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Research on the Reform of Teaching Methods for Hardware Fundamentals Courses in IoT Programs at University

Yu Zhou, Qi Peng*, Kun Zhang*

School of Information Science and Technology, Hainan Normal University, Haikou 571158, Hainan, China

***Corresponding authors:** *Qi Peng, qipeng@hainnu.edu.cn; Kun Zhang, kunzhang@hainnu.edu.cn*

Abstract: With the rapid development of the Internet of Things (IoT) and the deep implementation of the "Made in China" strategy, higher standards are being set for the cultivation of hardware system competencies in IoT engineering programs at universities. As a core foundational course of the discipline, Fundamentals of IoT Hardware urgently requires systematic reform in its content structure, teaching methodology, and practical approach. Based on the teaching reform practices at Hainan Normal University, this study constructs a modular teaching content system guided by a comprehensive "Device–Model–Circuit–System" knowledge framework. Task-driven and inquiry-based teaching methods are introduced, and the LTspice simulation platform is integrated to enhance the course's systematicity and hands-on nature. Through two rounds of pilot reforms, significant improvements were observed in students' learning motivation, system-level understanding, and engineering capabilities, alongside a general increase in teaching satisfaction. The results indicate that this reform path effectively addresses the problems of fragmentation, weak practical engagement, and single-mode evaluation in traditional courses, offering valuable insights for curriculum development under the emerging paradigm of "New Engineering."

Keywords: IoT engineering; Hardware fundamentals; Teaching reform; LTspice simulation; Task-driven approach

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1. Introduction

1.1. Research background

With the continued advancement of a new wave of global technological revolution and industrial transformation, emerging technologies represented by artificial intelligence, big data, cloud computing, and the Internet of Things (IoT) are rapidly reshaping production methods and organizational structures across various industries. As a core component of next-generation information technology, the IoT plays a fundamental role in supporting the implementation of the "Made in China" strategy. In particular, under the framework of "Intelligent

Manufacturing 2025", the IoT's capabilities in sensing, control, communication, and intelligent decision-making have become key driving forces for the transformation and upgrading of the national manufacturing sector [1].

The "hardware foundation" layer, as a core element within the IoT technology system, has become increasingly important. IoT hardware systems serve as the functional basis for data acquisition, information exchange, and edge computing, and their level of construction directly determines the overall system's performance, reliability, and energy efficiency. Therefore, the systematic cultivation of talent equipped with modern electronic circuit design and hardware system integration skills has become a pressing issue in contemporary engineering education.

Fundamentals of IoT Hardware is a critical foundational course for IoT engineering majors in university, encompassing multiple modules such as basic electronic devices, circuit principles, embedded interfaces, and circuit simulation. It serves as a key component for students to acquire hardware system design capabilities and to build IoT node devices. However, in most Chinese universities, the teaching of this course still faces common issues such as being "strong in fundamentals but weak in system integration, heavy on theory but light on practice." The course content is often centered on discrete components, disconnected from the latest developments in integrated circuit technologies and industrial applications, and fails to establish a complete knowledge chain linking "device–circuit–system–application."

As a nationally significant strategic development region, Hainan Province has clearly outlined in its 13th Five-Year Plan for Scientific and Technological Development the need to develop intelligent sensing systems for sectors such as public safety, modern logistics, tropical agriculture, and intelligent transportation [2]. The plan emphasizes industrial deployment in key areas, including new sensor technologies, embedded devices, and edge computing. This strategic vision provides universities with both a clear direction and a practical demand for course reform. Against this backdrop, Hainan Normal University launched an educational reform project funded by the Hainan Provincial Higher Education Teaching Research Program. The project focuses on reforming the teaching methods and strategies for the Fundamentals of IoT Hardware course. It aims to construct a panoramic teaching model centered on CMOS devices and extending across the layers of "Device–Model–Circuit–System." Through content updates, methodological innovations, platform enhancements, and case-driven learning, the project strives to achieve a precise alignment between educational objectives and industrial needs.

1.2. Research significance

With the increasing national support for the development of the integrated circuit industry, there is a growing demand for talent proficient in hardware system design and simulation. The traditional engineering education model that emphasizes software while neglecting hardware is no longer sufficient to meet the talent structure requirements of the new-generation information industry. By optimizing the teaching content of the Fundamentals of IoT Hardware course, strengthening general education in VLSI design, and guiding students to master foundational simulation tools (such as LTspice), the university can effectively address the structural weakness in hardware knowledge among IoT students. This, in turn, contributes to the cultivation of foundational talent for key national sectors such as integrated circuits and secure, autonomous systems.

As a representative of the local university, Hainan Normal University's reform of this course carries significant practical relevance and replicability. Under constraints of limited funding and resources, the university has constructed a curriculum system that centers on educational software, employs inquiry-based tasks as the learning vehicle, and incorporates real-world case studies as instructional guidance. This approach not only enhances teaching quality but also broadens students' engineering perspectives, serving as a practical model for local universities exploring talent cultivation paths based on "specialized disciplines + industry-education integration."

Fundamentals of IoT Hardware serves as a bridge between theoretical circuit courses and applied system design courses. It requires students to possess a solid theoretical foundation as well as practical skills in modeling engineering problems, selecting devices, simulating circuits, and validating solutions [5]. This project proposes a reform philosophy centered on "de-emphasizing abstraction, emphasizing application, and aligning with the technological frontier," thereby strengthening the integration between course content and engineering practice. Students can not only transition their knowledge from "device" to "circuit" to "system" within the classroom, but also extend their learning to extracurricular engineering projects, technology competitions, and capstone designs, ultimately enhancing their comprehensive competencies and engineering capabilities.

2. Current situation analysis of course teaching

As one of the core foundational courses for IoT engineering majors, Fundamentals of IoT Hardware plays a pivotal bridging role in the undergraduate curriculum. It not only connects fundamental courses like circuit theory and analog electronics with follow-up courses such as embedded systems and wireless communication, but also serves as the students' first gateway to electronic system design and hands-on practice [3]. However, a review of current teaching practices in most Chinese universities—especially local institutions—reveals prominent issues in areas such as course content, instructional methods, experimental systems, and feedback mechanisms. These challenges call for systematic reform and innovation.

2.1. Outdated content structure lacking a systematic and forward-looking vision

At present, the teaching content of Fundamentals of IoT Hardware in most universities still follows the traditional electronic technology course structure, focusing on fundamental knowledge of discrete components and basic circuit analysis, with emphasis on separately teaching analog and digital circuit fundamentals [6]. This fragmented approach fails to deliver integrated and system-level design concepts, often leading to superficial and isolated knowledge acquisition. As a result, students struggle to form a cognitive chain that links "Device–Module–System" [4].

Moreover, current textbooks and syllabi are outdated and fail to incorporate key hardware concepts from emerging information technologies such as SoC design, low-power techniques, CMOS fabrication, and edge computing. This has caused a disconnect between course content and industry developments. For example, while teaching integrated operational amplifiers, their practical applications in embedded ADC interfaces are often neglected, and when introducing filter circuits, there is a lack of explanation regarding real-world system modeling within IoT signal acquisition chains.

2.2. Teacher-centered methods dominate, resulting in low student engagement

Classroom instruction in the Fundamentals of IoT Hardware course is still largely teacher-centered and lecture-driven, lacking effective integration of exploratory, case-based, and project-based teaching strategies. Teachers commonly follow the textbook in a linear fashion, while students rely primarily on note-taking and rote memorization for exams [7]. There is little inquiry-based interaction with real-world problems or comprehensive design training. This low-interaction, low-engagement teaching model falls short of the goal of cultivating IoT professionals with core engineering competencies. Particularly when tackling more complex topics such as

MOSFET characteristics, circuit modeling, and sequential circuit analysis, students often fall into a passive learning state — "listening without understanding, watching without doing." Teachers report that students frequently lose focus during class, and while homework completion rates are high, the quality is inconsistent. Students often stay at the stage of shallow imitation, lacking the ability to internalize knowledge or transfer it to new contexts.

2.3. Weakness in experimental teaching: Lacking simulation and engineering orientation

Experimental teaching, a vital part of the Fundamentals of IoT Hardware course, is currently centered on verification-based lab work using basic circuit assembly and measurements. Typical lab projects include building discrete amplifiers, logic gate experiments, and voltage comparator tests. Although these offer some fundamental training, they are often low in complexity, repetitive in nature, and lack design challenges, thus failing to cultivate students' system modeling and problem-solving capabilities [8]. Most labs do not incorporate circuit simulation tools or EDA design workflows. Students lack experience with SPICE modeling, simulation analysis, and device parameter tuning, and thus fail to establish a complete experimental chain linking "theory–simulation–construction–testing." For example, when learning about multistage amplifiers, students can only observe signal waveforms in physical circuits and are unable to fine-tune device biasing or analyze distortion sources in a simulation environment. They also cannot verify performance variations under different process parameters, which severely limits the development of their engineering analysis skills.

2.4. Single-mode assessment system fails to reflect competency development

In terms of assessment, most universities still rely heavily on final exams as the primary grading method, with midterm assignments and lab reports serving as supplementary components. This exam-oriented evaluation model, which emphasizes "knowledge reproduction", tends to encourage rote learning over deep understanding and fails to foster intrinsic learning motivation. In practice, key engineering qualities such as project competence, creative thinking, teamwork, and communication skills are often overlooked. Although students may complete the "assigned tasks" during the course, they frequently struggle to apply their knowledge in real-world integrated design scenarios, exhibiting difficulty with knowledge transfer and problem-solving in unfamiliar contexts [9].

3. Teaching reform objectives and overall design

As a core foundational course in the IoT engineering major, Fundamentals of IoT Hardware plays a crucial role in developing students' understanding of electronic circuits, hardware system modeling, design, and implementation capabilities. In the context of rapidly evolving technologies and industrial demands, traditional course content and teaching methods are no longer sufficient to meet the requirements of cultivating next-generation engineering talent. In response to the issues identified in Chapter 2—such as outdated content, limited instructional approaches, weak experimental systems, and insufficient student skill output—this chapter proposes a systematic teaching reform framework grounded in the principles of "industry-driven needs, system-level capability enhancement, and instructional innovation." The chapter outlines a set of targeted reform goals and presents a practical and scalable implementation plan for curriculum transformation.

3.1. Teaching reform objectives

The central objective of the teaching reform for the Fundamentals of IoT Hardware course is to align with the evolving competency structure required for modern engineering professionals. The reform aims to establish a comprehensive "Device–Model–Circuit–System" teaching framework centered on CMOS integrated circuits and system-level design concepts, supported by task-driven and inquiry-based teaching methods, and industrial-grade simulation tools (**Figure 1**). The ultimate goal is to achieve an integrated educational model that links "theoretical instruction, practical training, and capability development." Specifically, the reform focuses on the following five objectives.

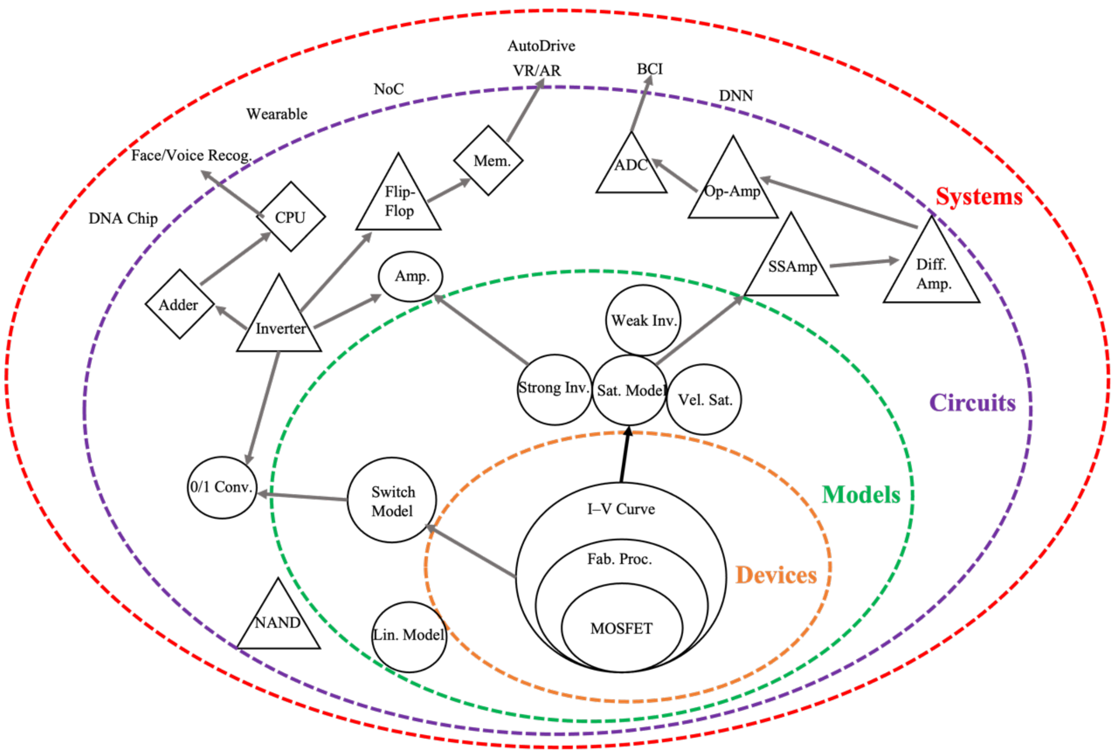

Figure 1. Construction of a device-centered "device–model–circuit–system" radial knowledge network

Develop a modular and systematic course content framework. Centered on the MOSFET as the core device, the course integrates circuit analysis, modeling, and system interfacing content to form a radial knowledge network covering "Device–Model–Circuit–System–Application," enabling students to develop a comprehensive engineering cognition pathway.

Reform traditional classroom teaching models. Introduce a "task-driven + thematic inquiry" classroom approach, incorporating tools such as mind mapping, case analysis, and reverse application design to shift students from passive reception to active exploration.

Build a simulation practice platform centered on LTspice. Based on industrial-grade SPICE models, the platform includes simulation tasks aligned with the course content, ensuring seamless integration between theoretical learning and practical training.

Incorporate real-world engineering application cases to enhance course engagement. Guide students to understand the hardware implementation principles in typical systems such as smartphone facial recognition, autonomous driving, and brain–computer interfaces, increasing the practical relevance and immersion of the learning experience.

Establish a multi-dimensional evaluation system to foster diverse competencies. Implement a dual-layer “process + outcome” assessment mechanism to ensure students not only master knowledge but also achieve capability output and overall quality improvement.

3.2. Overall curriculum reform design

To achieve the aforementioned goals, the reform of the Fundamentals of IoT Hardware course follows a guiding framework centered on “content restructuring, methodological innovation, platform upgrading, and evaluation mechanism enhancement.” The overall teaching design is structured as follows.

3.2.1. Constructing a “device–model–circuit–system” knowledge network

Leveraging the widespread relevance and practical significance of CMOS devices, the reform builds a radial instructional framework centered on the MOSFET, as shown in **Figure 1**. Beginning with the structure and characteristics of the MOS transistor, the framework expands to cover small-signal modeling, amplifier and switching circuit design, integrated module development, and system-level interface applications. This approach breaks away from the fragmented, topic-by-topic instruction of traditional curricula, instead forming a horizontally connected and vertically expandable knowledge map.

3.2.2. Implementing a “thematic unit + task-driven” instructional strategy

The reform shifts away from a linear, chapter-based instructional structure toward a thematic unit design centered on real-world engineering tasks. For example, under the theme “Designing a Low-Power Temperature Sensing Node”, students are required to complete subtasks such as thermistor modeling, voltage amplifier design, filter configuration, and ADC interface design. Each subtask serves as a focal module within the curriculum, fostering a holistic learning process.

3.2.3. Integrating industrial-grade simulation platforms to enhance practical training

To address the limitations of traditional lab teaching, such as excessive focus on hands-on work with limited modeling and weak analytical thinking, the reform introduces LTspice as the core simulation tool. LTspice offers high-precision SPICE modeling, cross-platform accessibility, and a rich set of simulation functionalities, enabling students to explore device models and manufacturing processes in depth, thereby strengthening the integration between theory and practical skills.

3.2.4. Embedding real-world application scenarios to enhance relevance and engagement

The course is closely aligned with current industrial technology trends by incorporating real-world cases, such as iPhone Face ID circuitry, Tesla autonomous driving sensor nodes, and Brain-Computer Interface (BCI) circuits, into the instructional process. Through problem-based learning and reverse engineering, students are guided to analyze the core circuit design challenges and component selection logic behind these applications, enhancing their engagement and broadening their technological perspective. For instance, when teaching differential amplifiers, students are encouraged to understand how they suppress common-mode noise in EEG signal acquisition; when covering CMOS inverters, discussions include their role in edge detection modules of image processing chips, highlighting their high-speed, low-power characteristics. This real-world problem-driven approach helps students contextualize and engineer abstract concepts.

3.2.5. Developing a multidimensional evaluation system to support holistic competency growth

Traditional evaluation models rely heavily on summative assessments, which fail to fully reflect students' comprehensive abilities. To address this, the course reform introduces a diversified evaluation framework focused on "knowledge acquisition, competency development, and process participation." This system comprises three dimensions: Knowledge dimension: Mid-term and final exams, along with simulation reports, assess students' theoretical understanding; Skill dimension: Group project designs and course papers evaluate application skills and innovation capabilities. Participation dimension: Class performance, task progress, and reflective journals measure learning initiative and engagement.

The course emphasizes the integration of formative assessment and final performance presentation, promoting balanced development in cognitive, practical, and critical thinking abilities. Additionally, student self-assessment and peer evaluation mechanisms are incorporated to foster self-regulation and teamwork skills.

4. Teaching implementation path and process design

With the goals and overall framework of the Fundamentals of IoT Hardware course reform clearly established, the key challenge lies in translating these ideas into practical, replicable, and assessable teaching practices. Taking into account students' current learning characteristics, the availability of teaching resources in the university, and the structural features of the course content itself, this chapter systematically outlines the implementation path and process design. The discussion is structured around five aspects: instructional unit design, classroom organization, simulation and lab platform development, teacher–student interaction mechanisms, and the evaluation system.

4.1. Modular design of teaching content

To enhance the logical flow and coherence of the course, the reform restructures the original chapter-based content into a modular format. Content is decomposed into five hierarchical levels—device, model, circuit, system, and application—and divided into corresponding thematic modules (**Table 1**). Each module is aligned with real-world engineering problems and associated with subtasks that foster the integration of theoretical knowledge and practical application.

Table 1. Teaching module design and application examples for the *Fundamentals of IoT Hardware* course

Teaching module	Teaching topic	Core knowledge points	Application scenario examples
Module 1	MOSFET Structure and Operating Principles	CMOS devices, current control mechanism, I–V characteristics	Amplifier circuits, switching components
Module 2	Small-Signal Modeling and Circuit Analysis	Small-signal model, gain, frequency response	Sensor interface circuits
Module 3	Digital Circuits and CMOS Logic Gates	Inverter, NAND gate, transmission gate, logic function analysis	Embedded GPIO modules
Module 4	SPICE Modeling and Simulation Practice	SPICE syntax, waveform observation, parameter tuning	Temperature acquisition system simulation
Module 5	Circuit System Design and Interface Applications	Voltage comparators, filters, ADC interface	Smart data acquisition node design
Module 6	Case-Driven System Design Integration	Differential signals, anti-interference design, system integration architecture	EEG acquisition systems, smart lighting control nodes

Each module is centered around a typical engineering problem, preserving the training of foundational knowledge while placing emphasis on the development of problem-solving skills.

4.2. Classroom instructional organization

In terms of classroom organization, the reform introduces a "thematic inquiry + mind mapping + task collaboration" triadic teaching model. This model emphasizes student-centered learning and promotes deep learning and team collaboration under teacher guidance.

Thematic inquiry-based teaching: Each class begins with a thematic question or application challenge, such as: "How do you design a temperature acquisition circuit that balances power consumption and response speed?" This problem-driven approach sparks student interest and encourages them to actively construct their own knowledge systems.

Mind mapping for conceptual understanding: Teachers construct knowledge maps for each module (Device — Equivalent Model — Submodule — System Architecture) to help students understand the knowledge network at a macro level. Students are also encouraged to build their own personalized learning maps, aiding internalization of knowledge.

Small group task collaboration: Students are divided into groups of 4–6 members to work collaboratively through four stages—ideation, modeling, simulation, and presentation—based on course challenges. Each stage includes deliverables and presentations, enhancing students' hands-on engagement, teamwork, and communication skills.

Blended flipped classroom with micro-lectures: Teachers pre-record key micro-lectures, including 3D animated explanations of CMOS processes and experimental procedure demos. Students engage in self-paced learning before class, while in-class sessions focus on problem-solving, simulation operations, and idea exchange, improving the overall efficiency of instructional time.

4.3. Construction of the experiment and simulation platform

To create an experimental learning path that is "observable, adjustable, and optimizable," the course reform builds a simulation platform centered on LTspice, accompanied by the development of six integrated experimental task packages see Table 2 for details.

Table 2. Correspondence between experimental tasks and knowledge modules in the Fundamentals of IoT Hardware course

Experiment title	Key content	Corresponding module
MOS Transistor I–V Characteristic Simulation	Analyze the effect of parameter variation on breakdown voltage and current	Module 1
Frequency Response Analysis of Common-Source Amplifier	Observe gain variation, -3dB frequency, and biasing methods	Module 2
CMOS Inverter Transmission Characteristic Simulation	Observe the impact of gain variation, -3dB frequency points, and biasing approaches	Module 3
SPICE Parameter Fitting	Analyze real device models (e.g., 0.18 μm CMOS)	Module 4
Filter + Comparator Interface Design	Design RC filters and simulate the comparator output interfacing with a microcontroller	Module 5
System-Level Simulation of Smart Node	Complete module-level design integrating sensor interfaces, amplification, ADC, and communication logic	Module 6

All experimental tasks are supported by: short preview micro-lectures (5–10 minute demonstration videos); foundational design documents and SPICE templates; encouragement for students to optimize designs, introduce noise, and tune advanced parameters such as temperature drift; and support for both in-class demonstrations and post-class deep refinement, thereby expanding students' initiative and engagement.

4.4. Teacher-student interaction and learning support mechanisms

To enhance instructional interaction quality and student engagement, the course is equipped with dedicated interaction and feedback mechanisms, including: Weekly "Question Wall" Q&A sessions where the instructor addresses and analyzes common student-submitted questions. Open lab sessions are held twice weekly outside of class for simulation-based experimental discussion and support. Online discussion forums hosted on digital platforms (e.g., Rain Classroom, MOOC), with a dedicated discussion area for each module. Peer evaluation system, in which group project assessments incorporate peer review weights to foster responsibility and engagement. Teaching log system, where instructors record reflections and student feedback after each session to inform ongoing course improvement.

4.5. Learning outcome evaluation framework

The course adopts a tri-dimensional evaluation structure consisting of formative assessment + project-based evaluation + summative testing, as shown in **Table 3**. This structure ensures that knowledge mastery, competency development, and learning participation are all taken into account. A multi-dimensional and diversified assessment system effectively guides students to value the learning process and skill enhancement, avoids the pitfalls of one-time high-stakes testing, and allows instructors to continuously monitor and respond to student learning dynamics.

Table 3. Multi-dimensional assessment framework for the Fundamentals of IoT Hardware course

Evaluation type	Weight	Evaluation content and methods
Formative Assessment	30%	Classroom participation, completion of phased tasks, simulation report submission, mini-quizzes
Project-Based Evaluation	40%	Group system design deliverables, design documentation, and technical presentations
Summative Assessment	30%	Written final exam + open-ended questions

5. Teaching practice and analysis of reform effectiveness

Since the implementation of this project, systematic teaching reform and practical exploration have been carried out for the Fundamentals of IoT Hardware course, focusing on content restructuring, instructional method optimization, experimental platform upgrading, and evaluation system enhancement. Over two complete teaching cycles, pilot and iterative practices were conducted for students in the IoT Engineering program from the cohorts of 2019 and 2020. Through a comparative analysis of pre- and post-reform outcomes—supplemented by student feedback, teacher evaluations, and teaching data—this chapter provides a systematic assessment of the reform's effectiveness and identifies areas that require further optimization.

5.1. Overview of reform implementation

According to the reform objectives, a teaching reform pilot for this course was launched during the 2022–2023 academic year at the School of Information Science and Technology, Hainan Normal University, targeting IoT Engineering majors. The course comprised a total of 48 instructional hours, including 28 hours of theoretical instruction and 20 hours of practical training, fully covering the six modules outlined in the previous chapters. The teaching team consisted of five instructors, all of whom received training in LTspice simulation and task-driven instructional workshops to ensure consistency and standardization in teaching implementation.

5.2. Student feedback and learning outcome analysis

To comprehensively assess the effectiveness of the reform, surveys and interviews were conducted after the course. A total of 96 students who completed the course were invited to participate, and 94 valid responses were collected. The findings indicate significant positive impacts in the following areas.

Marked increase in student learning interest: 89% of students stated that the course content was "more closely aligned with real-world applications and more engaging," compared to pre-reform responses indicating they studied "just to pass exams." Most students reported a clearer understanding of hardware systems and greater motivation to learn.

Enhanced practical skills: Over 81% of students felt that LTspice simulation exercises "effectively helped them understand circuit operating principles" and noted that they were able to apply the skills in capstone projects and research work. The overall quality of group system design tasks surpassed previous years, with some projects selected for university innovation competitions.

Improved self-learning and team collaboration abilities: The group task-based structure and phased reporting format of the reformed course significantly enhanced students' communication and project execution skills. 77% of students reported that "through project development, they gradually mastered design processes and collaborative working methods."

Stronger system-level understanding of engineering problems: In response to the question "Did the course help build a comprehensive understanding of system design?", 89% gave positive feedback, stating that "the course bridged the gap between theory and application." The shift from "learning components" to "understanding systems" notably deepened students' learning experiences.

5.3. Comparison of teaching evaluation data

The composition of course performance, learning process data, and assignment outcomes before and after the teaching reform for two class cohorts is shown in **Table 4**.

Table 4. Comparison of teaching effectiveness before and after the reform of the Fundamentals of IoT Hardware course

Evaluation indicator	Pre-reform class	Post-reform class	Change
Average Overall Course Score	78.5	84.2	Increased by 5.7 points
Project Task Completion Rate	63%	91%	Increased by 28%
Average Number of Simulation Report Submissions per Student	2.1	5.3	Increased by 3.2 submissions
Student Initiative Rate (Classroom/Online Platform)	18%	43%	Increased by 25%
Course Satisfaction (4-point scale)	3.2/4	3.8/4	Increased by 0.6 points

Quantitative data indicate that students in the reformed class demonstrated significant improvements in learning initiative, project performance, and overall competency output, thereby validating the effectiveness of the instructional design and evaluation mechanisms.

5.4. Teacher evaluation and classroom observation results

During course implementation, the teaching team conducted regular teaching reflections and peer evaluations. Overall feedback revealed both positive outcomes and areas for further improvement. Most instructors agreed that task-oriented, modularized teaching effectively captured students' attention, while the introduction of SPICE-based simulation greatly enhanced classroom effectiveness and practical engagement. In terms of instructional organization, the flipped classroom model encouraged students to prepare more thoroughly before class, leading to deeper in-class interaction and cognitive engagement. However, some instructors also noted increasing disparities in student ability, with less-prepared students falling behind in project-based tasks. This highlights the need for more targeted and differentiated instructional support in future iterations of the course.

6. Conclusion

Through the research and practice of this project, a preliminary teaching reform framework for the Fundamentals of IoT Hardware course has been established to meet the evolving demands of talent cultivation in the new era of IoT engineering. Centered on a "device–model–circuit–system" knowledge structure, the course adopts a modular content framework, integrates task-driven and inquiry-based teaching methods, and incorporates the industrial-grade LTspice simulation platform. These reforms have guided students from theoretical understanding toward the development of comprehensive system design capabilities. Teaching practices indicate that the reform has not only significantly increased students' interest and engagement in the course but also substantially enhanced their practical skills and engineering literacy. Course performance, task completion rates, and student satisfaction have all shown notable improvements compared to traditional teaching approaches. However, the reform has also revealed some challenges, such as the wide variance in student capabilities leading to uneven task performance, and the insufficient level of digitalization of course resources. Future efforts will focus on platform-based resource development, layered experimental tasks, and the exploration of integrated "course–competition–research" education models. These initiatives aim to deepen industry-education integration, promote interdisciplinary teaching, and ensure the continued optimization and broader dissemination of reform outcomes. Overall, this project offers a replicable and scalable model for engineering course reform. It also provides valuable insights and practical support for improving the quality of education in local universities and responding to the strategic talent needs of the nation.

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Disclosure statement

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