ISSN 2663-8169 Vol. 6, Issue 10: 179-183, DOI: 10.25236/IJNDE.2024.061026

Reform and Practice of Microcontroller Education through Multidimensional Integration and Academic-Industrial Synergy

Dan Wang*

College of Mechanical and Automotive Engineering, Zhaoqing University, Zhaoqing, China
carolwangdan@sina.com
**Corresponding author*

Abstract: *The course 'Principles and Applications of Microcontrollers' has a significant gap between theoretical knowledge and practical application, lacking real-world case studies. The content updates lag behind technological advancements, resulting in outdated knowledge that fails to meet the needs of actual development. To improve teaching effectiveness, a cross-disciplinary, project-oriented curriculum framework using the CDIO (Conceive-Design-Implement-Operate) project-based teaching approach has been proposed. We integrate local characteristics and implement multidimensional teaching resource integration. A project-based learning path has been established based on the OBE-CDIO engineering education philosophy and a collaborative education model between schools and enterprises, jointly building and sharing high-quality teaching resources has been constructed. Focusing on automotive microcontrollers, we have perfected the curriculum system, covering automotive microcontroller simulation experiments, student competitions, and innovation and entrepreneurship projects.This innovative reform has benefited students from various engineering disciplines, significantly enhancing their innovative and practical skills. Students have showcased innovative ideas and addressed social issues in projects, achieving excellent results in related competitions within the field.*

Keywords: *Microcontroller principles and applications; Curriculum reform; New engineering disciplines*

1. Introduction

With the rapid development of technology and social transformation, applications of embedded systems and the Internet of Things are becoming increasingly widespread. In the context of new engineering disciplines, there is a clear trend in educational needs and teaching reforms[1,2]. As a core component of embedded systems, microcontrollers have a series of advantages such as small size, powerful function, low cost, and ease of application, making them widely used in various fields including industry, agriculture, national defense, transportation, and civilian applications. The course "Principles and Applications of Microcontrollers," as an important part of engineering courses, not only carries the task of imparting theoretical knowledge but also focuses on cultivating students' innovative thinking and practical abilities. The basic goal of the course is to ensure that students can grasp the fundamental principles of microcontrollers, have the ability to read hardware circuits, and possess software design and debugging skills. Higher-level goals emphasize developing students' abilities to use microcontrollers for embedded system development and to analyze and solve complex engineering problems[3,4]. At the same time, it focuses on fostering students' scientific way of thinking, practical innovation capabilities, the spirit of great craftsmanship, and a sense of dedication to serving the country through technology[5]. These qualities will become a solid foundation for students' future career development in fields such as new energy vehicles, automotive electronics, and embedded system development, contributing to local economic growth and technological advancement[6,7]. Therefore, the reform of the "Principles and Applications of Microcontrollers" course is of significant importance.

The current challenges of the course are as follows: (1) In light of the vast and ever-evolving landscape of new technologies and devices, the course design and content have become relatively outdated. The independent planning and teaching of individual knowledge points make it difficult for students to effectively connect these concepts. (2) As economic transformation and upgrading lead to the high-end development of industries, there is an increasing demand in the new energy vehicle sector for innovative capabilities and a trend towards personalized engineering talent. However, the teaching

ISSN 2663-8169 Vol. 6, Issue 10: 179-183, DOI: 10.25236/IJNDE.2024.061026

content often fails to cater to the specific needs and characteristics of projects, which hinders the development of students' engineering thinking and innovation abilities necessary for solving complex engineering problems. (3) University-industry cooperation is a crucial pathway for cultivating engineering talents. Currently, there are deficiencies in resource integration between university-industry collaboration and industry-education coordination, with a superficial level of integration that has not deeply influenced course content and teaching methods. This prevents the full utilization of practical experience and demands from enterprises to enrich the curriculum.

To solve the above issues, this paper takes the core ideas of the new engineering education and teaching reform as guidance. It uses the actual needs of enterprises as the driving force and closely integrates the development of vehicle engineering disciplines to achieve a fusion of theory and practice, as well as industry-education integration, thereby enhancing the difficulty and level of the curriculum. Project-oriented teaching methods are adopted, incorporating project cases derived from real-world demands into the teaching process. Based on the CDIO project-based teaching approach, the curriculum content is organically linked through automotive electronic control modules, automotive instrument display modules, and automatic tracking modules for vehicles. Leveraging the advantages of the new energy vehicle industry and the unique talent training features of our school, we introduce outstanding local enterprise resources and actual engineering requirements. Guided by the practical problem-solving with microcontrollers and featuring automotive microcontrollers, we establish an experimental framework with four levels: "Microcontroller Basic Simulation → Automotive Microcontroller Control → Interdisciplinary Integration → Academic Competition Challenges," providing strong support for the step-by-step innovation in talent capability cultivation processes.

2. The proposed method

2.1. Project-based learning path

Guided by the core ideas of the new engineering education and teaching reform, with the core goal of enhancing student abilities and driven by the actual needs of enterprises, we closely integrate the development of the vehicle engineering discipline to achieve a fusion of theory and practice, as well as industry-education integration, thereby increasing the difficulty and level of the curriculum. Adopting a project-oriented teaching method, with enterprise engineers and on-campus professional teachers serving as co-instructors, we integrate project cases derived from real-world demands into the teaching process, making students' learning more targeted and practical. Using a CDIO-based project teaching method, we organically link the course content through three meticulously designed project modules: automotive electronic control module, automotive instrument display module, and automotive automatic tracking module. Each module aims to consolidate students' professional foundational knowledge and expand upon it. To further increase the challenge of the course, a comprehensive project module is designed. The comprehensive project uses "project tasks" as the main thread and "actual demands" as guidance, employing an active driving teaching method of "innovative activities + scientific research projects" to stimulate students' interest in proactive learning and enhance their spirit of exploration and innovation capabilities.

2.2. Diversified teaching evaluation system

2.2.1. Practical teaching platform

Leveraging the project of deepening the collaboration between Zhaoqing City's institutions and local new energy vehicle enterprises to jointly build a practical training platform, we utilize the advantages of the new energy vehicle industry and the distinctive talent training features of our school. We introduce outstanding local enterprise resources and actual engineering requirements. Guided by practical problem-solving with microcontrollers and featuring automotive microcontrollers, we establish an experimental framework with four levels: "Microcontroller Basic Simulation → Automotive Microcontroller Control → Interdisciplinary Integration → Academic Competition Challenges," providing strong support for the step-by-step innovation in talent capability cultivation processes, as shown in Figure 1.

ISSN 2663-8169 Vol. 6, Issue 10: 179-183, DOI: 10.25236/IJNDE.2024.061026

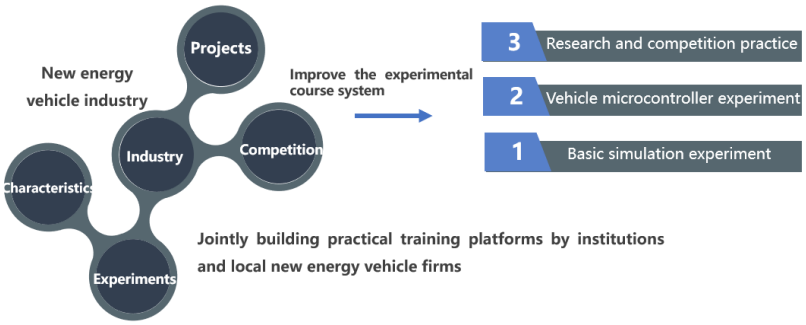

Figure 1: The experimental course system

2.2.2. Multi-dimensional integrated teaching resource libraries.

To further enhance teaching effectiveness, a multi-dimensional integrated teaching resource library has been constructed, as shown in Figures 2. The resource library integrates real enterprise needs, innovative competition topics, scientific research projects, extended chip data experimental examples, and software and hardware development resources. By introducing outstanding local enterprise resources and actual engineering requirements, we establish an automotive microcontroller teaching laboratory with local industrial characteristics, guided by practical problem-solving with microcontrollers. This allows students to participate in real business scenarios. The introduction of competition resources aims to stimulate students' creativity and competitive spirit. The multi-dimensional teaching resources enable students to better combine theoretical knowledge with practical experience, thereby enhancing their ability to solve complex engineering problems and preparing them for future careers.

Figure 2: Combining Theoretical and Practical Approaches in Resource Development

2.2.3. Joint laboratories based on enterprise projects

A new energy vehicle electronics laboratory with enterprises provides rich experimental resources for courses related to computer programming, automotive electronics technology, sensor applications, and microcontrollers is jointly established. We fully leverage the complementary advantages of talent cultivation between universities and enterprises. Using specialty class construction as a practical model for integration of industry and education, we explore the path of cultivating applied talents in the new engineering field. Zhaoqing Kunpeng Power Co., Ltd. provided two sets of new energy vehicle motors and control systems, hosting multiple motor and control technology training sessions for students of the college's new energy formula racing team. Zhihua (Guangdong) Intelligent Connected Vehicle Research Institute provided our college with an autonomous driving teaching platform and related textbooks, conducting teaching and scientific research around intelligent connected vehicles and industrial design, covering intelligent connected vehicle technology and visual design, human-vehicle interaction design, autonomous driving, etc. A new energy vehicle specialty class was established with XPeng Motors, with 7 students participating in the 3+1 training program in 2020 and 14 students in 2022. Based on students' individual career development goals, the enterprise learning phase offers three directions: "technical service, technical management, and technical R&D," catering to students' personalized development needs.

2.3. Multidimensional Assessment Methods

Under the context of the "student-centered" approach in emerging engineering disciplines, and

ISSN 2663-8169 Vol. 6, Issue 10: 179-183, DOI: 10.25236/IJNDE.2024.061026

based on the training objectives for undergraduates majoring in vehicle engineering and the course teaching goals, we have constructed a multidimensional formative assessment system. This system integrates practice projects, experimental projects, flipped classroom assessments, online exams, and final assessments, adopting both online and offline, qualitative and quantitative evaluation methods. It implements a multidimensional, multifaceted, and comprehensive evaluation system involving students, peers, and teachers as evaluators. The assessment content reflects the achievement of course objectives, namely, evaluating changes in students' cognition, abilities, and emotions during the learning process. Online tests account for 10% of the grade and is conducted online through the Rain Classroom platform for knowledge point assessment. One comprehensive final project practice accounts for 50%, carried out in groups for development and demonstration. Students engage in peer evaluation and collaborate with teacher grading to comprehensively assess each group's performance, reflecting students' innovation and teamwork abilities. Process evaluation is primarily designed for three modules, each including online tests, self-learning, group cooperation, project presentations, and exploratory learning. Phased targets are set according to the characteristics of tasks at each stage, with grading criteria as shown in Figure 3. By evaluating each module, we understand students' grasp of classroom teaching. At the same time, teachers will promptly feedback evaluation results to individual students, urging them to make improvements.

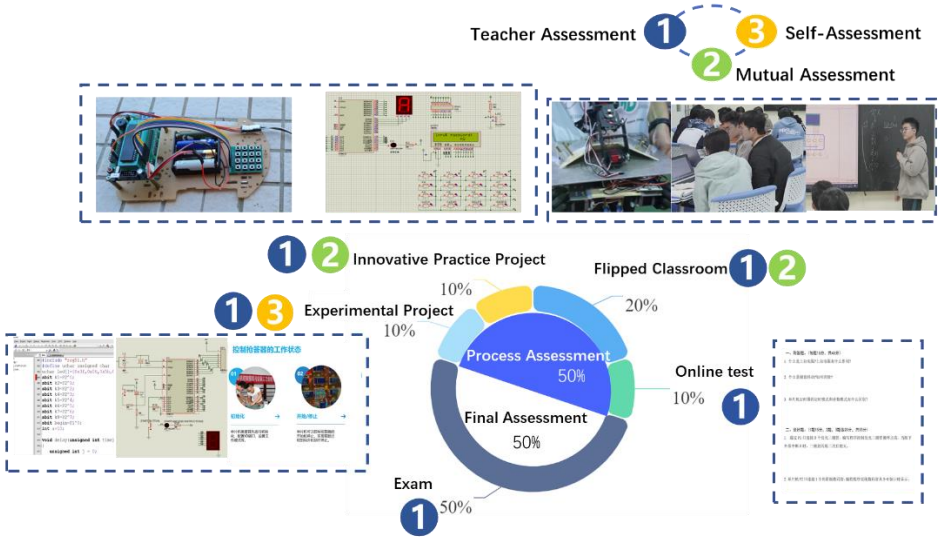

Figure 3: Multidimensional Assessment Methods

2.4. Effect Analysis

The teaching team and enterprises engage in in-depth communication to understand the actual production needs of the enterprises, deeply integrating these insights with course teaching to solidly advance practical teaching. The effectiveness and recognition of the course teaching continue to improve, receiving unanimous praise from students during actual lectures. To assess the teaching effectiveness, a survey questionnaire was designed and administered to students who have taken the course in the past year through random sampling, with 317 questionnaires distributed and collected. Figure 7(d) shows an analysis of the comparison between current students' satisfaction with their abilities after the implementation of course innovations and previous students' satisfaction. Figures 7(a)-7(c) present statistical analyses of the course satisfaction survey. Students' enthusiasm and initiative have significantly increased; they are more willing to participate in classroom discussions and practical projects, able to proficiently use microcontrollers to design and implement projects, solving real-life problems.

The teaching practice of this course has transcended the traditional on-campus teaching model by actively integrating social practice and establishing close industry connections. The teaching team was interviewed by Xijiang Daily, participated in activities such as Guangdong (Zhaoqing) Intelligent Driving Day and the Automotive Industry Talent Training Deans Forum, and also attracted visits and exchanges from Foshan University, Guangdong Science and Technology Polytechnic College, and other institutions. By co-hosting public lectures and forums on intelligent vehicles with Zhihua Intelligent Connected Vehicle Research Institute and inviting renowned professor teams from Beijing Institute of Technology, participants included faculty and students from various institutions such as Guangdong University of Technology, Guangdong Business and Technology University, and Zhaoqing City Technician College. Through deep cooperation with local enterprises like XPeng Motors and Asia Pacific New Materials,

ISSN 2663-8169 Vol. 6, Issue 10: 179-183, DOI: 10.25236/IJNDE.2024.061026

actual engineering projects are integrated into the curriculum and students' innovation and entrepreneurship projects and academic competitions, allowing students to accumulate valuable practical experience while solving real engineering problems and giving them a more intuitive understanding of industry trends and technological innovations.

Under the guidance of the course team teachers, students actively participate in various scientific research activities and academic competitions, with an increasing number of participants achieving remarkable results. In the past three years, the team teachers have guided students to obtain more than 20 national and provincial-level projects. Students have won multiple awards at various domestic academic competitions. Among these achievements are one national bronze award and one provincial silver award in the China "Internet Plus" College Students Innovation and Entrepreneurship Competition; one first prize and one second prize in the "Challenge Cup" College Students Extracurricular Academic Science and Technology Works Competition in Guangdong Province, along with several third prizes. There are two national projects under the College Students Innovation and Entrepreneurship Training Program, multiple provincial-level projects, several Guangdong Province Climbing Plan projects; and multiple awards in the National College Students Intelligent Car Competition South China Division.

3. Conclusions

The microcontroller course is an integrated and applied course that requires a combination of theoretical and practical teaching. It aims to stimulate students' interest through case studies and experiments, extending the learning time through post-class practice and academic competitions. The innovative teaching reform have sparked students' innovative thinking and problem-solving abilities, with outstanding performances in open-ended questions and project practices. Through collaboration with enterprises, real engineering projects are incorporated into the curriculum, providing students with practical experience and a deeper understanding of industry trends. It has benefited nearly 500 students, significantly improving teaching quality. Students' engagement has increased, showing greater enthusiasm and autonomy in their learning. The application of this course extends beyond the campus, integrating social practice and industry cooperation. Under the guidance of the course team, students actively participate in various scientific research activities and academic competitions, achieving commendable results. Additionally, practical teaching has been solidly advanced, deeply integrating with course instruction. The continuous improvement in teaching effectiveness and increasing recognition have led to unanimous praise from students.

References

[1] Ji Zhao, Yinbo Xie. New Engineering Construction and Innovation in Engineering Education [J]. Journal of Higher Engineering Education, 2017(5): 13-17, 41.
[2] Yong Lv, Lei Yu, et al. Exploration and Discussion on the Reform of Embedded System Teaching in the Context of Emerging Engineering Education [J]. Modern Education Forum, 2022, 5(2): 33-35.
[3] Wei Liu, Yonghua Xiong, et al. Exploration and Practice of Higher-Order Learning Teaching Models for Engineering Courses in the Context of Emerging Engineering Education [J]. Journal of Higher Engineering Education, 2021, 3: 163-168.
[4] Yelan Wu, Yuxin Xie, et al. Exploration and Practice of Microcontroller Course Design Teaching Reform under the Background of New Engineering Education [J]. Computer Education, 2022(6): 149-152.
[5] Jiajia Li, Wei He, et al. Research and Exploration on Microcontroller Course Teaching under the Background of New Engineering Education [J]. Modern Education, 2019, 6(24): 86-87.
[6] Chengbin Ye, Zhixiong Guo, et al. Discussion on Enhanced Microcontroller Teaching and Talent Training Reform [J]. Automation Technology and Application, 2016, 35(10): 149-152.
[7] Shunyu Long, Wei Yang, et al. Practice of Project-Based Microcontroller Course Teaching under the New Engineering + PBL Model [J]. Internet of Things Technology, 2018, 8(11): 112-113, 115.