Construction of Innovative and Open Experimental Teaching Platform for Embedded Systems

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ABSTRACT

In order to improve the independent innovation of embedded system experiments, an open experimental teaching platform that integrates experimental resources is built to provide comprehensive services for students to practice. Combining the engineering application background of the automation discipline, this paper discusses the construction scheme of a new experimental platform for embedded systems, explores the intelligent open laboratory management mechanism, and forms an experimental teaching reform idea characterized by informatization, service, and progressiveness, so as to stimulate students' potential for embedded system learning.

Keywords: Embedded system, Construction of experimental platform, Open laboratory, Teaching reform

1. INTRODUCTION

An embedded system is a product integrating advanced computers, semiconductors, electronic technologies, and specific applications in various industries. It is a special computer system designed for specific applications and is widely used in various industries of the national economy [1-2]. Typical equipment incorporating embedded systems includes smart home appliances, automobiles, and industrial automation robots. The Embedded System and Application Experiment Course is an important practice and innovation course for the automation discipline. Students shall master the development technology of embedded systems and be capable of applying embedded systems with ease in future practical projects [3-4].

2. CURRENT SITUATION OF EMBEDDED SYSTEM EXPERIMENT COURSES

At present, for the Embedded System and Application Experiment Course, most colleges and universities have made great progress and development in both experimental facilities and teaching and management modes. The practice has been greatly improved [5-7]. However, the experiment design still stays in the stage of experimental box demonstration and experiment, which is less related to actual projects. Students do not complete projects independently. With such a practical training method, it is difficult to meet the requirements of talent ability [8-10]. On one hand, after several years of development, the Embedded System and Application Experiment Course (Bilingual) of our computer discipline has achieved initial results. On the other hand, experimental resources can only meet the basic experimental requirements of the course, and students' comprehensive innovation ability is still weak. The mechanism of open experiments in the laboratory is not perfect, and the intelligent laboratory management platform requires further building. Moreover, teachers still need to make breakthroughs and improvements in teaching forms, experimental content design, and incentives for innovation.

3. OBJECTIVES OF EXPERIMENTAL PLATFORM CONSTRUCTION

Objectives: To meet the needs of students' practice, innovation, and entrepreneurship; to achieve informatization of experimental education and build a first-class computer discipline; to build an experimental teaching platform for embedded systems characterized by informatization, service, and progressiveness, and transform and upgrade the laboratory to achieve unattended and intelligent management. The platform mainly supports the core courses of the

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computer discipline (such as embedded system and application, embedded system course design, and others), students' competitions, innovation practices, and entrepreneurial projects.

4. CONSTRUCTION SCHEME OF THE EXPERIMENTAL PLATFORM

Based on the goal of "building a networked, digital, personalized, and modular open experimental teaching platform for embedded systems to provide comprehensive services for students' learning, practice, innovation, and engineering application", the scheme mainly includes modular construction of experimental resources, systematic construction of experimental teaching, and intelligent construction of experimental management. The construction architecture of the experimental platform is shown in Figure 1.

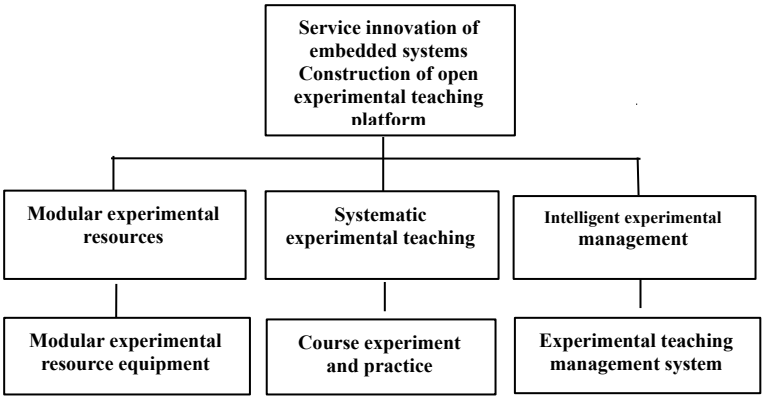

Figure 1. Construction Architecture of the Experimental Teaching Platform for Embedded Systems

(1) The modular construction of experimental resources is to establish the modular experimental resource pool, in which students can freely select experimental elements to set up their own exclusive experimental platforms.

(2) Experiment course system construction consists of four parts, namely, basic function experiment, system practice experiment, innovation project experiment, and creative design experiment. The basic function experiment enables students to master the development environment and development process; the system practice experiment focuses on cultivating students' practical ability and application design methods; the innovation project experiment emphasizes cultivating students' engineering project quality; the creative design experiment mainly gives full play to students' creative imagination. Students can design and implement their own embedded systems on the basis of the experimental materials given by teachers.

(3) Intelligent construction of experimental management: The experimental teaching platform provides experimental projects with rich contents in various forms in each section. The teachers of the experimental team record videos for these projects and form a teaching video library on the experimental teaching website. Students can freely choose from the four kinds of experiments according to their interests, mastery, and class hours, and complete the experiments in the laboratory through the platform website reservation system. Teachers finally give an overall score based on the comprehensive quality of the creative project defense, experimental design report, and other aspects.

4.1. Modular Construction of Experimental Resources

Embedded system experiments and innovation practice activities rely on hardware platforms. A variety of experimental resources can greatly expand students' imagination and creativity, fully arouse students' initiative, and stimulate students' enthusiasm for innovation practice [10-12]. The modularization and standardization of experimental resources are conducive to the rapid, efficient, and flexible construction of embedded systems. Students can freely select and combine experimental elements such as functional peripherals, controlled objects, and components in the experimental resource pool to establish an experimental platform that meets the requirements of design contents.

In order to cater to the needs of the innovation experiment project for embedded systems, the functional modules for setting the system practice experiment and the innovation project experiment are added, such as hardware modules related to omnidirectional robots, balancing vehicles, wireless transmission, Internet of Things, and fingerprint recognition. Commonly used components, experimental consumables, and testing and measuring equipment constitute the experimental modular resource pool to satisfy the requirements of innovation practice. This is a major innovation in

the construction of the experimental teaching platform. The modules of the experimental resource pool and physical objects are shown in Figure 2.

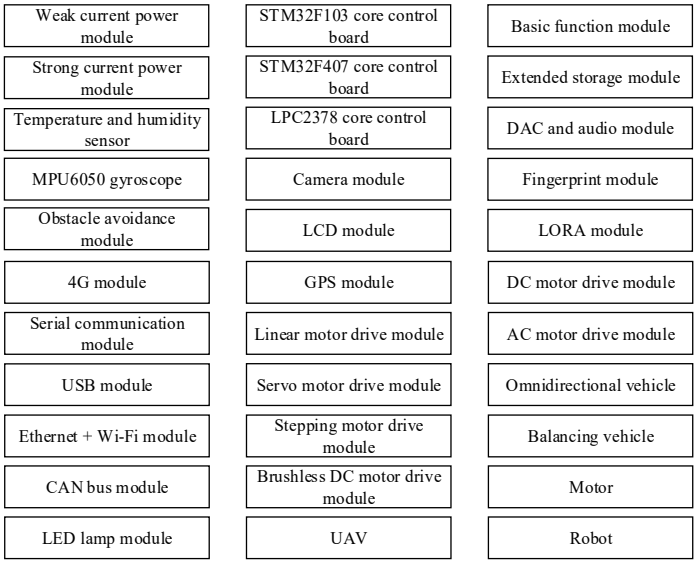

Figure 2. Modules of the Experimental Resource Pool

4.2. Construction of Experimental Teaching System for Embedded Systems

The experimental teaching platform is designed to help students fully master embedded systems and build a new experimental system for embedded systems.

4.2.1 Basic Function Experiment

It is a functional experiment designed based on the STM32 series development board of the embedded system. Through such experiments, students can familiarize themselves with the programming language, master the development environment and development process, and understand the hardware resources of embedded system chips. The experimental platform supports six experiments, as shown in Table 1. Students can freely choose experiments according to the class hours.

Table 1. Available Basic Function Experiments

No.	Experiment	Class Hour
1	Basic program design	2
2	Timing control experiment for LED lamps	2
3	Analog sampling communication experiment	2
4	Key interruption control experiment	2
5	Music player experiment	2
6	LCD experiment	2

4.2.2 System Practice Experiment

The STM32 series ARM development board is selected as the core experiment device, accompanied by functional modules, such as temperature sensors, ultrasonic range finding modules, and cameras. Students can make practice on an embedded small system to learn to apply hardware peripherals and master programming skills. Table 2 shows the system practice experiments supported by the experimental platform.

Table 2. Available System Practice Experiments

No.	Experiment	Module to Be Used
1	Obstacle range finding experiment	Ultrasonic range finding module
2	Temperature (humidity) monitoring experiment	Temperature (humidity) measurement module
3	Waveform generator	Amplifier module
4	Digital voltmeter (frequency meter) design	Voltage conversion module
5	Multi-channel data acquisition experiment	AD module and power conversion module
6	MEMS motion information measurement	MEMS module
7	Weight measurement experiment	Pressure sensor
8	Stepping motor control experiment	Stepping motor
9	DC motor speed	DC motor
10	Omnidirectional vehicle control system	Omnidirectional vehicle
11	UAV control system	UAV
12	Robot control system	Robot

4.2.3 Innovation Project Experiment

Based on the actual complete embedded system projects, such as electric vehicle motor control system, LED energy-saving lamp system, and fingerprint recognition system, students can experience a complete embedded system project and master the development process and design ideas. The available projects are shown in Table 3.

Table 3. Comprehensive Innovation Projects

No.	Experiment	Remarks
1	Electric vehicle motor control system	Scientific research project
2	Intelligent regulation system for LED energy-saving lamps	Student competition
3	Fingerprint access control system	Student competition
4	Motor operation monitoring system	Scientific research project

4.2.4 Creative Design Experiment

The experimental element resource pool is fully open to students. Hence, students can freely choose functional modules or mobile platforms to design system functions and give their ideas full play. Teachers finally give an overall score by assessing the demonstration and defense of the designed system and the experiment report of each experiment. The experimental system enables students to start from basic function experiments, consolidate through system practice experiments, develop ideas through innovation project experiments, and finally give full play to their initiative and innovation through creative design experiments. Some products of open experiments and the embedded systems built by students using the experimental materials in the experimental module resource pool can bring students advantages in competitions, comprehensive curriculum design, and graduation design.

4.3. Intelligent Construction of Experimental Management

The service-based, innovative, and open experimental teaching platform for embedded systems realizes open and intelligent management and serves students. The experimental management process is shown in Table 4.

Table 4. Intelligent Management

Student Experiment Link	Embedded System Platform Support	Platform Support Mode
Experimental project study	Teaching videos of experimental projects	Platform website
Experimental schedule	Online reservation system on the platform	Platform website
Experimental project operation	Experimental module resource management system	Laboratory
Submission and evaluation of experiment reports	Experimental teaching management system	Platform website

(1) The construction of the open and shared video library and other resources for experimental teaching is mainly to record complete experimental videos to form a teaching video library for the basic function module. For the innovation practice module, the project discussion section can be added, so that students can upload their experimental videos, post messages, and discuss problems with other students and teachers.

(2) Construction of the reservation system for the experimental platform: Students can make reservations online for time and appliances in the laboratory. Thus, the laboratory can be efficiently managed.

(3) Construction of management system for the resource pool: Through the system, students can apply for the experimental hardware and software resources in the resource pool online, and teachers can confirm the applications. After that, teachers put the experimental equipment into the self-pickup cabinet and respond to students through the platform. Then students take the equipment using the pickup code. In this way, unattended and intelligent experimental management is realized.

(4) Construction of the experimental teaching management system: Upload and submission of experiment reports by students and online performance evaluation by teachers are achieved.

5. CHARACTERISTICS OF EXPERIMENTAL TEACHING METHOD REFORM

The key point of teaching method reform for embedded systems is to put students at the center of teaching. Students can watch experimental teaching videos through the experimental platform website to obtain the experimental content. According to the teaching schedule, the experimental time is arranged by students through the online reservation system on the platform to independently complete the experimental projects. Teachers of experimental courses will become secondary roles. They just guide students in designing the experimental process. Students are free to choose experiments in the experimental project according to their interests and preferences, provided that the requirements of class hours are met. They can choose any function module from the resource pool to design a great embedded system.

6. CONCLUSION

To make students fully understand and master embedded systems, experimental elements such as functional peripherals, controlled objects, and components are specially added to the experimental platform, thus forming an experimental resource pool for combining elements to build a more powerful and flexible experimental hardware platform. An experimental system for embedded systems is built, which allows students to start from basic function experiments, consolidate through system practice experiments, develop ideas through innovation project experiments, and finally give full play to their initiative through creative design experiments. Moreover, a new experimental teaching method is designed. The links, including video teaching, online reservation, and defense and examination, are organically associated to establish a complete experimental teaching platform for embedded systems. Taking the experiment practice and innovation courses of cognizing embedded systems as the main part, the platform changes the previous experimental course teaching mode and constructs a student-oriented and intelligent experimental teaching mode that serves students. By virtue of the experimental projects that are classified by complexity and the fully open experimental teaching videos, experimental equipment, and experimental sites, students can give full play to their initiative and innovation.

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