Driven by Industry-Education Integration and OBE Concept: The Path to Innovation in Microcontroller System Practice Course Teaching

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Abstract. Based on a deep deconstruction of the pain points in practical teaching of traditional microcontroller systems, a teaching design reconstruction plan guided by enterprise needs and driven by Outcome Output (OBE) is proposed. Through the two-way penetration of school enterprise resources, industry demand is transformed into teaching ability indicators, forming a closed-loop training system of "demand analysis goal setting implementation evaluation". Through implementation paths such as actual projects, comprehensive projects, design projects embedding, and dual teacher collaborative evaluation guidance, students' learning interest, course participation, subject competition output, engineering practice ability, and innovation ability are significantly enhanced

Keywords: Integration of industry and education, OBE, Microcontroller practice, teaching reform

1 Introduction

Single chip microcontroller is a key technology in the field of electronic information, widely used in many industries such as industrial control, smart home, automotive electronics, aerospace, etc[1]. The demand for professional talents with the ability to design, develop, and apply microcontroller systems continues to grow, and the requirements are also increasing. They not only need to master solid theoretical knowledge, but also need to have rich practical experience and comprehensive qualities to solve practical problems[2]. However, there are problems in the current practical teaching of microcontroller systems in universities, such as a disconnect between theory and practice, and a mismatch between teaching content and industry needs, which makes it difficult for the students trained to meet the actual needs of enterprises. This also highlights the importance and urgency of integrating industry and education in the reform of microcontroller course teaching. Outcome Based Education (OBE) is the correct direction for the reform of higher engineering education[3-4]. In the teaching of microcontroller courses, the application of OBE concept can effectively solve the problems of unclear goals, weak targeted teaching content, and single evaluation methods in traditional teaching[5]. On the basis of in-depth analysis of the problems existing in the current practical teaching of microcontroller systems, this article explores how to organically

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combine the integration of industry and education with the OBE concept, and construct a new teaching mode guided by industry needs and centered on student learning objectives. By introducing practical projects and resources from enterprises, optimizing the curriculum system and teaching content, improving teaching methods and evaluation methods, cultivating students' practical, innovative, and problem-solving abilities, enabling them to better adapt to industry development needs and enhance their competitiveness in employment.

2 Problems in the Practical Teaching of Single Chip Microcomputer Systems

The microcontroller system practice course is a centralized practical course offered to students after completing courses such as programming fundamentals, microcontroller principles and applications. It is an extension and expansion of classroom theoretical teaching, and an important link in combining theory with practice[6]. The existing practical teaching of microcontroller systems mainly uses Keil, Proteus, 51 microcontroller development boards, etc. to carry out simple project practice. Four main issues were highlighted during the teaching process [7].

2.1 The Teaching Content is Disconnected from Actual Needs

In traditional microcontroller system practice courses, the teaching content often focuses on imparting theoretical knowledge, while neglecting the close integration with practical applications. The cases and experimental projects in the course are mostly designed to verify theoretical knowledge, and there is a significant disconnect between them and actual engineering projects and industry demands. For example, the comprehensive project designed in previous microcontroller system practice courses was "Design and Implementation of Multi functional Electronic Clock Based on Development Board". The disconnect between this teaching content and actual needs makes it difficult for students to understand the value and significance of microcontrollers in practical applications during the learning process, and to flexibly apply the knowledge learned to practical projects. After graduation, it is also difficult to meet the requirements of enterprises for microcontroller development talents.

2.2 Single Teaching Method

The traditional teaching method of microcontroller system practice course mainly relies on students' independent practice, which lacks interactivity and initiative, and students' learning enthusiasm and participation are not high, making it difficult to stimulate students' learning interest and innovative thinking [8]. Often, teachers send lengthy programs to students, who download them to the development board to verify their functionality and consider the task completed. This leads to students losing their motivation and initiative in learning, and their practical abilities cannot be effectively exercised.

2.3 Weak Practical Link

Firstly, there is a lack of practical teaching resources. Due to limited funding and outdated experimental equipment, the quantity is insufficient to meet the practical needs of students. Secondly, the experimental content has strong verifiability and lacks comprehensive and innovative projects [9]. Comprehensive and innovative experimental projects can enable students to comprehensively apply their learned knowledge, independently design and complete experimental tasks, and further exercise their practical abilities and innovative thinking. However, in actual teaching, the proportion of such experimental projects is relatively low and cannot meet the needs of students. In addition, practical teaching is disconnected from actual projects of enterprises. Under the traditional teaching mode, practical teaching is often conducted in school laboratories, where students are not exposed to actual projects and work environments in enterprises. This makes it difficult for students to understand the actual needs and workflow of enterprises for microcontroller development talents during the practical process, and it is difficult for them to quickly adapt to the work of enterprises after graduation.

2.4 The Evaluation System is Incomplete

The traditional evaluation system for microcontroller system practice courses mainly focuses on the grades of practice reports and project completion status, and is given by a single subject, ignoring the evaluation of students' learning process and practical ability. There is less assessment of students' practical operation ability, innovation ability, team collaboration ability, and other aspects. This evaluation system cannot comprehensively and objectively reflect students' learning outcomes and comprehensive qualities, which can easily lead to students only focusing on the submission of final projects and practical reports, while neglecting the cultivation of process oriented practical abilities.

3 Course Design Driven by Both Industry-Education Integration and OBE Concept

In response to the above issues, this article constructs a "project driven, layered teaching, and diversified evaluation" teaching model based on the integration of industry and education and the OBE concept. The teaching team follows the OBE concept and integrates production and education to determine the target level that students should achieve from three aspects: knowledge objectives, ability objectives, and quality objectives. The course objectives are clarified and output oriented. Based on the course objectives, reverse engineering is carried out to develop teaching content for progressive ability cultivation. Especially in the process of setting teaching content, the integration of production and education is fully considered, and the projects set have engineering or competition backgrounds.

3.1 Teaching Content Design

Single Chip Microcomputer System Practice is a professional practice course in the talent training program of Industrial Intelligence and Robotics Engineering majors at Shandong Management College. It aims to guide students' innovative thinking and application ability improvement based on the background of modern electrical automation engineering and industry development. On the basis of having studied courses related to microcontrollers, it aims to enhance students' comprehensive application ability and system design ability of microcontrollers, laying a necessary foundation for the subsequent learning of embedded courses and the development of graduation projects. The course objectives mainly include:

- Knowledge objective: To master the basic structure and working principle of MCS-51 series microcontrollers, as well as their functional modules, mainly including the working principles of parallel I/O ports, timers/counters, interrupt systems, and serial ports.
- Ability objective: To have the preliminary ability to design simple microcontroller systems, analyze and design the hardware principles of simple systems, apply interface chips, write software and debug functions, and develop projects with engineering or competition backgrounds.
- Quality objective: To cultivate students' engineering literacy and scientific thinking in identifying, analyzing, and solving problems.

The objectives of the microcontroller system practice course are shown in Table 1.

Table 1. Objectives of the Single Chip Microcomputer System Practice Course

Target	Course Objectives
Knowledge objectives	Master the basic structure and working principle of MCS-51 series microcontrollers, as well as their functional modules,including the working principles of parallel I/O ports, timers/counters, interrupt systems, and serial ports
	Familiar with commonly used electronic components and chips, master the working principles and applications of various commonly used peripherals, such as LED lights, buttons, stepper motors, buzzers, human-machine interfaces, etc
Capability objectives	Preliminary ability to design simple systems using microcontrollers, analysis and design of hardware principles for simple systems, application of interface chips, software development, program compilation, and debugging capabilities
	Preliminary ability to develop projects with engineering or competition backgrounds
Quality objectives	Cultivate students' pioneering and innovative learning spirit and teamwork spirit
	Cultivate students' engineering literacy and scientific thinking in identifying, analyzing, and solving problems

Based on the course objectives and relying on the university plan project of Hunan Diwen Technology Co., Ltd., the traditional 51 development board is abandoned and a laboratory is jointly built by schools and enterprises. The T5L intelligent screen development board EKT043E, which combines GUI design and C51 development, is used.

EKT043E is developed and provided by Hunan Diwen Technology Co., Ltd., and corresponding consumables such as memory cards, card readers, and power supplies are provided.

At the same time, in collaboration with enterprise engineers, a dual level four stage teaching content was designed based on enterprise needs, reverse engineering project driven, and capability hierarchical achievement. The design of practical teaching content for microcontroller systems is shown in Figure 1.

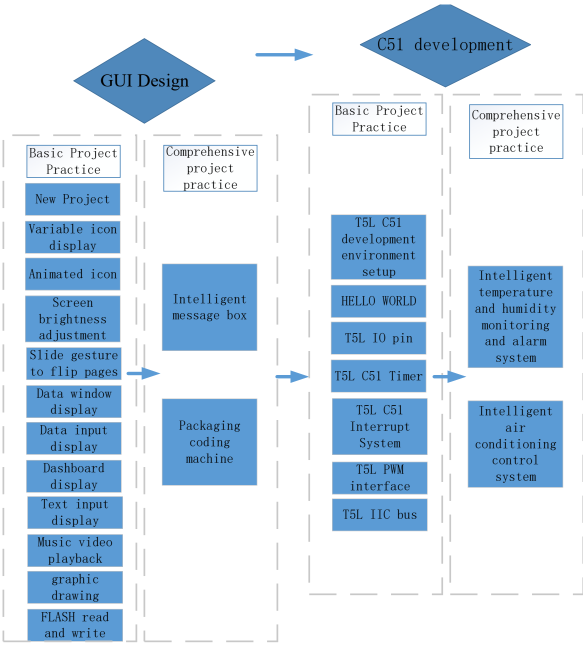

Fig. 1. Design of Practical Teaching Content for Single Chip Microcomputer System

As shown in Figure 1, the two levels and four stages are organically related from low to high, integrating theory, practice, and innovation, guiding students to consolidate knowledge in practice, enhance abilities through exploration, and gradually cultivate students' abilities to discover, analyze, and solve problems.

3.2 Design of Evaluation System for Practical Course of Single Chip Microcomputer System

This course has developed a process oriented evaluation method that emphasizes the cultivation of practical and innovative abilities. The overall evaluation process focuses on the diversification of subjects, the multidimensionalization of content, the transparency of the process, the diversification of methods, the clarification of standards, and the timeliness of improvement. Comprehensive and objective evaluations will be conducted from five levels: C51 development evaluation, GUI design evaluation, project report evaluation, project outcome evaluation, and defense evaluation. The evaluation method for the practical course of microcontroller system is shown in Figure 2.

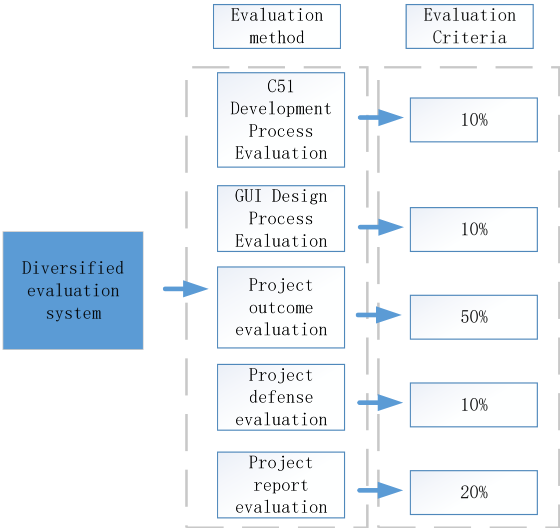

Fig. 2. Evaluation Method for Practical Course of Single Chip Microcomputer System

As shown in Figure 2, the project outcome evaluation in the evaluation method is based on enterprise standards, with a weight of 50%. The project evaluation criteria are issued by Hunan Diwen Technology Co., Ltd. The evaluation criteria issued by the enterprise are shown in Table 2. At the same time, according to the evaluation criteria, the enterprise engineer serves as a judge to evaluate the project, select first, second, and third prizes, and give cash rewards.

Table 2. Project evaluation standards issued by enterprises

Attendance (20 points)	*GUI Design (30 points)*	*C51 development (50 points)*
According to the actual attendance assessment, 5 points will be deducted for each missing time until all points are deducted	According to the "Complete Engineering Task" demo function and interface aesthetics assessment, 5 points will be deducted for each missing function, and 5 points will be deducted for any defects in the interface, until all are deducted; Independently designing UI materials and interface functions will earn an additional 10 points	According to the assessment of the "reference topic", 5 points will be deducted for unreasonable interface design, 5 points will be deducted for unattractive interface design, 10 points will be deducted for failure to implement functions, and an additional 20 points will be added for independently designing innovative topics and implementing functions
(1) The first prize winner requires a comprehensive score of no less than 90 points. The second prize winner requires a comprehensive score of no less than 80 points Third prize winners are required to have a comprehensive score of no less than 70 points (2) The attendance score is given based on the attendance sheet, and the GUI design and C51 development score is given based on the code and demonstration video uploaded by students to the Diwen Technology Forum		

The evaluation of C51 development process is based on the 51 source code, GUI source engineering, and project function demonstration videos submitted by students, with scores given in proportions of 50%, 30%, and 20%, with a weight of 10%.

The process evaluation of GUI design is based on the completeness of functionality and interface aesthetics of the projects submitted by students, with scores given in a ratio of 70% to 30%. For each missing feature, 5 points will be deducted, and for each interface defect, 5 points will be deducted. The weight will be 10% until all deductions are made.

The evaluation and assessment dimensions of project defense not only focus on the project results themselves, but also pay attention to students' performance in problem solving, logical expression, and innovative thinking. The defense process is mainly based on three aspects: content logic, language expression and demeanor, and thinking ability and adaptability. Scores are given in proportions of 40%, 30%, and 30%, with a weight of 10%.

The evaluation of project reports mainly assesses students' summary and academic standardization of the project, based on the completeness of content, logical rigor, and compliance with standards. Scores are given in proportions of 40%, 30%, and 30%, with a weight of 20%.

3.3 Project Library for Practical Courses on Microcontroller Systems Jointly Built by Schools and Enterprises

In collaboration with R&D engineers from Hunan Diwen Technology Co., Ltd., we jointly built a project library of over 20 items based on the teaching design content in the teaching objectives. To ensure the practicality and foresight of the teaching content, the construction of the project library also fully considered extracting practical teaching projects from authoritative innovation and entrepreneurship competitions or subject competitions, enterprise engineering projects, teacher research projects, and innovation and entrepreneurship activities. In the C51 development and GUI design comprehensive project practice, students independently selected topics and were required to carry out innovative design and development based on the basic requirements of the project library. The project library of school enterprise joint construction is shown in Table 3, Taking some examples.

Table 3. School enterprise joint construction project library (partial display)

Project	*Project Introduction*	*Project Requirements*
Design of Temperature and Humidity Monitoring System Based on DTH11 Temperature and Humidity Sensor	When it comes to temperature and humidity measurement in daily life, temperature and humidity sensors are needed to obtain air temperature and humidity data	Complete temperature and humidity display UI interface C51 completes the control and analysis program of DHT11 temperature and humidity sensor The air temperature and humidity data measured by DHT11 can be accurately displayed on the screen. Alarm for temperature and humidity exceeding the limit, and password login is required to set the temperature and humidity threshold
Design of Air Conditioning Fan Opening	Stepper motors can convert electrical	Complete stepper motor control UI interface: 0-180 °

Project	*Project Introduction*	*Project Requirements*
and Closing Control System Based on 28BYJ-48 Stepper Motor	pulse signals into angular or linear movements, thereby controlling the opening and closing of air conditioning fan blades.	C51 completes the control program for the 28BYJ-48 stepper motor The stepper motor can move normally according to the selected angle, with a red light at 0 degrees and a green light at 180 degrees as the limit indicator
Design of proximity alarm system based on HC-SRO4 ultrasonic sensor	Ultrasonic sensors can detect the distance between objects and achieve functions similar to proximity (reverse) alarms	Complete UI interface: distance display data window, alarm icon C51 completes the data reading and display program of HC-SRO4 ultrasonic sensor Can accurately measure distance, and the buzzer will automatically sound an alarm when approaching a certain distance; The alarm will be lifted after the distance is increased

4 Effectiveness of Curriculum Reform Practice

The 2023 Industrial Intelligence major is a major that Shandong Management College has successfully applied for and started enrollment in 2023. Among them, the practical course of single-chip microcomputer system is a professional practical course offered in the first semester of the sophomore year of this major, with a total of 32 hours and 1 credit. Through reform research on this course, significant results have been achieved.

4.1 Enhancement of Course Participation

Before the curriculum reform, the classroom atmosphere was prone to a dull state, and students' enthusiasm for learning was low, making it difficult to achieve the expected teaching effect. After the curriculum reform, new teaching design content was introduced, which is more closely related to practical applications, and projects are more innovative and comprehensive. Students' interest has significantly increased, and after the project is completed, each person is required to submit the GUI source code of the project C51 code, demonstration videos and other procedural materials will be evaluated based on the submitted materials. At the same time, each person is required to upload the project to the Diwen forum according to the categories of work introduction, working principle, design ideas, achievement display, demonstration videos, engineering codes, etc. for achievement display. By adopting this method, students' summarizing and problem analysis abilities will be trained invisibly. At the same time, students will take their own work design and achievement display more seriously, and their participation in hands-on practice will be significantly improved. For innovation bonus points, that is, in addition to the technical requirements specified in the project, students can independently add innovative elements for innovation bonus points, which greatly improves the competitive drive among students. Student works are uploaded to the Diwen Enterprise Forum as shown in Figure 3.

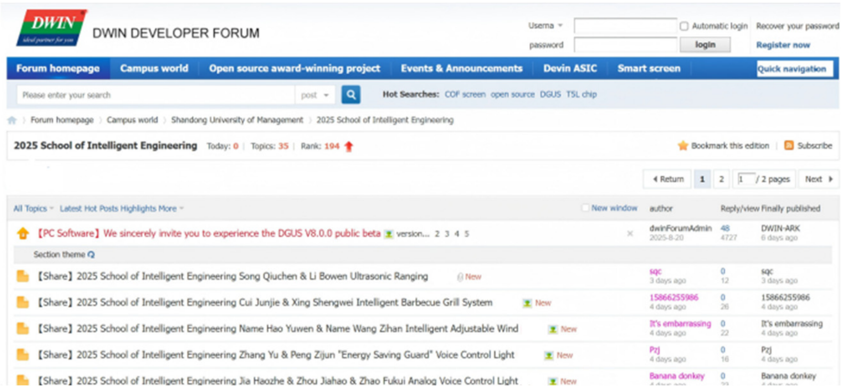

Fig. 3. Student works uploaded to the Diwen Enterprise Forum

4.2 Outstanding Achievements in Academic Competitions

Before the curriculum reform, the participation rate of 2023 industrial intelligence major students in subject competitions was almost zero. After the curriculum reform, students have achieved great success in various subject competitions. As shown in Figure 4， For example, in the EDA hardware design competition of the Blue Bridge Cup National Software and Information Technology Professional Talent Competition, they won 1 national second prize,1 provincial first prizes, 6 provincial second prizes,and 6 provincial third prizes. They also participated in the 19th CIMC "Siemens Cup" China Intelligent Manufacturing Challenge in 2025 and won 3 provincial second prizes and 2 provincial third prizes in the national preliminary intelligent manufacturing innovation research and development category: industrial hardware research and development direction, fully demonstrating their innovative thinking and problem-solving abilities. These competitions have enhanced students' practical abilities and effectively strengthened their spirit of collaboration and competitiveness.

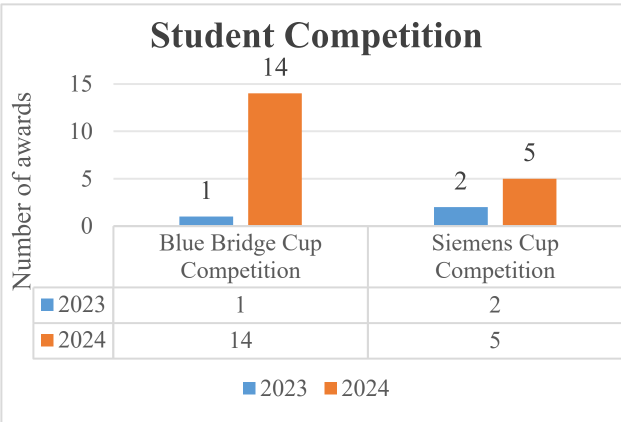

Fig. 4. Comparison of student competition awards between 2023 and 2024

4.3 Improving Students' Comprehensive Quality

The reform of microcontroller system practice course has significantly improved students' comprehensive quality in multiple dimensions:

1)Practical ability improvement: By adding comprehensive and innovative projects, students can independently complete the design and production of microcontroller systems. The teaching reform under the application-oriented talent cultivation mode enables students to transform theoretical knowledge into practical operational abilities.

2)Innovative ability cultivation: Project driven teaching stimulates students' innovative potential. By designing practical electronic application systems, such as intelligent temperature and humidity monitoring systems, students have gained valuable practical opportunities and developed innovative thinking.

3)Problem solving ability: The reformed curriculum emphasizes a complete system development process, and students need to face and solve practical problems. This type of training enhances students' ability to analyze and solve problems.

4)Teamwork ability: Group project-based teaching cultivates students' spirit of teamwork.

5)Improvement of engineering literacy: Through exposure to real engineering cases and industry standards, students have established a standardized engineering awareness. The teaching reform under the OBE concept enables students to understand the technical standards of electronic product development.

6)Enhanced learning initiative: The reformed teaching methods have increased students' interest and autonomy in learning. Student participation and enthusiasm for learning have significantly increased.

5 Conclusions

This article deeply integrates the integration of industry and education with the OBE concept, and proposes a new practical teaching mode for microcontroller systems. In the teaching process, the course objectives and learning outcomes are determined based on industry demand, and practical projects and resources from enterprises are introduced through the integration of industry and education. Teaching content and activities are designed around learning outcomes, and comprehensive teaching evaluation and continuous improvement are carried out based on students' learning outcomes, achieving the organic unity of education and industry, theory and practice, and goals and evaluation.

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