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Reform in Practical Teaching of Internet of Things Engineering Based on Loongson

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Abstract: Aiming at the problems existing in the current practical teaching of Internet of Things engineering, such as the dependence of hardware platforms on foreign chips and the disconnection between teaching content and industrial needs, this paper proposes a teaching reform scheme based on the domestic Loongson processor. Through the construction of a Loongson Internet of Things experimental platform, the development of supporting teaching resources, and the optimization of the practical curriculum system, the in-depth application of domestic technologies in teaching has been realized. Practice shows that this reform scheme has effectively improved students' independent innovation ability and application ability of domestic chips, providing a new path for cultivating Internet of Things engineering and technical talents that meet the national strategic needs.

Keywords: Loongson processor; Internet of Things engineering; Practical teaching; Teaching reform; Domestic technology

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1. Introduction

With the rapid development of Internet of Things (IoT) technology, talent cultivation in related fields is facing new opportunities and challenges [1]. Currently, universities generally adopt development platforms based on foreign chips for IoT engineering practice teaching, which have problems such as strong technical dependence and lagging updates in teaching content [2,3]. At the same time, the country is vigorously promoting the innovation industry of information technology application, creating an urgent demand for talent cultivation related to domestic chips. This study reconstructs the IoT practice teaching system based on the Loongson processor, aiming to explore a teaching reform path that meets national strategic needs. By analyzing the shortcomings of the existing teaching model and combining the technical characteristics of Loongson, a complete teaching reform plan is designed, and its effectiveness is verified in actual teaching.

2. Analysis of the current situation of IoT engineering practice teaching

There are three main problems in the current IoT engineering practice teaching: strong dependence on hardware platforms, lagging teaching content, and insufficient practical ability of students [4–6]. Most colleges and universities adopt experimental equipment based on ARM or Intel architectures. These foreign chips dominate the market, leading to a deviation between teaching and domestic industrial needs [7,8]. At the same time, the update speed of practical courses is slower than the development of technology, and most experimental projects are verification-oriented, lacking innovative design links. Surveys show that more than 60% of IoT major graduates report a gap between the skills they have learned and the needs of enterprises, especially their weak ability in the application of domestic chips.

Combined with cases from multiple colleges and universities, the specific manifestations of the core problems in IoT practice teaching are summarized in **Table 1**.

Table 1. Specific manifestations of core problems

Problem dimensions	Specific manifestations
Hardware conditions	Outdated laboratory equipment, low software operation efficiency in public computer rooms, and a shortage of expandable equipment such as IoT sensors
Course content	Emphasis on traditional embedded development (such as STM32), lack of cutting-edge modules such as domestic chip adaptation and security encryption
Teacher competence	Teachers have insufficient practical experience in enterprises, making it difficult to guide students in solving development and debugging problems in the Loongson ecosystem
Integration of industry and education	School-enterprise cooperation remains at the level of cognitive internships, failing to form a closed loop of "research - learning - application"

This paper proposes a practical teaching reform plan with the domestic Loongson processor as the core. By reconstructing the curriculum system, building a Loongson IoT experimental platform, and deepening school-enterprise collaboration, a three-stage ability training path of "foundation - integration - innovation" is constructed, providing a promotable paradigm for the training of domestic independent and controllable technical talents.

3. Practice teaching reform plan for Internet of Things based on Loongson

The reform plan proposed in this study includes three core contents: the construction of the Loongson Internet of Things experimental platform, the development of teaching resources, and the optimization of the curriculum system [9]. The experimental platform adopts the Loongson 1C300 processor as the core, matched with independently developed sensor modules and communication interfaces, supporting multiple IoT protocols such as LoRa and Zigbee. In terms of teaching resource development, a series of textbooks such as "Loongson Internet of Things Development Tutorial" has been compiled, and a resource library containing 30 typical experimental projects has been established. The curriculum system adopts a three-level structure of "basic-integrated-innovative", organically combining the characteristics of Loongson technology with IoT engineering knowledge, and emphasizing the cultivation of system design and problem-solving abilities [10–13].

3.1. Curriculum system reconstruction: layered empowerment of domestic technology stack

(1) Basic layer: Add the compulsory course "Loongson Processor Architecture and Instruction Set" to

replace the traditional single-chip microcomputer course.

(2) Integrated layer: Develop experimental modules for the Loongson cloud platform (communication protocols + sensor data collection + AI + containerization), and offer comprehensive training projects such as "smart agriculture and industrial Internet of Things";

(3) Innovation layer: Based on the needs of enterprises in the Loongson ecosystem, offer innovative training projects such as "Loongson + RISC-V heterogeneous computing, digital twin simulation system, and AIoT federated learning framework."

Table 2 shows the design of 30 typical experimental projects in the "Internet of Things Development Tutorial" based on Loongson processors, covering a complete learning path from basic to comprehensive applications, highlighting the characteristics of domestic technologies and the cultivation of engineering practice capabilities.

Table 2. Design of 30 typical experimental projects

Experiment type	Experiment project	Experiment content
Basic Development Experiments (1-8)	1. Construction of Loongson Development Environment	Loongnix system installation, cross-compilation toolchain configuration, serial port debugging
	2. GPIO-controlled LED Breathing Light	Adjust brightness through PWM and master Loongson GPIO register operations
	3. UART Serial Communication Experiment	Realize data transmission between Loongson and PC, and parse the Modbus protocol
	4. I2C Temperature and Humidity Sensor Driver	Write SHT30 sensor driver, data collection and calibration
	5. SPI Interface OLED Display	Drive 0.96-inch OLED to display sensor data
	6. Timer Interrupt Application	Use Loongson hardware timer to achieve accurate data sampling
	7. ADC Illumination Intensity Detection	Photosensitive resistor analog signal collection and digital processing
	8. Watchdog and System Reliability	Configure hardware watchdog to prevent program runaway
Communication Protocol Experiments (9-16)	9. LoRa Wireless Networking	Build a star network of Loongson + LoRa modules, RSSI testing
	10. Zigbee Ad Hoc Network Communication	Coordinator and terminal node communication, network topology analysis
	11. MQTT Protocol Cloud Connection	Connect to domestic MQTT Broker (such as EMQX), publish and subscribe to messages
	12. HTTP RESTful API Development	Develop API based on Loongson lightweight web server (such as Tinyhttpd)
	13. Bluetooth BLE Data Transparent Transmission	Loongson acts as a Central device to scan and receive sensor data
	14. 4G Cat.1 Module Networking	Upload data to the cloud platform through domestic 4G modules (such as Quectel EC200)
	15. National Secret Algorithm Encrypted Transmission	SM4 encrypts sensor data, SM2 digital signature verification
	16. Multi-Protocol Gateway Conversion	Realize Zigbee to Wi-Fi protocol conversion (requires supporting protocol stack)

Table 2 (Continued)

Experiment type	Experiment project	Experiment content
Comprehensive Application Experiments (17-25)	17. Smart Agriculture Monitoring System	Soil moisture + light + CO2 multi-sensor fusion, LoRa backhaul
	18. Industrial Vibration Monitoring Terminal	Acceleration sensor data FFT analysis, edge computing early warning
	19. Smart Street Light Control System	Light control + remote dimming + energy consumption statistics (adapted to domestic PLC protocol)
	20. RFID Asset Management System	Loongson drives 13.56MHz card reader, data encryption storage
	21. Speech Recognition Edge Terminal	Port lightweight ASR model (such as Kaldi) to Loongson platform
	22. AI Camera Target Detection	USB camera + YOLOv3-tiny model deployment (OpenCV adaptation)
	23. OTA Remote Upgrade System	Differential upgrade package generation and security verification (national secret SM3 hash)
	24. Containerized Application Deployment	Run Docker containers on Loongson platform (requires adaptation to MIPS architecture)
	25. Energy Monitoring and Optimization	Electric energy metering chip driver + load dynamic scheduling algorithm
Innovation Expansion Experiments (26-30)	26. Loongson + RISC-V Heterogeneous Computing	Loongson as the main control, connecting RISC-V coprocessor through SPI
	27. OpenHarmony OS Porting	Porting of OpenHarmony lightweight system on Loongson 1C300
	28. Digital Twin Simulation System	Loongson data docking with Unity3D/domestic Web3D engine
	29. AIoT Federated Learning Framework	Multi-Loongson terminal collaborative training of lightweight models
	30. National-wide Localization Certification Experiment	Full-stack localization compatibility testing from chips, OS to applications

3.1.1. Features of this IoT engineering experiment design

(1) Gradient Progression: From register operations to system-level design, covering the entire IoT technology stack.

(2) Domestic Integration: 60% of the experiments involve national cryptographic algorithms, domestic operating systems, or domestic cloud platforms.

(3) Integration of Virtual and Physical: Supporting simulation tools (Loongson QEMU image) to reduce hardware dependency.

(4) Industry Alignment: Experimental cases refer to real scenarios such as smart homes and industrial Internet.

(5) Open-Source Support: Providing code repositories and hardware design references maintained by the Loongson community.

3.2. Construction of the Loongson Internet of Things laboratory

(1) Hardware configuration: Loongson 1C300 development board + domestic sensor modules + LoRa gateway, supporting the Loongnix operating system.

(2) Virtual expansion: Establish a Loongson cloud experiment platform to address the bottleneck of the number of physical devices.

(3) Laboratory construction: Build an IoT engineering practice laboratory based on Loongson, equipped with corresponding hardware devices and software tools to provide students with a good practical environment.

(4) Virtual simulation experiments: Utilize virtual simulation technology to develop a Loongson-based IoT virtual simulation experiment platform, allowing students to conduct experiments and practices in a virtual environment, thereby improving the safety and efficiency of experiments.

3.2.1. Features of laboratory equipment

(1) Teaching + training: Based on the goals and methods of talent cultivation for IoT majors in vocational colleges, optimize and design the training teaching. It puts forward the teaching concept of progressing from the cognition of IoT knowledge and technology, to the training of IoT practical skills, and finally to the improvement of professional post capabilities in the IoT field.

(2) Comprehensive technical coverage: The design will integrate as many mainstream IoT devices or technologies as possible into the system, including sensor technology, data acquisition technology, radio frequency identification technology, wireless network technology, mobile Internet technology, embedded technology, intelligent terminal technology, upper computer application software technology, etc. It covers all relevant technical fields of the IoT completely and comprehensively.

(3) Wide range of applications: The system takes three application scenarios of IoT, artificial intelligence, and cloud computing, as well as various business sub-items based on these three scenarios, to reflect the theme of IoT smart life. All application scenarios and functional business sub-items are selected from real IoT industry applications.

(4) Easy expansion: The hardware and software systems adopt platform-based and modular design, combined with generalized and standardized IoT training workstations. In addition to completing the demonstration and training of supporting training content, more technologies or businesses can be connected and expanded based on the IoT training workstations and the system's hardware and software modules.

(5) Complete supporting facilities: In addition to the complete hardware and software system, the product is also equipped with a complete IoT training guide for the equipment, rich teaching and training material resources, and IoT teaching video CDs based on the equipment system. The experimental equipment comes with free installation and deployment services and equipment training services.

3.3. School-enterprise collaborative "Four-Dimensional Driving" model

Table 3. Dimensions and implementation strategies in the model

Dimension	Implementation strategies
Industry	Enterprises donate Loongson development kits and jointly release practical training projects.
Learning	Engineers are stationed in the school to guide the debugging of the Loongson platform and participate in the guidance and evaluation of graduation projects.
Research	Teachers and students undertake horizontal projects from enterprises (such as optimization of Loongson edge computing gateways).
Application	Students' achievements are implemented in communities/campuses (such as the Loongson smart manhole cover monitoring system).

3.4. Upgrading of teachers' competence

(1) Teachers go to Loongson-related research institutions for further study on domestic chip development technology and obtain LoongArch certification;

(2) Engineers from Loongson-related enterprises are hired as teachers for practical courses in Internet of Things engineering.

4. Implementation of teaching reform and effect evaluation

4.1. Adjustment of teaching content

Integration with Loongson characteristics: Conduct in-depth research on the architecture, performance, and features of Loongson processors, and integrate them into the teaching content of Internet of Things (IoT) engineering. For example, when explaining the construction of IoT hardware platforms, introduce Loongson-based development boards to enable students to learn about hardware selection, circuit design, and system integration based on Loongson.

4.2. Update of knowledge system

Keep up with the development trends of IoT technology and Loongson technology, and promptly update teaching content to ensure students master the latest technologies and applications. For instance, add application cases and technical explanations of Loongson in IoT security, edge computing, and other fields.

4.3. Improvement of teaching methods

(1) Project-driven teaching: Design IoT engineering projects based on Loongson, allowing students to participate in project practice in groups. They will experience the entire project implementation process from requirement analysis, design, development to testing, thereby improving their practical abilities and teamwork skills.

(2) Integration of practical operations and theoretical teaching: On the basis of theoretical teaching, increase practical operation sessions to help students deepen their understanding and mastery of theoretical knowledge through hands-on practice. For example, when explaining IoT communication protocols, let students implement protocol programming and debugging on Loongson-based development platforms.

4.4. Strengthening the construction of teaching staff

(1) Training and learning: Organize teachers to participate in Loongson-related training and learning activities to improve their professional level and practical capabilities, enabling them to better carry out Loongson-based IoT engineering practice teaching.

(2) Enterprise cooperation: Encourage teachers to cooperate with enterprises, participate in enterprise project development and technical research, understand the latest industry needs and development trends, and bring practical enterprise experience into classroom teaching.

4.5. Evaluation of students' learning effects

(1) Mastery of knowledge: Evaluate students' mastery of Loongson-based IoT engineering knowledge through examinations, assignments, and experimental reports.

(2) Improvement of practical abilities: Observe students' performance in project practice to assess the

improvement of their practical operation skills, problem-solving abilities, and innovative capabilities.

(3) Learning satisfaction: Understand students' satisfaction with teaching content, teaching methods, and practical teaching environment through questionnaires and student forums.

4.6. Evaluation of teaching quality

(1) Achievement of teaching objectives: Compare teaching objectives before and after the teaching reform to evaluate their achievement, and verify that the practical teaching reform has effectively improved teaching quality.

(2) Teaching effectiveness of teachers: Evaluate teachers' teaching effectiveness through student evaluations and peer reviews to understand their performance and existing problems in the teaching process.

4.7. Evaluation of social feedback

(1) Employment situation: Track the employment status of graduates, understand the employment proportion and quality of graduates in Loongson-based IoT engineering-related fields, and evaluate the effect of the teaching reform on enhancing students' employment competitiveness.

(2) Enterprise feedback: Communicate with cooperative enterprises to understand their evaluations and feedback on graduates, obtain their suggestions and opinions on the teaching reform, and provide references for further improving teaching.

The reform plan has been implemented in the IoT engineering major of our university for two academic years, covering 4 classes with a total of 120 students. Data were collected through various methods such as questionnaires, skill tests, and project evaluations. The results show that students' ability to apply domestic chips has improved significantly, with proficiency in Loongson platform development reaching over 85%; their innovative practical abilities have been significantly enhanced, completing 20 innovative projects, 5 of which won provincial competition awards. Compared with traditional teaching classes, the experimental group students have an average improvement of 30% in system design ability and problem-solving ability. Enterprise feedback indicates that graduates participating in this project are more adaptable to the domestic technical environment, with a 25% increase in job matching.

5. Conclusion

The teaching reform of Internet of Things (IoT) engineering practice based on Loongson processors has proven that the application of domestic chips in teaching can effectively improve the quality of talent cultivation and meet the needs of the national strategy for innovation in information technology application [14,15]. Future research will further expand the scope of implementation, optimize curriculum content, strengthen school-enterprise cooperation, and develop more typical application cases based on Loongson. Meanwhile, it will explore the integrated application with other domestic technologies, build a more complete independent innovation practice teaching system, and provide continuous support for cultivating high-quality IoT engineering and technical talents.

Disclosure statement

The author declares no conflict of interest.

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