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Research On The Reform Of Wireless Sensor Network Technology Course Oriented Towards Academic Competitions

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Abstract:
Aiming at the problems of disconnection between theory and practice and insufficient cultivation of students' innovative ability in the traditional teaching of the Wireless Sensor Network Technology course, and combining the requirements of academic competitions for engineering practice, teamwork, and innovative thinking, a course reform plan is proposed. By reconstructing the course content system, innovating the teaching model, optimizing practical links, and improving the evaluation mechanism, elements of academic competitions are deeply integrated into the entire teaching process, achieving "promoting learning, teaching, and reform through competitions". Practice shows that after the reform, students' theoretical application ability, engineering practice level, and competition award rate have significantly improved, and the quality of course teaching has been effectively enhanced.
Key Word: *Wireless Sensor Network Technology; Academic Competitions; Course Reform; Practical Teaching; Innovative Ability*

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I. Introduction

Wireless Sensor Network Technology, as a core supporting technology for emerging fields such as the Internet of Things and intelligent manufacturing, has broad application prospects and strong talent demand. The "Wireless Sensor Network Technology" course offered by universities aims to cultivate students' core abilities in sensor node design, network topology construction, data transmission protocols, and system integration development. However, traditional course teaching has many drawbacks: firstly, the teaching content focuses heavily on theoretical explanation and is not closely integrated with engineering practice; secondly, the practical components are mostly verification experiments, lacking comprehensive and design-oriented project training; thirdly, the teaching model is single, students passively receive knowledge, and the cultivation of innovative thinking and teamwork ability is insufficient[1].

Academic competitions (such as the National Undergraduate Electronic Design Contest, IoT Design Competitions, etc.) are oriented towards practical engineering problems, emphasizing theoretical application, innovative design, and teamwork, providing an important starting point for course reform. Deeply integrating academic competitions with course teaching can effectively make up for the shortcomings of traditional teaching, stimulate students' learning interest, and enhance their engineering practice and innovation capabilities. Therefore, conducting research on the reform of the Wireless Sensor Network Technology course oriented towards academic competitions has important practical significance[2].

II. Analysis Of The Current Course Teaching Situation

1. Disconnection between Teaching Content and Engineering Practice

Traditional course teaching content mostly revolves around textbooks, covering theoretical knowledge such as basic concepts of wireless sensor networks, protocol stack architecture, and sensor principles. However, there is insufficient explanation of practical technologies commonly used in actual engineering, such as node development platforms (e.g., Arduino, STM32), wireless communication modules (e.g., ZigBee, LoRa), and data processing algorithms. Furthermore, there is a lack of integration with industry application scenarios (e.g., environmental monitoring, intelligent security, smart agriculture), making it difficult for students to apply the knowledge they have learned to practical problems.[3]

2.Weak Practical Teaching Links

Practical sessions are mostly classroom-based verification experiments, such as sensor data acquisition and simple point-to-point communication. The experimental content is fixed and the steps are singular; students only need to follow the instruction manual to complete them, lacking space for independent design and innovation. At the same time, practical teaching resources are limited, making it difficult to carry out large-scale comprehensive and design-oriented project training, and students' engineering practical ability cannot be effectively improved[4].

3. Singular Teaching Model and Evaluation Mechanism

The teaching model is primarily based on "teacher lecture + student listening", where students are in a passive learning state, lacking opportunities for active thinking and exploration. The evaluation mechanism focuses on final exam results, neglecting process evaluation and practical ability assessment. This leads students to prioritize theory over practice and results over process, making it difficult to stimulate learning enthusiasm and innovation motivation.

4.Insufficient Integration of Academic Competitions and Teaching

Currently, academic competitions are mostly participated in by students independently after class, lacking systematic support from course teaching. During the competition preparation process, students need to supplement relevant knowledge and skills on their own, facing difficulties such as a steep learning curve and slow progress. It is challenging to form a large-scale and normalized atmosphere for competition participation, and the role of competitions in promoting teaching has not been fully utilized.

III. Design Of The Competition-Oriented Course Reform Plan

1.Restructuring the Course Content System

Guided by the requirements of academic competitions and industry needs, restructure the course content system into a trinity of "theoretical foundation + practical skills + competition projects", as shown in Figure 1.

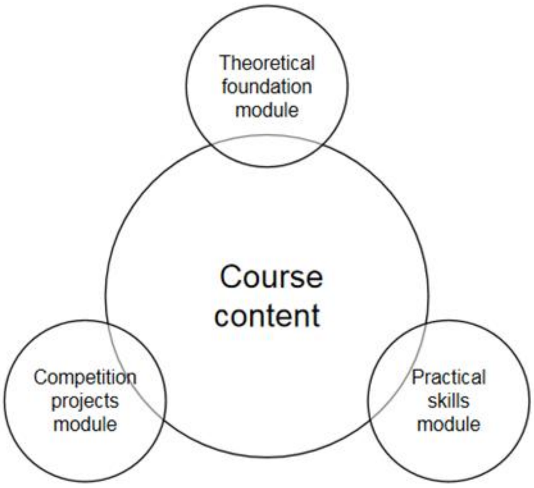

Figure 1: Schematic diagram of the restructured course content system

(1) Theoretical Foundation Module

Streamline redundant theories and focus on core knowledge points, including wireless sensor network topology, MAC protocols, routing protocols, data fusion technology, etc. Simultaneously, supplement theoretical knowledge commonly used in competitions, such as embedded programming, sensor interface development, and wireless communication protocol applications, to lay the foundation for practical sessions and competition projects[4].

(2) Practical Skills Module:

Strengthen practical skills training, covering sensor node hardware design (e.g., STM32 minimum system setup, sensor module selection and debugging), software programming (e.g., C language programming, FreeRTOS operating system application), wireless communication module configuration (e.g., ZigBee module networking, LoRa module data transmission), data processing and visualization (e.g., Python data analysis, Web interface design), etc., to enhance students' engineering practical ability[5,6].

(3) Competition Projects Module

Transform real competition topics (e.g., environmental monitoring wireless sensor networks, smart agriculture data acquisition systems) into course design projects. Organize teaching according to the process of "project requirement analysis → scheme design → hardware setup → software development → system debugging → result presentation" to cultivate students' project development ability and innovative thinking[7].

2. Innovating the Teaching Model and Process

Adopt a blended teaching model combining "online + offline", "theory + practice", and "teaching + competition", accompanied by a designed closed-loop teaching process to ensure the deep integration of academic competition elements into all aspects of teaching. The teaching process is shown in Figure 2.

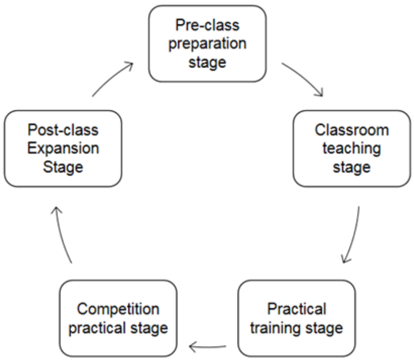

Figure 2: Block diagram of the competition-oriented course teaching process

(1) Pre-class Preparation Phase

Teachers release preview tasks (including theoretical knowledge points and competition case videos) on the MOOC platform; students submit questions after completing online learning. Meanwhile, based on the upcoming competition project (e.g., "ZigBee-based Smart Greenhouse Monitoring System"), guide students to form groups and complete a preliminary analysis of project requirements, laying the foundation for classroom teaching.

(2) Classroom Teaching Stage:

Adopt the process of "case introduction → theory explanation → skill demonstration → group discussion". Use technical difficulties in the competition project (e.g., "multi-sensor data synchronous acquisition") as the entry point to explain relevant theoretical knowledge (e.g., data transmission protocols) and practical skills (e.g., sensor interface debugging), and organize students to discuss project plans in groups, with teachers providing real-time guidance for optimization[9].

(3) Practical Training Stage

Advance through three levels: Basic verification experiments (e.g., "ZigBee module point-to-point communication test") consolidate what is learned in class; Comprehensive design experiments (e.g., "multi-node networking and data upload") exercise project development capabilities; Competition simulation experiments (using NS-3 to simulate "greenhouse monitoring system network performance optimization") simulate competition scenarios, allowing students to verify the feasibility of their schemes through simulation, reducing the cost of physical development[10].

(4) Competition Practical Stage

Select excellent teams from the course groups to carry out an 8-week competition training camp, using a "tutorial system" for group guidance: Weeks 1-2 complete the breakdown of real competition questions ; Weeks 3-5 involve hardware setup and software development; Weeks 6-7 focus on system debugging and optimization; Week 8 involves simulated defense and result finalization, ultimately pushing teams to participate in formal competitions.

(5) Post-class Expansion Stage

After the competition, organize a "Competition Achievement Sharing Session" where award-winning teams share development experiences and technical insights; teachers transform excellent competition works into teaching cases and update online teaching resources; simultaneously, guide students to apply for patents or innovation and entrepreneurship projects based on competition achievements, forming a closed loop of "learning - practice - competition - innovation".

3.Optimizing Practical Teaching Conditions

(1) Building Multi-functional Laboratories

Upgrade existing laboratory equipment, configure hardware resources such as STM32 development boards (100 sets), ZigBee/LoRa communication modules (80 sets each), various sensors (50 sets each of temperature/humidity, light, soil moisture sensors), and data acquisition cards (30 sets), and build a comprehensive wireless sensor network experimental platform to meet the needs of 60 people conducting basic experiments and comprehensive design experiments simultaneously.

(2) Building Competition Simulation Platform

Introduce simulation software like Matlab and NS-3 to build a wireless sensor network competition simulation platform. It includes 10 commonly used competition scenario models such as "Environmental Monitoring Network Performance Test" and "Smart Agriculture Data Transmission Optimization". Students can quickly verify design schemes through the platform, reducing the average experimental verification time from 2 days to 4 hours.

(3) School-Enterprise Cooperation to Build Practice Bases

Cooperate with 3 local IoT enterprises to jointly build off-campus practice bases. Enterprises provide 20 internship positions annually, select 10 engineers to participate in course teaching (e.g., lecturing on "Industrial Applications of LoRa Modules"), and sponsor some competition funds to ensure the synchronization of practical teaching with industry needs.

4.Improving the Evaluation Mechanism

Establish a diversified evaluation mechanism combining "Process Evaluation + Summative Evaluation + Competition Achievement Evaluation" to comprehensively assess students' learning outcomes and comprehensive abilities. The evaluation index system is shown in Table 1. In Table 1, Process evaluation focuses on the student's learning process and participation, summative evaluation assesses theoretical knowledge and project design ability, and competition achievement evaluation motivates students to participate in competitions and innovative practices, forming a virtuous cycle of "learning - practice - competition - improvement".

Table 1 Course Evaluation Index System

Evaluation Dimension	Evaluation Content	Weight	Evaluation Method
Process Evaluation	Online learning progress (20%), Classroom performance (30%), Lab reports (30%), Participation in group discussions (20%)	30%	Online platform data (e.g., MOOC completion rate) + Teacher scoring + Peer evaluation within groups
Summative Evaluation	Final exam (Theoretical knowledge 60%, includes routing protocols, data fusion, etc.; Project design proposal 40%, requires submission of competition-style project design documents)	40%	Closed-book exam + Proposal defense (5-minute presentation + 3-minute Q&A)
Competition Achievement Evaluation	Course design project results (40%, includes hardware physical object, software code, test report); Academic competition awards (40%, National/Provincial/University level converted at 100%/80%/50% respectively); Innovative work patents (20%, Utility model patents/Software copyrights converted at 80%/60% respectively)	30%	Project presentation scoring (joint evaluation by teachers + enterprise engineers) + Competition award verification / Patent certificate verification

IV. Reform Practice Effects And Data Comparison

1. Specific Competition Case Results

Taking two core types of competitions participated in during the course reform period from 2021-2024 as examples, the specific results data are shown in Table 2, covering competition level, number of participating teams, number of awards, and typical works, intuitively reflecting the improvement in competition ability brought by the reform.

Table 2 Comparison of Participation and Awards in Academic Competitions Before and After Reform

Competition Name	Competition Level	Pre-Reform (2021-2022)	Post-Reform (2023-2024)	Typical Award-Winning Works
National	National	3 participating	12 participating teams,	LoRa-based Forest Fire Monitoring

Undergraduate Electronic Design Contest		teams, 0 award-winning teams	5 award-winning teams (2 National Second Prize, 3 Provincial First Prize)	System (2023 National Second Prize), Multi-node WSN Water Quality Detection Platform (2024 Provincial First Prize)
China University IoT Innovation Design Competition	National	2 participating teams, 1 award-winning team (Provincial Third Prize)	10 participating teams, 7 award-winning teams (3 National Third Prize, 4 Provincial Second Prize)	Smart Agriculture WSN Irrigation Control System (2023National Third Prize), Edge Computing-based Campus Security Sensor System (2024Provincial Second Prize)
Provincial Undergraduate IoT Design Competition	Provincial	5 participating teams, 2 award-winning teams (1 Provincial Second Prize, 1 Third Prize)	18 participating teams, 13 award-winning teams (4 Provincial First Prize, 6 Second Prize, 3 Third Prize)	WSN Campus Energy Consumption Monitoring System (2023 Provincial First Prize), Portable Environmental Parameter Sensing Detection Terminal (2024 Provincial Second Prize)

Judging from the typical works, students' works after the reform are closer to actual engineering needs, and the level of technical integration has significantly improved. For example, the 2022 National Undergraduate Electronic Design Contest award-winning work "LoRa-based Forest Fire Monitoring System" integrated temperature/humidity, smoke, and flame sensors, achieved multi-node data transmission within 10 kilometers through LoRa modules, and combined with solar power modules to achieve continuous monitoring. The hardware design, software programming, and system debugging capabilities of this work all reached a relatively high level in the competition, and such complex system development capabilities were rare among students before the reform.

2. Comparison of Core Indicators Before and After Reform

To quantify the effectiveness of the reform, three core indicators were selected for comparison before and after the reform: student competition award rate, practical project completion quality, and course satisfaction. The comparison results are shown in Figure 3.

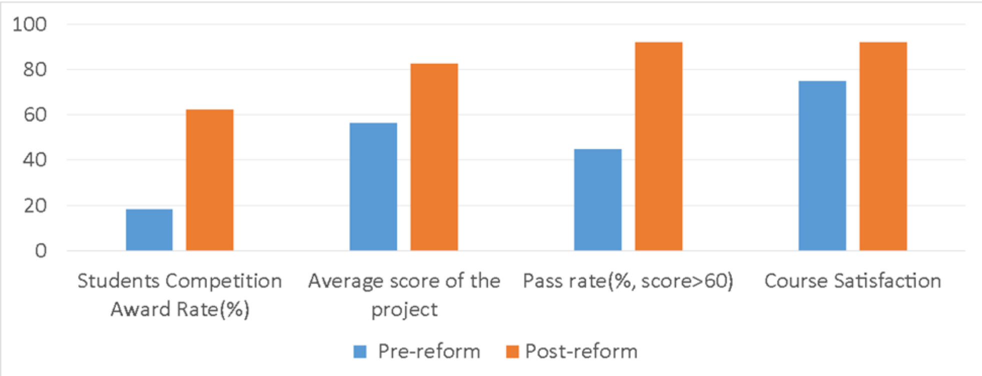

Figure 3: Comparison Chart of Core Indicators Before and After Course Reform (Note: Pre-reform data is from the 2021-2022 academic year; post-reform data is the average from 2023-2024)

(1) Student Competition Award Rate(%)

Before the reform, the award rate for students participating in academic competitions at all levels was only 18.2% (number of award-winning teams/number of participating teams). After the reform, through the deep integration of course teaching and competition training, the award rate increased to 62.5%, a growth of 243%. The national-level competition award rate increased from 0 to 41.7%, achieving a breakthrough in national-level awards.

(2) Practical Project Completion Quality(include average score of the project and pass rate)

Taking the course comprehensive design project "Wireless Sensor Network Environmental Monitoring System" as the evaluation object, scoring was conducted from three dimensions: hardware completeness (30 points), software function realization (40 points), and system stability (30 points). Before the reform, the average project score was only 56.3 points, and the pass rate (above 60 points) was 45%. After the reform, the average project score increased to 82.7 points, and the pass rate reached 92%. The proportion of excellent projects scoring above 80 points increased from 8% to 58%, indicating a significant improvement in students' engineering practical ability.

(3) Course Satisfaction

Collected through anonymous questionnaire surveys (out of 100 points). Before the reform, the average course satisfaction was 75 points, with main problems focusing on "insufficient practical components" and "disconnection from competitions". After the reform, course satisfaction increased to 92 points. Over 90% of students believed that the "course content is practical and can improve competition ability" and "practical components are rich and helpful for mastering core skills". The course teaching quality received widespread recognition from students.

3. Enhancement of Faculty and Teaching Resources

The reform not only improved student abilities but also promoted the construction of the teaching faculty and the improvement of teaching resources. Before the reform, only 25% of the course group teachers had experience in competition guidance, published 3 teaching reform papers, and had no cooperative horizontal projects with enterprises. After the reform, 80% of the teachers have experience in guiding competitions at various levels, published 8 teaching reform papers , presided over 2 provincial-level and 3 university-level teaching reform projects, and cooperated with enterprises to carry out 3 horizontal projects such as "Optimal Design of Wireless Sensor Network Nodes", forming a favorable situation of mutual promotion among "teaching - competition - research". Meanwhile, the course built a teaching resource library containing 12 competition case videos, 8 sets of comprehensive experiment instruction manuals, and 5 simulation experiment models, providing strong support for subsequent course teaching.

V. Conclusion And Outlook

The reform of the Wireless Sensor Network Technology course oriented towards academic competitions, by reconstructing the "theory - practice - competition" trinity content system, designing a closed-loop teaching process, optimizing practical teaching conditions, and improving the diversified evaluation mechanism, has effectively solved the problems of disconnection between theory and practice and insufficient cultivation of students' innovative ability in traditional teaching. Judging from the practical effects, after the reform, students' academic competition award rates, practical project completion quality, and course satisfaction have all achieved significant improvements. The teaching and research capabilities of the faculty have also been simultaneously enhanced, achieving the goal of "promoting learning, teaching, and reform through competitions".

In the future, we will further deepen the reform from three aspects: First, update technical content, closely follow the development of 5G and AI technology, and add modules such as "5G + Wireless Sensor Network Convergence Application" and "AI-based Sensor Data Anomaly Detection" to enhancing the cutting-edge nature of the course. Second, expand competition cooperation, establish a "Competition Resource Sharing Alliance" with 10 universities nationwide, jointly develop competition training projects, organize cross-university simulated competitions, and expand the scale of competition participation. Third, promote resource radiation, compile the course's teaching resource library and competition guidance plan into standardized materials, and share them through the National-level top-quality online open courses platform to provide references for similar course reforms and assist in the cultivation of high-quality talents in the field of Wireless Sensor Network Technology.

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