification, and the link between lab exercises and real engineering tasks is weak, making it hard for students to develop systematic thinking through experiments. Therefore, instructors should integrate laboratory resources to connect fragmented content, enabling learners to master the entire process from basic components to system design and strengthening their grasp of digital-system operating principles. When planning lab content and resources, teachers should keep pace with the evolution of digital-electronics technology and progressively refine the arrangement of experiments in line with course objectives. The practice platform should cover areas such as fundamental circuit design, deepening students' understanding of overall electronic-system structure as they learn. Against the backdrop of continuous advancement in digital electronics, building an adaptable practice platform has become a key focus of teaching reform.

For example, to help students gain a deeper understanding of the course content, teachers need to systematically integrate laboratory resources and build a well-structured, progressively layered practical platform. First, the experiments should start with basic logic circuits and gradually extend to functional design of digital systems, enabling students to master the entire process from component identification to system construction. Experimental tasks must align with the teaching focus, allowing students to grasp the practical role of circuits and the basic structure of digital systems while building and verifying circuits. When constructing the experimental platform, teachers should consider the actual needs of students at different learning stages, select appropriate equipment and task content, and ensure each stage has clear objectives. Common logic chips and interface modules can be centrally arranged on a unified platform, facilitating operation and improving resource utilization. The experimental content should span from single-logic-function verification to multi-module collaborative system design, guiding students to develop a complete engineering mindset. Second, in the later stages of the course, teachers can assign comprehensive experimental tasks that require students to combine previously mastered modules to fulfill functions such as information acquisition. Evaluation should not only check whether the results are correct but also assess the rationality of the circuit structure and the standardization of operations. Through resource integration and hierarchical task arrangement, students can enhance their ability to build digital systems in practice, laying a foundation for future engineering applications.

3.4 Introducing Project-Based Learning to Enhance Comprehensive Competence

Incorporating project-based learning into the course helps break the traditional separation between theory and practice, enabling students to understand the application value of knowledge in real tasks [4]. Project tasks usually involve multiple aspects, improving students' thinking and hands-on abilities. Through exploration and collaboration in projects, students gain a more comprehensive understanding of how digital circuits are applied in engineering, thereby strengthening their professional identity. When implementing project-based learning, teachers should arrange course content and project tasks reasonably according to the characteristics of digital electronic technology and engineering requirements. The teaching structure should be task-driven, tightly integrating knowledge delivery with competence development. Content design should focus on current trends in electronic technology, allowing students to understand the practical applications of digital technology in areas such as smart terminals while solving specific problems.

For example, when designing course content, instructors can arrange project tasks around the key knowledge points of the course, integrating logical analysis and other elements into a complete project so that students grasp the practical use of knowledge through hands-on practice. The project tasks should be close to real engineering contexts, with clear functional requirements and technical objectives, guiding students to gradually master the construction methods of digital systems while completing the tasks and deepening their understanding of the content. At the same time, instructors need to thread the tasks through different stages of the course, allowing students to solve specific problems at each stage; the project content should cover the entire process from logic design to circuit construction, encouraging students to start from input–output requirements, analyze the relationships among modules, and clarify the functional positioning of each part. As the project progresses, instructors should guide students to sort out their design plans and learn how to transform theoretical knowledge into workable circuit structures. In addition, the project goals should have a certain practicality, such as realizing simple control functions or digital display tasks, so that students experience the application of electronic technology in real scenarios during completion. Teaching evaluation should focus on students' participation in the project and the rationality of their structural design; it should not merely look at whether the result is correct but should pay more attention to whether the entire process is well-organized. Through this approach, students can master professional knowledge and enhance their hands-on ability and capacity to solve problems independently, laying a solid foundation for subsequent engineering practice.

4. CONCLUSION

Against the backdrop of deepening reform in engineering education, the teaching reform of the Digital Electronics course has become a key link in promoting program transformation and improving talent cultivation quality. Instructors should carry out reform practices centered on content renewal and project-based teaching, which can not only respond to the practical requirements that emerging engineering education imposes on the curriculum system but also provide a feasible path for building a teaching structure that balances theory and practice. Using an engineering orientation to guide the reconstruction of teaching content and using competency cultivation to drive the innovation of teaching forms will help comprehensively enhance students' professional literacy and engineering practice capabilities. In the future, instructors should further strengthen the linkage between the course and industrial needs, continuously advance the optimization of teaching resources and platform construction, and constantly expand the openness of teaching methods to build a more scientific, efficient, and adaptable engineering education teaching system.

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