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Reform and Exploration of Integrated Hybrid Teaching of "Microcomputer Principle" and "Microcontroller"

Xin Wang, Junlin Wang, Daoerji Fan, Liang Wang, Zhaonan Zhong, Yu Huo

College of Electronic Information Engineering, Inner Mongolia University, Huhhot, China
Email: wangxin219@imu.edu.cn

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Abstract

Based on the concept of OBE education, for the problems of highly overlapping contents and similar cultivation objectives of "Principles of Microcomputer" and "Microcontroller" courses, reforms and explorations have been carried out from the aspects of cultivation objectives, teaching contents, credit hour arrangement and assessment methods, and finally the two courses "microcomputer principles" and "microcontroller" are merged into a single course titled "Microcomputer Principles and Microcontroller Technology". On this basis, the teaching mode of "MOOC + SPOC + Flipped Classroom" is organically integrated with the traditional teaching mode. And the hybrid teaching reform and exploration of "Microcomputer Principles and Microcontroller Technology" course is carried out. Through the above integrated hybrid teaching reform and exploration, it effectively mobilises students' enthusiasm for learning, improves students' participation in the classroom, and plays a significant role in cultivating students' self-learning ability, expression ability, analysis and problem-solving ability, and teamwork ability.

Keywords

Microcomputer Principle, Microcontroller, Integration, Hybrid Teaching

1. Introduction

As a foundational course for majors such as automation, electronic information science and technology, communication engineering, electrical engineering, and computer science, "Microcomputer Principles and Interface Technology" (referred to as "Microcomputer Principles") typically uses the Intel 80X86 as an example to introduce the architecture, instruction set, working principles, and pro-

cesses of microprocessors. While "Microcontroller Principles and Applications" (referred to as "Microcontroller") usually takes the MCS-51 series as an example to introduce the hardware structure, instruction set, working principles, and processes of microcontrollers. As a follow-up course of "Principles of Microcomputer", the contents of "Microcontroller" course about the foundation of microcomputer, instruction system, interface extension and data transmission, assembly language programming and "Principles of Microcomputer" course are highly overlapped. If the same content is repeatedly introduced, it will not only take up too much class time, but also reduce students' interest and efficiency in learning, so it is imperative to organically integrate the courses with similar content and output based on the concept of Outcomes-Based Education (OBE) (Qiao et al., 2021).

In order to achieve the cultivation of students' innovation ability, exploration and research ability as well as independent re-learning ability, higher education must insist on adopting a reasonable and effective teaching mode in the teaching process. Along with the rapid development of higher education and information technology, the traditional classroom teaching mode inherited for thousands of years has been greatly impacted by new ideas and new technologies. Educators continue to think and actively innovate, and have tried to combine new teaching modes such as Massive Open Online Courses (MOOC), flipped classroom and other new teaching modes with traditional teaching modes, which makes the teaching process of higher education burst with new vitality and vigour (Wu, 2014; Zhang, 2021; Ge et al., 2022).

The course teaching team has always adhered to the teaching philosophy of "student-centered and outcomes-oriented", starting from the actual situation of students and courses, actively thinking, continuously innovating, and constantly improving. Firstly, we integrate and reconstructe the content of "Microcomputer Principles" and "Microcontroller" and merge them into one course "Microcomputer Principles and Microcontroller Technology". Secondly, we optimise the whole teaching process of the course, integrate online and offline teaching organically, and actively carry out the hybrid teaching reform and exploration of "Microcomputer Principles and Microcontroller Technology" in the new engineering background.

2. Reform of the Integrated Teaching of "Microcomputer Principles" and "Microcontroller"

1) Objectives of the course "Microcomputer Principles and Microcontroller Technology"

Understand and master the basic architecture of microcomputer, basic working principle, basic input/output control methods, common interface circuits and basic interface technology, programming skills and design methods of assembly language applications. Understand and master the basic structure of microcontroller, basic interface technology and system expansion, application design meth-

ods. Train students to use the basic knowledge of microcomputers and microcontrollers to design, analyse and develop simple interface applications, and to compare and synthesise different solutions. Enable students to understand and master the basic input and output methods, interrupt control technology and basic interface technology, with the application of control system research and development programmes for the design, demonstration and formulation, the construction of a complete microcomputer system, to understand the various factors affecting the design objectives and technical solutions, and be able to analyse common failures, judgement and timely elimination of the ability.

2) Course content and credit hours for "Microcomputer Principles and Microcontroller Technology".

The course "Principles of microcomputer and microcontroller technology" consists of 4 credits (theory) + 1 credit (laboratory), 64 hours (theory) + 16 hours (laboratory). In theoretical teaching, "microcomputer principles" part of the content accounts for 48 hours, "microcontroller" part of the content accounts for 16 hours. In order to help students solidify their foundational knowledge, the "Microcomputer Principles" section should allocate more class hours to focus on key topics such as the basic components of microcomputer systems, fundamental working principles, basic input and output methods, commonly used interface circuits, basic interface technologies, and programming skills and design methods for assembly language applications. The content of the "microcontroller" part mainly guides students to use the method of comparative learning to find the similarities and differences between the Intel 80X86 microprocessor and the MCS-51 microcontroller in terms of the basic structure, basic principles, memory organisation, instruction system, data transfer methods, connection methods of the interface chip, and the design of assembly language application programs. These help students to integrate the knowledge of microcomputer principles and microcontroller, and then train students to use the basic knowledge of microcontroller to design, analyse and develop simple interface applications, and compare and synthesise different programmers.

In the experimental sessions, focusing on the actual widely used microcontroller-based learning, so that students understand and master the coordination of the internal parts of the microcomputer system mechanism, training students to carry out microcomputer system hardware and software design and development of the basic ideas, so as to have the application of the control system research and development programmers for the design, demonstration and development, and be able to analyse the common faults, judgement and timely removal of the ability.

So we organically integrate the "Microcomputer Principle" and "Microcontroller" two courses, seek course content similarities and differences, allocate teaching hours reasonably, guide students to use different learning methods, clarify the key points, take into account the theory and practice, principles and applications, and ultimately achieve the training objectives from engineering knowledge, problem analysis, design/development of solutions to the use of modern tools and other

indicators.

3) Course Assessment and Marks Allocation for "Microcomputer Principles and Microcontroller Technology".

The course assessment of "Microcomputer Principles and Microcontroller Technology" consists of two parts: theory and experiment. The theory course accounts for 80%, including regular grades, midterm examination and final examination; the laboratory course accounts for 20%, including experimental operation, laboratory report and physical acceptance.

In the theoretical assessment, the usual grade accounts for 30% of the total theoretical course grade, mainly including usual study, usual assignments/quizzes and classroom discussions, focusing on the students' mastery of the basic knowledge of each chapter. The midterm examination accounts for 20% of the total theoretical course grade, which mainly examines the students' understanding and mastery of the basic concepts, basic principles and other basic knowledge of the chapters that have been studied in this course. The final examination accounts for 50% of the total theoretical course results, which mainly investigates the basic concepts of the course, the basic principles of the understanding and mastery of knowledge, but also assesses the flexibility of students to use the knowledge gained for the application of system analysis and design capabilities. The examination form is closed book.

Experimental courses accounts for 20% of the total score. On the one hand, students verify the theory through their own experiments to deepen their understanding of the theory, concepts. On the other hand, students use the knowledge to achieve the application of system hardware and software design, and be able to analyse the common faults, judgement and timely elimination.

3. Online and Offline Hybrid Teaching Reform of "Microcomputer Principles and Microcontroller Technology"

1) Inadequacy of traditional teaching mode

The course content of "Microcomputer Principles and Microcontroller Technology" has a lot of knowledge points, with strong theoretical and practical components, and is challenging to learn. Due to the limitation of class time, traditional teachers generally adopt the teaching mode of "PPT + Board + Teacher Lecture". The classroom teaching lacks students' interaction and discussion, and students' sense of presence in the classroom and learning initiative are poor, which leads to students' gradual loss of interest after a period of time, and seriously affects the teaching effect. It is difficult to monitor whether students have done the pre-study and post-study practice in a comprehensive way in the traditional teaching mode, and it is impossible to provide students with effective self-study resources and pathways. In addition, the traditional teaching mode usually adopts the structured assessment method of "regular grades (including regular homework and attendance) + midterm grades + final grades", which makes it difficult to make stage-

by-stage evaluation of the learning process of the students, and is unable to make all-round and comprehensive evaluation and feedback on the mastery of the knowledge and the comprehensive application ability of the students.

2) Online and offline hybrid teaching mode

With the rapid development of information technology and Internet technology, a variety of multimedia resources emerge one after another. MOOC, SPOC and other large-scale online open courses have emerged one after another, making online learning very convenient. Online collaborative communication is also more convenient, promoting the reform of the traditional classroom teaching mode. However, we must be aware of the fact that the rich online teaching resources can not completely replace the offline teacher classroom teaching. Purely relying on online teaching will lead to the lack of effective guidance and in-depth participation of teachers and face-to-face interaction between teachers and students, making it difficult to achieve the expected learning results. Therefore, integrating "online self-directed learning" with "offline classroom teaching" and adopting a hybrid learning approach are key to seeking reforms in teaching models.

Hybrid teaching means that students use online teaching resources and open online courses to complete self-directed knowledge learning. And in the classroom, teachers and students, students and students achieve further mastery and consolidation of the knowledge they have learnt through interactive exchanges such as answering questions, discussing problems, and applying knowledge, so as to give full play to the teacher's guiding, inspiring, and supervising role in the process of teaching and to stimulate the enthusiasm, initiative, and creativity of the students as the main body of learning.

3) Reform of hybrid teaching of "Microcomputer Principles and Microcontroller Technology".

"Microcomputer Principles and Microcontroller Technology" is a course with many knowledge points, which requires high learning and comprehension ability of students. And the objectives of the course emphasise on the application of knowledge and the cultivation of system design ability of students. Therefore, for the students who have grown up under the traditional mode of teaching, it is difficult for them to learn the course, and many students are unable to truly understand and master what they have learnt, and lack the ability of independent relearning, which makes it difficult for them to integrate the knowledge of the course and apply it to the study of subsequent courses and professional research.

In view of the characteristics and objectives of the course "Microcomputer Principles and Microcontroller Technology", combined with the students' learning characteristics and learning feedback, the teaching team organically integrates MOOC, SPOC, flipped classroom and traditional classroom teaching, and carries out reforms and explorations of online and offline hybrid teaching mode.

Firstly, based on MOOC, the online teaching resources are strictly selected and effectively integrated. The course team finally chose "Microcomputer Principles and Interface Technology" from Xi'an Jiaotong University and "Microcontroller

Principles and Applications" from Harbin Institute of Technology as the MOOC courses, and effectively integrated the teaching resources to establish an asynchronous SPOC course, including the content of the courses to be learnt by students, the teaching calendar, performance statistics and evaluation methods. According to the teaching calendar, course assignments and discussion questions are regularly released to guide students in discussion and exploratory learning. Through online tests, assignments and online discussions to understand the learning process and mastery of students, the offline course focuses on teaching the key points and difficulties of the course and fully interacting with students, answering questions, discussing issues and guiding students to apply their knowledge.

Secondly, the course structure and teaching process are reasonably arranged. The course "Microcomputer Principles and Microcontroller Technology" is based on Intel 80x86 microprocessor and MCS-51 microcontroller respectively, teaching the basic structure of microcomputer, basic principles, interface technology and assembly language programming. The teaching team has refreshed, arranged and organised all the course contents, and identified the contents that need to be studied under the classroom and taught in the classroom as well as the contents and topics of classroom discussions and exercises respectively, in order to adapt to the requirements of hybrid teaching. Under the teaching mode of "MOOC + SPOC + Flipped Classroom", students are required to watch the "MOOC + SPOC" course video before class, prepare for the content in advance, complete online discussions, assignments and tests on time, and discover and summarise the problems, so as to cultivate the students' self-learning ability and organizational and summarizing ability. For the key points and difficulties of the course, teachers need to use traditional classroom lectures to explain to students, repeatedly emphasise and elaborate on the important knowledge points, and at the same time, they can also use the flipped classroom approach to help students learn and understand the course content in depth through part of the Q&A session. In addition, teachers should set up and arrange the topics and contents of classroom discussion in advance for the knowledge points of the course, group the students and ask them to prepare the report PPT or report to be presented in the classroom in advance, and then the teacher will make comments and guide the students to discuss, help the students solve problems in the discussion, so as to cultivate the analytical and problem-solving ability of the students as well as their teamwork ability. The arrangements for online and offline hybrid teaching of "Microcomputer Principles and Microcontroller Technology" is shown in **Table 1**.

Besides, in order to better practice online-offline hybrid teaching, in addition to the use of MOOC, SPOC and other large-scale online open courses and other online teaching resources, teachers can also make their own teaching micro-video, online self-test exercises, key knowledge point animation and other kinds of auxiliary resources. The course teaching team organises teachers to record their own teaching micro-videos for students' self-study in accordance with the knowledge points, and arranges corresponding questions and answers at the end of the video

as a follow-up test. For some of the more difficult to understand content, such as the internal structure of the microcomputer, the basic working principles and processes, the execution process of the instructions, animations and simulations based on Proteus can be used to demonstrate these concepts to students. This approach not only enhances the interest of the course but also helps students gain a deeper understanding of challenging knowledge points.

Table 1. Arrangements for online and offline hybrid teaching of "Microcomputer Principles and Microcontroller Technology".

No.	Course contents	Teaching methods	Lesson time	Specification
1	Introduction to Microcomputer Fundamentals	Video Learning Classroom Lectures Classroom Discussion	4	Extracurricular online video learning Self-assessment exercises Discussion (student-led) Post-class assignments
2	Microprocessors and buses	Video Learning Classroom Lectures Classroom Exercises Topic Discussion Focused Q&A	8	Extracurricular online video learning Self-assessment exercises Topical discussions (teacher-led) After-class homework Focused Q&A
3	8088/8086 instruction system	Video Learning Classroom Lectures Classroom Exercises Classroom Discussion	12	Extracurricular online video learning Self-assessment exercises Discussion (student-led) Post-class assignments
4	assembly language programming	Video Learning Classroom Lectures Classroom Exercises Topic Discussion Focused Q&A	8	Extracurricular online video learning Self-assessment exercises Topical discussions (teacher-led) After-class homework Focused Q&A
5	memory system	Video Learning Classroom Lectures Classroom Exercises Classroom Discussion	4	Extracurricular online video learning Self-assessment exercises Discussion (student-led) Post-class assignments
6	I/O interface technology	Video Learning Classroom Lectures Classroom Exercises Topic Discussion Focused Q&A	12	Extracurricular online video learning Self-assessment exercises Topical discussions (teacher-led) After-class homework Focused Q&A
7	Microcontroller hardware structure and Principle	Video Learning Classroom Lectures Classroom Discussion	6	Extracurricular online video learning Self-assessment exercises Class Discussion Post-class assignments
8	Microcontroller Instruction System and Programming	Video Learning Classroom Lectures Classroom Exercises Classroom Discussion	4	Extracurricular online video learning Self-assessment exercises Class Discussion Post-class assignments Focused Q&A
9	Microcontroller System Expansion and Interface Technology	Video Learning Classroom Exercises Topic Discussion Focused Q&A	6	Extracurricular online video learning Self-assessment exercises Topical discussions (teacher-led) After-class homework Focused Q&A

In terms of course evaluation, the course "Microcomputer Principles and Microcontroller Technology" needs to examine students' mastery of microcomputer architecture, working principles and working process from both theoretical and practical aspects, and to assess whether students have the ability to design, demonstrate and formulate the R&D programme of the application control system in order to build a complete microcomputer system. The ability lays the foundation for future work in microcomputer hardware and software technology and scientific research. After adopting the online and offline hybrid teaching mode, the final score of the theoretical part of this course includes both online and offline grades, of which online self-study, homework and test grades account for 20%, offline discussion, answering questions, and post-course homework account for 10%, the midterm examination accounts for 20%, and the final examination accounts for 50%. The grades of the experimental part include experimental operation, experimental report and physical acceptance.

4. Conclusion

Under the guidance of OBE advanced teaching concept, the teaching team firstly reformed the training objectives, teaching contents, credit hour arrangement and assessment methods of "Microcomputer Principles" and "Microcontroller" courses, and two courses are integrated and reconstructed, merged into "Microcomputer Principles and Microcontroller Technology" course, which stimulates the students' interest in learning and improves the students' learning efficiency and ability. Secondly, based on the teaching mode of "MOOC + SPOC + Flipped Classroom", the traditional teaching content, teaching mode and assessment method of "Microcomputer Principles and Microcontroller Technology" course were reformed, which mobilises students' enthusiasm for learning, improves students' participation in the classroom, enlivens the classroom atmosphere, and plays a significant role in cultivating students' self-learning ability, expression ability, analytical and problem-solving ability, and teamwork ability. At the same time, the reform of the integrated hybrid teaching mode of the course "Microcomputer Principles and Microcontroller Technology" has also trained the teachers, improved their teaching ability and classroom organisational ability, improved the quality of teaching and accumulated the experience of cultivating innovative talents. In the future, it is necessary for schools, teachers and students to work together to overcome the limitations of environment, class time and ideology, and to continue to deepen the reform of education and teaching, so as to play an important role in the continuous improvement of the quality of education.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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