Research on Reforming the STM32 Microcontroller Experiment Course Driven by Scientific Achievements

Xiaochun Xu*, Xin Wang, Huibin Feng, Haibo Luo

School of Computer and Big Data, Minjiang University, Fuzhou, 350108, China

*xuxiaochun0303@126.com

Abstract. The microcontroller course is a vital application-oriented undergraduate course. This paper uses employment in the microcontroller industry as an entry point to systematically research and analyze key issues in the microcontroller course, including course challenges, learning needs, research integration, and employment outcomes. It proposes an application-oriented talent cultivation approach that leverages scientific achievements to drive the reform of the STM32 microcontroller experiment course. This approach focuses on overcoming the content limitations of current experimental classes by incorporating the latest scientific achievements into teaching, ensuring that the course remains advanced and practical. It extends the depth and breadth of experimental course design, effectively aligning the microcontroller course with the current job market, and ultimately achieving the goal of cultivating application-oriented undergraduate education and teaching talents.

Keywords: Microcomputer, Scientific Achievements, Teaching Reform.

1 Introduction

The microcontroller course [1,2] is a foundational and critical professional course and it is a highly integrative, application-oriented course [3] with strong engineering practice and high relevance to employment positions [4], serving as a bridge for students after learning C language, analog electronic circuits, and digital electronic circuits.

With the development of the artificial intelligence industry, the application scope of microcontrollers is steadily expanding[5,6]. Consequently, the job market's skill requirements for undergraduates in related fields are increasing, making course reform essential. Currently, the demand for products based on microcontroller technology remains strong, and microcontroller research and development have become an indispensable branch of product development for technology companies. It is a major employment direction for students in majors such as electronic information, communication engineering, electrical engineering, automation, and mechatronics.

The teaching goal of the undergraduate microcontroller course is to enable students to become familiar with the core theories of microcontroller systems and develop the ability to independently build microcontroller applications. However, the current microcontroller lab course design hardly meets market demands. To solve these issues,

D. Hu et al. (eds.), *Proceedings of the 2024 5th International Conference on Modern Education and Information Management (ICMEIM 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 29,
https://doi.org/10.2991/978-94-6463-568-3_13

Zhang et al.[7] proposed a microcontroller lab reform and taken “Design of an electronic cipher lock” as an example to explain the new teaching methods. Literature [8] discussed the students’ innovation ability based on MCU. Literature [9] analyzed the course design for engineering education innovation. Geng et al.[10] designed a task-driven teaching method, however, it uses the 8051 microcontroller and is not aligned with the current market trends. This paper designs a teaching reform for the practical STM32 microcontroller experiment course driven by scientific achievements. Its purpose is to train students to have a solid theoretical foundation, strong practical skills, and comprehensive system engineering analysis and application capabilities.

1.1 Background of the Reform

To gain a deeper understanding of the current job market's demand for microcontroller technology, we conducted a survey of companies that have recruited on campus over the past two years. This survey aimed to thoroughly comprehend the skills these companies seek in candidates, thereby providing valuable insights for our curriculum reform. Fig.1 outlines the basic demands for microcontroller technology as specified by recruiting companies.

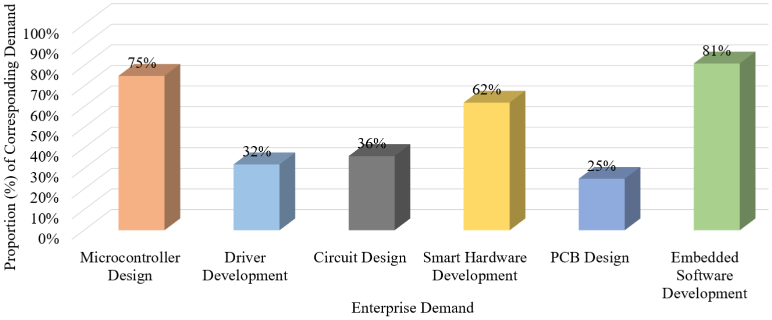

Fig. 1. The basic demands for microcontroller technology as specified by recruiting companies.

As shown in Fig.1, microcontroller design, smart hardware development, and embedded software development have become the mainstream demands for most recruiting companies. However, the traditional microcontroller courses, which primarily focus on theoretical lectures supplemented by simple basic experiments, clearly fail to meet the demands of the job market. The market demand for professionals skilled in practical operations and innovation in microcontroller technology is increasing. Using development boards for basic validation experiments with dispersed functions cannot meet the training needs of application-oriented undergraduate education. In the face of fierce competition in the job market, students urgently need the microcontroller course to seamlessly connect with the job market, extend the depth and breadth of course design, and integrate with scientific research achievements or projects. This paper aims to comprehensively enhance students' abilities in research innovation and project development. Its goals are to encourage students to take initiative in their learning and improve their learning efficiency, and broaden the depth and breadth of teaching, reform the curriculum to meet job market demands, and align classroom instruction with cutting-edge academic research. and leverage the teaching process to cultivate students' professional qualities while ensuring the course remains advanced and practical.

1.2 The Reform Plan

Curriculum Design.

Develop a new type of classroom driven by the integration of industry and education, science and education, as well as innovation and entrepreneurship. As shown in Fig.2, in the microcontroller course, the integrated teaching of theory and practice gradually progresses from simple to complex, with the 16-hour lab sessions structured into foundational tasks, extended tasks, and comprehensive tasks.

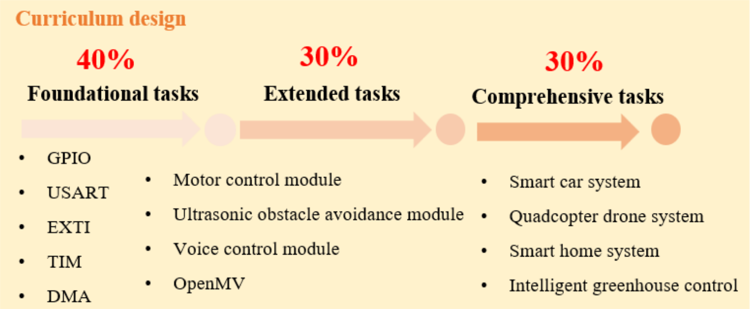

Fig. 2. Curriculum design for Reform Plan.

For the foundational tasks, by implementing pre-class discussions, students can address gaps in background knowledge and overcome initial difficulties outside the classroom. The course design for the foundational tasks (4 hours) aims to help students grasp the basic principles and functions of microcontrollers, thereby preventing feelings of intimidation. This approach also fosters students' self-assurance and confidence to a certain extent. In the extended tasks phase, platforms such as smart cars and intelligent drones can be used for course practice. Guided by specific tasks, students can implement multifunctional system integrations. The primary teaching objective is to deepen students' understanding of the fundamental principles and basic functions learned in class while enhancing their ability to analyze practical functional tasks and design systems. This allows students to directly engage with the teacher's cutting-edge academic achievements and projects during class. This approach not only extends the depth and breadth of the current microcontroller lab course design but also provides students with opportunities to encounter advanced academic research and projects. Such exposure is more conducive to stimulating students' enthusiasm for learning and their proactive exploration of knowledge.

Comprehensive tasks assess students' ability to apply microcontrollers in a holistic manner, with a focus on cultivating their independent innovation capabilities. Through comprehensive task training, students can genuinely engage in doing, learning, and thinking, thereby enhancing their initiative, fostering innovative thinking, and further promoting the development of applied talents.

Create a Comprehensive Learning Process.

The comprehensive learning process includes pre-class discussions, in-class practice, and post-class summaries, as shown in Fig.3. Before the class, teachers analyze student performance and prepare their lessons. Students independently schedule and complete their pre-class preparation and share their perspectives in the discussion forum. This approach effectively enhances students' proactive learning interest and creative initiative.

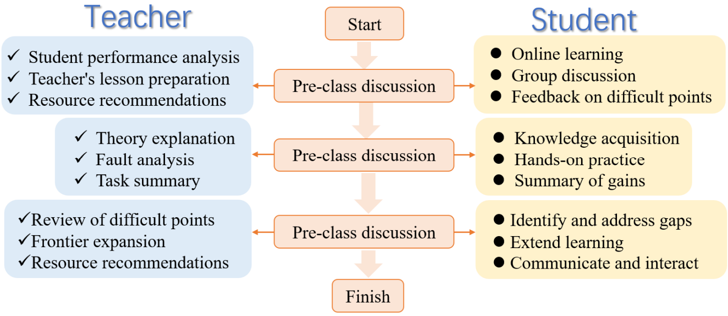

Fig. 3. Comprehensive learning process for Reform Plan.

In the classroom, the instructor provides targeted explanations of key concepts and conducts systematic analyses and demonstrations of essential practical projects. They design reasonable and effective teaching tasks, emphasizing the coherence and completeness of these tasks. Interactive classroom activities such as discussions, quick-response sessions, and Q&A should be appropriately incorporated to enhance student participation and learning efficiency. Through theoretical study and hands-on practice, students understand and master knowledge within specific project tasks, effectively combining cognitive and manual efforts. The process of developing independent software and hardware projects fosters students' healthy professional qualities and proactive innovation awareness.

After class, teachers leverage online learning platforms such as Learning Pass and Rain Classroom to integrate cutting-edge technology into the curriculum. By recommending additional resources, they extend the depth and breadth of the course. Through interactive discussions, students identify and fill knowledge gaps, actively engaging with advanced academic research and its practical applications. This approach stimulates their enthusiasm for learning and fosters a proactive attitude towards innovation.

Develop a Triad Assessment and Evaluation Plan.

The triad assessment and evaluation plan include teacher's main evaluation, student self-evaluation, and peer group evaluation. Currently, most universities assess microcontroller lab courses using traditional methods, where teachers record students' classroom performance and grade their lab reports to evaluate their overall performance. This approach completely overlooks students' perspectives on the lab projects, thereby missing the crucial role of students in the evaluation process. To address this issue, a comprehensive triad assessment plan should be developed, incorporating teacher evaluations (T), student self-assessments (SS), and peer group evaluations (PG). The course evaluation formula is as follows:

$$\text{Course Score} = \text{T} \times 50\% + \text{SS} \times 20\% + \text{PG} \times 30\% \tag{1}$$

As shown in (1), teachers can thoroughly assess students' practical skills on targeted lab projects. Therefore, the assessment includes teacher evaluations, which account for 50% of the student's total lab grade. Students move beyond the traditional single role of being tested and take on dual roles as both evaluators and participants. Student self-assessments contribute 20% of the lab grade, while peer group evaluations account for 30%. Students actively compare their work with that of other groups, gaining a clear understanding of their strengths and weaknesses, which enhances their learning enthusiasm and class participation.

1.3 Expected Outcomes and Promotion Value

This paper delves into the integration of cutting-edge research achievements by faculty into microcontroller lab courses, aiming to enhance application-oriented undergraduate education. Incorporating new technologies and knowledge, such as big data, large models, and artificial intelligence, into microcomputer and microcontroller principles lab courses allows us to create a comprehensive theoretical and practical curriculum system that encompasses “classroom teaching-lab courses-innovation and entrepreneurship”. Fig.4 gives the course reform results where the total number of surveyed students is 70. The student satisfaction scores is the weighted average of student satisfaction throughout the entire evaluation process, including course design satisfaction (CDS), experiment satisfaction (ES), self-improvement satisfaction (SIS) and course teacher satisfaction (CTS), which is defined as:

$$\text{Student satisfaction scores} = \text{CDS} \times 40\% + \text{ES} \times 30\% + \text{SIS} \times 15\% + \text{CTS} \times 15\% \tag{2}$$

In the Fig.4, after the course reform, most students are quite satisfied with the course, achieving the expected objectives. This paper aims to create a tri-integrated experimental classroom that bridges “science and education”, “industry and education” and “learning and application”. By summarizing and enhancing the teaching experiences of experimental courses, it establishes an open, efficient, and market-responsive teaching and research mechanism. Integrating teachers’ cutting-edge academic research with the experimental courses on microcomputer and microcontroller principles reforms the practical teaching approach. This enhances innovation in practical teaching, significantly improving students' innovative application abilities while simultaneously promoting the professional growth of the instructors.

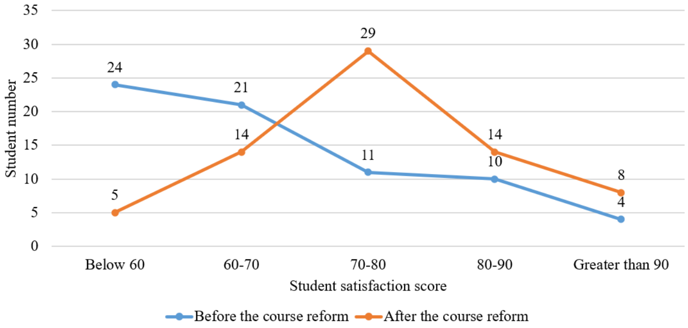

Fig. 4. The Course Reform Results Char.

2 Conclusion

To address the significant disconnect between current STM32 microcontroller course design and the job market, this paper proposes a method for integrating cutting-edge research achievements of teachers with microcontroller lab courses to cultivate application-oriented professionals. By leveraging the strong engineering practice focus and high job relevance of microcontroller courses, this study systematically analyzes and addresses key issues such as course difficulties, learning requirements, research integration, and employment outcomes. Specific teaching reform solutions are provided. The successful implementation will help microcontroller courses overcome existing limitations, extend their depth and breadth, and achieve effective alignment with the current job market.

Funding

Supported by the Minjiang University 2023 Teaching Research and Construction Project (University-Level Key Project) (MJUJG202323379), Fujian Natural Science Foundation Project (2023J05243), Guiding Project of Fujian Provincial Department of Science and Technology (2021H0054).

References

1. Zheng, Z., Dong, L., & Yan, X. Teaching Reform and Practice of Microcontroller Application Technology Course Based on OBE-CDIO concept. *International Journal of Social Science and Education Research*, *6*(7), 56-60 (2023).
2. Yang, P., Lai, S., Guan, H., & Wang, J. Teaching Reform and Practice Using the Concept of Outcome-Based Education: A Case Study on Curriculum Design for a Microcontroller

Unit Course. *International Journal of Emerging Technologies in Learning*, *17*(3), 68-82 (2022).

3. Mendes E G, Sigahi T F A C, de Souza Pinto J, et al. Teaching Electronics in the Context of Industry 4.0: A Survey on the Brazilian Scenario in the Areas of Reconfigurable Logic and Microcontrollers[J]. IEEE Transactions on Education, 67(1):65-73 (2024).
4. Budi A H S, Juanda E A, Fauzi D L N, et al. Implementation of simulation software on vocational high school students in programming and arduino microcontroller subject[J]. Journal of Technical Education and Training, 13(3): 108-114 (2021).
5. Fan H, Zhang J, Li Y, et al. Innovative Engineering Education in Circuits & Systems[C]//2020 IEEE ISCAS. 1-4 (2020).
6. Song J, Meng H. Research and Teaching Practice on Experiment Course of STM32-Embedded Microcontroller. [C]// ICEEMR 2019. Atlantis Press, 342-345 (2020).
7. Zhang, Bei, et al. Teaching reform of single-chip microcomputer experiment course and a case study. [C]// *ICGNC 2020.* 23–25, (2020).
8. Guo, H., & Cui, H. Discussion on the MCU Course Reform Based on the Cultivation of Students' Innovation Ability. *DESD 2021.*112-117 (2021).
9. Ni, J., & Luo, J. Microcontroller-based engineering education innovation. In *2010 International Conference on Educational and Information Technology*. V3-109 (2010).
10. Geng, L. Q., Zheng, T., Bian, Y., Ren, S. Y., & Li, H. W. Teaching reform of microcomputer principle and interface technology. *Advanced Materials Research*, *271*, 1737-1740, (2011).