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Exploration of Project Driven Teaching Mode in the Course of "Principles and Applications of Single Chip Microcontrollers"

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Abstract: To explore the application of project-driven teaching mode in the course of "Principles and Applications of Single Chip Microcontrollers," this article first designs a project-driven teaching mode. Then, organize the important knowledge points and key content of the course, and design 6 practical projects. Finally, demonstrate the teaching process through the implementation of the temperature and humidity alarm system project. Through project-based teaching, not only does it achieve a deep integration of theory and practice, but it also exercises students' hands-on ability, problem-solving ability, and innovative thinking.

Keywords: Microcontroller; Project-driven; Temperature and humidity alarm system

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1. Background

As a key course in the electronic information major of our university, "Principles and Applications of Microcontrollers" is crucial for cultivating students' professional competence. However, the traditional teaching model focuses on imparting theoretical knowledge, with relatively weak practical links, resulting in students having difficulty applying theory to practical projects, insufficient practical and innovative abilities, and a gap with the demand for applied talents in society.

2. Introduction

In the process of promoting the "New Engineering" education reform, project-based teaching methods have been widely applied in the teaching of engineering majors in universities [1,2]. As the foundation of electronic product design, microcontrollers have broad application prospects in intelligent perception, human-machine collaboration, and other fields. The course "Principles and Applications of Microcontrollers" is a core course for electronic and information majors, playing an important role in the construction of the curriculum system [3].

Traditional teaching usually adopts the method of teachers lecturing in the classroom and students passively receiving, and students lack practical operation and problem-solving training, resulting in ineffective exercise of students' thinking and innovation abilities [4]. Practical teaching is an important component of the course "Principles and Applications of Single Chip Microcontrollers." However, in traditional teaching, practical activities often have many shortcomings. On the one hand, practical classes account for a relatively small proportion, and students have limited time for actual operation, which makes it difficult for them to fully master the application skills of microcontrollers. On the other hand, the practical content is mostly confirmatory experiments, and students operate according to established experimental steps, lacking space for independent design and innovation, making it difficult to cultivate students' ability to solve practical problems and innovative thinking [5].

Exploring project-driven teaching methods in the course of "Principles and Applications of Microcontrollers", creating practical application scenarios through projects, combining knowledge points with actual projects, enabling students to acquire knowledge and apply it in practice during the project completion process [6]. This not only stimulates students' interest in learning, but also deepens their understanding and memory of knowledge points through practical operations, cultivating and exercising students' ability to solve practical problems [7].

3. Design of project-driven teaching mode

In the project-driven teaching mode of the course "Principles and Applications of Microcontrollers," before class, the teacher sorts out the course content, extracts important content and key knowledge points, and re-integrates the knowledge points [8]. The course content is decomposed into corresponding small projects, and the corresponding knowledge points are interspersed and integrated into specific projects. Project production and demonstration videos are made, and relevant preview materials are pushed to students through the online teaching platform.

As shown in **Table 1**, there are a total of 6 project tasks in this design, covering multiple difficulty levels from basic projects to comprehensive applications. For example, in the basic project of LED lighting, flashing,

Table 1. Correspondence between projects and course knowledge points

Project design	Related knowledge points
Project 1: LED lights on, flashing, flowing lights	1. The internal structure of the microcontroller; 2. Application of microcontroller ports.
Project 2: Traffic Light Control System	1. Operation of microcontroller I/O ports; 2. Timer/counter of microcontroller; 3. Interrupt operation of microcontroller.
Project 3: Design of 5V DC digital voltmeter	1. LCD display; 2. A/D converter; 3. Timer and Delay.
Project 4: Design of Simple Electronic Piano	1. Expansion of microcontroller I/O ports; 2. Matrix keyboard application; 3. Application of microcontroller timer/counter; 4. Interrupt control of microcontroller.
Project 5: Stepper Motor Control	1. Independent button application; 2. Working principle of stepper motor; 3. Pulse width modulation.
Project 6: Temperature and Humidity Alarm System	1. Sensor applications; 2. Buzzer application; 3. Single chip microcontroller power system.

and flowing lights, simple microcontroller I/O port control and the internal structure of the microcontroller will be involved. By controlling the turning on and off of the LED lights, students can become familiar with the basic working principles and instruction system of the microcontroller [9]. In the advanced project, “Temperature and Humidity Alarm System,” more complex sensor applications such as temperature sensors, humidity sensors, etc. will be introduced. Students need to use their learned knowledge to collect sensor data and process and display it through a microcontroller.

Theoretical courses are no longer about explaining theoretical knowledge first, but rather using multimedia, Proteus simulation, and Keil C integration to visually demonstrate the functions that each project needs to accomplish. Each project is a microcontroller system, and the explanation of the project is generally divided into two parts: hardware design and software design [10]. The hardware design utilizes Proteus simulation software. As an excellent circuit simulation software, Proteus can provide students with a virtual hardware environment to build microcontroller system circuits and conduct various functional simulation tests in the software [11]. While explaining hardware, introduce relevant basic knowledge points of microcontrollers. The software explanation utilizes the debugging function of Keil C software. Keil C51 is a professional software development tool for microcontrollers, where students can write and debug C language programs to control the microcontroller. Step by step debugging the program while explaining the relevant hardware structure, instructions, and C language syntax while programming. Then, under the guidance of the teacher, students actively engage in the process of completing project tasks. They first completed the circuit design and construction in Proteus, then wrote and debugged the program in Keil C51, and verified the correctness of the design through simulation. After the simulation passes, hardware debugging is carried out to burn the program into the actual microcontroller hardware for further testing of the system’s performance [12].

The experimental class enters the laboratory, and based on the simulation design of theoretical courses, the hardware circuit of specific projects is built and debugged for operation. In the process of completing this series of project tasks, students not only have a solid grasp of the key content in the course but also have a deep understanding of the internal structure, working principle, instruction system, etc., of the microcontroller [13]. Through practical operation, they have proficiently mastered the software and hardware design methods of the microcontroller control system. From the design of hardware circuits, the selection and layout of components, to the writing, debugging, and optimization of software programs, students have accumulated rich experience, truly achieving a deep integration of theory and practice, and achieving the expected goals of the course learning.

4. The specific implementation of project-driven teaching

Teachers distribute designed projects to students based on their knowledge level and learning progress, analyze project requirements together with students, explain the knowledge points involved, and guide students in designing solutions. This article takes the temperature and humidity alarm system as an example to explain the specific implementation process of project project-driven teaching mode.

4.1. Scheme design

The temperature and humidity alarm system consists of a microcontroller control module, a temperature and humidity acquisition module, a display module, an alarm module, and a power module. The temperature and humidity acquisition module is responsible for collecting environmental data and transmitting it to the microcontroller. After processing the data, the microcontroller sends the results to the display module for display, and at the same time determines whether to trigger the alarm module. The power module provides stable power for each part.

4.2. Hardware circuit design

The microcontroller control module is the core part of the entire temperature control system. In this project, the STM32 series STM32F103C8T6 microcontroller is selected as the core component of the control circuit, responsible for collecting temperature and humidity sensor signals, calculating and processing the collected data, displaying the collected temperature and humidity values through LCD, and comparing the collected temperature and humidity values with the threshold. When the temperature and humidity data exceed the threshold, the microcontroller controls the buzzer and LED indicator light to start the alarm [14].

The temperature and humidity acquisition module adopts the digital temperature and humidity sensor DHT11, which can directly output digital signals, communicate through a single bus, be easy to use, have a low cost, and meet the basic temperature and humidity acquisition needs. The sensor includes a resistive humidity sensing element and an NTC temperature measuring element, and connected to a high-performance 8-bit microcontroller. After receiving the request signal from the host, DHT11 sends the collected temperature and humidity values to the microcontroller. The microcontroller compares the collected temperature and humidity data with the preset threshold to determine if it exceeds the normal range [15].

The display module is mainly used to display temperature and humidity values and their upper and lower thresholds. The LCD used in this project is the LCD1602 character LCD. Choose the LCD1602 LCD display screen, which can display two lines with 16 characters per line, and can clearly display temperature and humidity values. The interface is simple and easy to connect to the microcontroller. The alarm module consists of an active buzzer and four red LED indicator lights. The buzzer emits a sound when sounding an alarm, and the LED indicator lights up for visual reminder. The above devices are controlled through the I/O port of the microcontroller.

4.3. Software design

The microcontroller code for this project is written in the C language and developed in the Keil uVision4 environment. The system mainly implements the following functions:

(1) Display temperature and humidity values through LCD;

(2) Compare the monitored temperature and humidity values with the alarm settings, and if they exceed the limit, the buzzer will sound an alarm prompt;

(3) Control the operation of the temperature and humidity regulation system according to the corresponding temperature and humidity values.

4.3.1. Main program flow design

The main program first initializes the LCD1602 LCD display screen to prepare for the subsequent display of temperature and humidity data. This project selects a display mode of 2 rows and 16 columns, an 8-bit data interface, no cursor display, and other parameters default. Initialize other parts of the microcontroller system, including I/O ports, timers, interrupts, etc., to ensure that all parts of the system can work properly. Next, monitor the current temperature and humidity, send the collected temperature and humidity data to the initialized LCD1602 display screen for real-time display, and compare it with the set upper and lower limits to determine if it exceeds the range. If exceeded, proceed to the next alarm step; If it does not exceed, return to continue detecting the current temperature and humidity, and cycle to monitor the environmental status.

4.3.2. Display program flow design

In the display program, first initialize the relevant GPIO pins and set the working mode to 16 × 2 display, 5 × 7 dot matrix, and 8-bit data port mode. Close the cursor and set the text to remain still and the address to automatically increment by 1 mode. Before writing data/instructions, set the data port to input mode, select the instruction register by pulling down RS, and read by pulling up RW. Read the LCD1602 status word and continue to detect until it reaches 0. During the data writing process, first send the address information of the data to be displayed to the LCD module, informing the module of the position of the data in the display area, and then write characters one by one. Pull down EN, pull up RS (select data register), send data to the data port, pull up EN, delay for 3ms, then pull down EN to achieve data writing and display.

4.4. Simulation

This project uses Proteus software to simulate the designed circuit, uses Keil C51 to write C language programs, and burns the generated executable files into the microcontroller of the schematic. As shown in **Figure 1**, the system can measure and display temperature and humidity. When the temperature and humidity values exceed the preset threshold, the buzzer will sound an alarm and light up the corresponding LED lights to provide visual prompts.

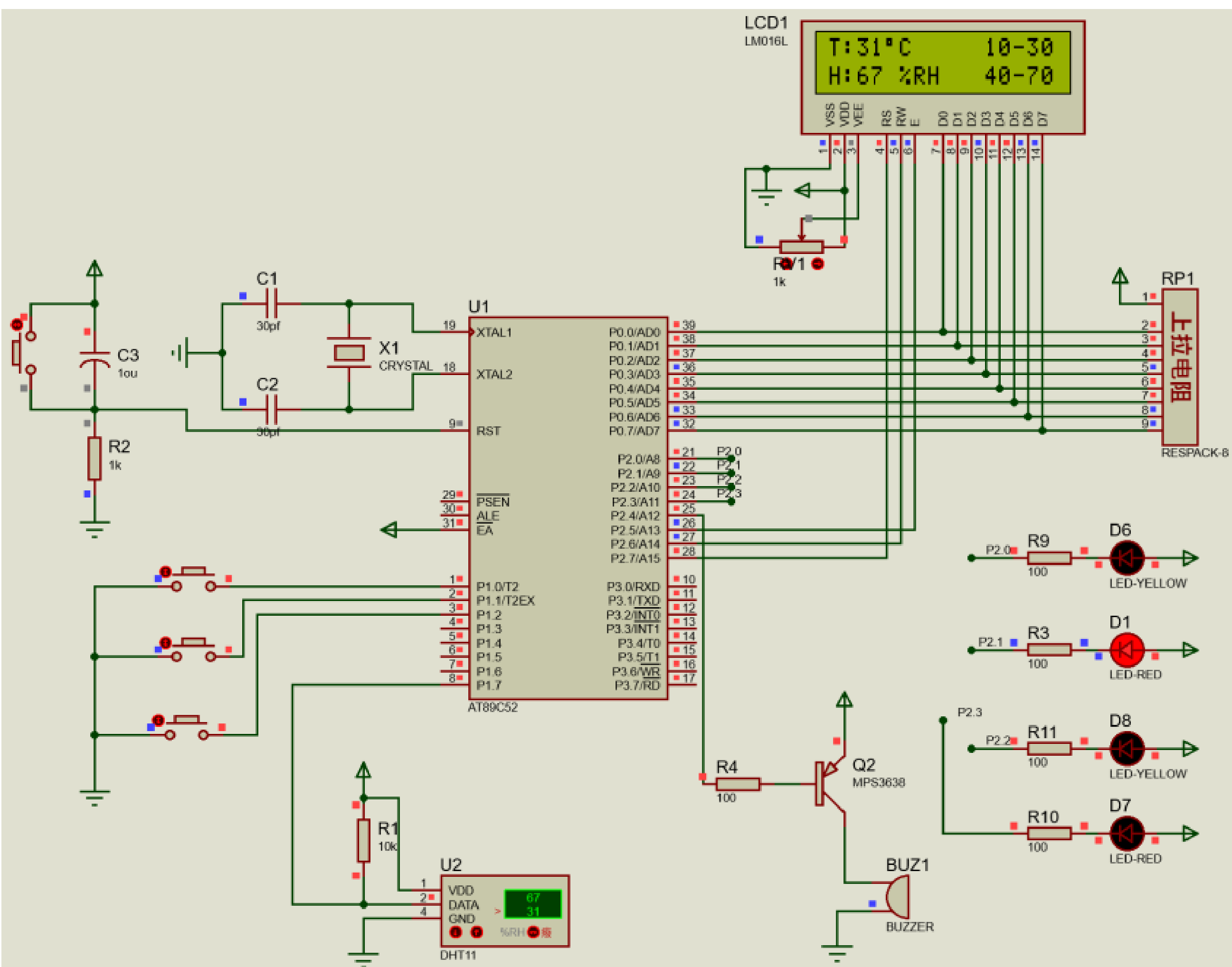

Figure 1. Simulation effect diagram.

Based on the design foundation of simulation software, use experimental courses to enter the laboratory to build and debug hardware circuits for specific projects. Through hardware construction and debugging, the functional integrity of the temperature and humidity alarm system can be comprehensively verified under various real conditions, including the accuracy of sensor data acquisition, the timeliness and reliability of the alarm module, etc. In the process of building hardware circuits, students need to have a deep understanding of the functions, pin definitions, and connection methods of each component, which helps to deepen their understanding of theoretical knowledge such as microcontroller principles, sensor working mechanisms, and circuit design. This not only achieves a deep integration of theory and practice, but also exercises students' hands-on ability, problem-solving ability, and innovative thinking.

5. Conclusion

This article explores the project-driven teaching mode based on the course of "Principles and Applications of Microcontrollers," designs practical projects around the main knowledge points of the course, and demonstrates the specific implementation plan of the project. Exploring project-driven teaching methods in this course can help students better understand and apply microcontroller technology. By combining knowledge points with actual projects and creating practical application scenarios, students can gain knowledge and practice while completing projects.

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