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Online and Offline Hybrid Embedded System Practical Training Teaching Reform

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Abstract. In order to improve the teaching quality of embedded system courses and cultivate students' engineering practice and self-learning innovation ability, a hybrid online and offline teaching mode is proposed. The embedded system practical training course in this paper breaks the traditional teaching system and knowledge structure, and reorganizes the teaching knowledge points according to the specific tasks of engineering practice. Knowledge points are fragmented and processed to build online digital teaching resources, knowledge points are integrated to carry out offline engineering project practical training teaching, and the course aims at solving practical problems to implement engineering practical training teaching that combines theoretical learning and practical education. Teachers release teaching resources in the teaching platform before class, students can use online resources to realize one-to-one teaching guidance during practical training, and complete teaching extension and summary through online simulation after class. The reform of this course is conducive to learners breaking through time and space constraints, and learning becomes possible anytime and anywhere.

Keywords: embedded system · engineering practice · online and offline · hybrid · digitalization · practical training · simulation

1 Introduction

For a long time, practical teaching in applied undergraduate colleges and universities has been bound by the traditional teaching mode, in which teachers, as the main part of practice, arrange practical training projects and experimental contents before each class [1]. In class, teachers explain the basic principles of practical training, practical training content and practical training operation steps, etc., and then students only need to follow the teacher's explanation and the operation steps on the practical training instruction book to complete the practical training tasks. This mechanical, rigid and single mode of practical training teaching greatly limits students' enthusiasm, initiative and creativity in learning, and cannot stimulate students' interest and enthusiasm in independent thinking, so that it is difficult to improve the quality of practical teaching and hinders the cultivation

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of students' engineering practical ability and innovation ability [2–4]. At present, the content of the embedded system training course is simple and has limited integration with production practice, mainly around the writing of independent module programs, but fails to introduce the engineering practice application scenarios, such a teaching method is difficult to satisfy the expectations of engineering practice application as the teaching goal, and the course content needs to be reformed [5]. The following is a teaching design project case of a MCU-based automatic washing machine simulation device, and the details of building online digital teaching resources, implementation of online and offline hybrid teaching, and analysis of the implementation effect are introduced.

2 Implementation of Online and Offline Hybrid Teaching

The specific implementation of online and offline hybrid teaching of the course is divided into 5 steps: students' pre-class preview (online), virtual simulation teaching of practical training projects (online), learning effect evaluation (flipped classroom), students' practical training practice (offline) and assessment and evaluation (online and offline), as shown in Fig. 1.

2.1 Preview for Students Before Class

In the pre-course stage, teachers publish fragmented teaching resources, which include teaching videos, chapter tests, discussion forum exchanges, installation of virtual simulation software, and other forms of content. Students use the online course resources for independent learning, to complete the test questions corresponding to each task point, this way can dispel the students' psychological dependence on the teacher's lecture and practical training instruction book. In the process of independent learning, students can discuss with each other and think and answer the questions raised by the teacher in the discussion forum. The teacher can also understand the personalized learning effect of students through the completion of task points such as video viewing progress and chapter tests, and summarize common problems for classroom lectures and discussions [6, 7].

2.2 Virtual Simulation Teaching

The teacher proposes the project design requirements, students discuss the design requirements in groups, analyze the task requirements, determine the design ideas, key points and difficulties, and the teacher is responsible for answering questions and providing advice. In this paper, we take the project "Automatic washing machine" (shown in Fig. 2-a) as an example. The project simulates the actual working process of a washing machine, and the topics are selected from daily life, which facilitates students' understanding of the project design principles and lowers the learning threshold. In teaching, the above functions can be virtually simulated using Proteus software (as shown in Fig. 2-b), and students are first required to draw all the schematic diagrams. Compared with offline physical teaching, students can directly draw circuit schematic diagrams, which is easier to feel the circuit characteristics than seeing the real thing, and can master the

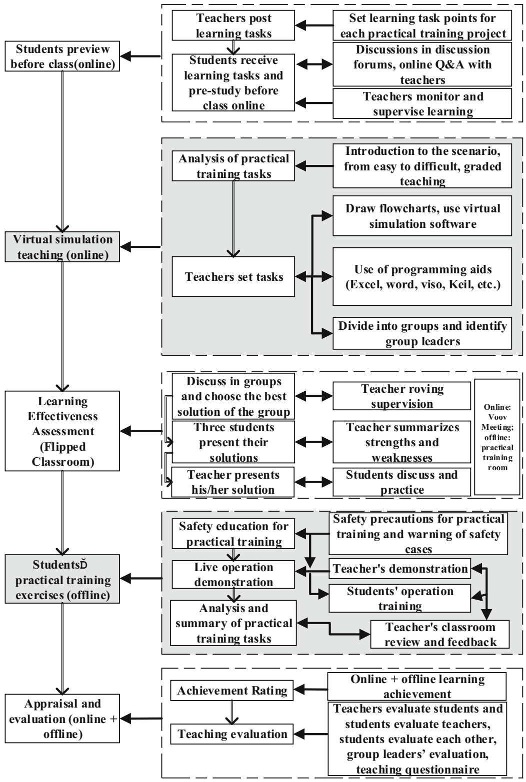
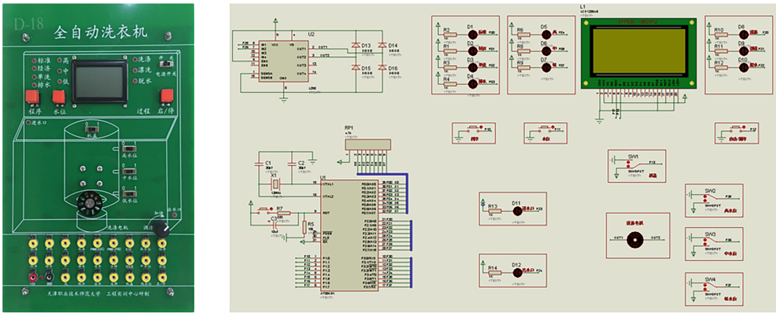


Fig. 1. The implementation process of online and offline hybrid teaching

detection principle of the circuit through simple digital and analog analysis. The online course is conducive to the retention of experimental data, which provides experimental phenomena and data reference for the offline practical training exercises later. In the development of specific practical training tasks, each project is divided into several levels according to the difficulty, from easy to difficult, and the difficulty gradually increases, so that students can choose according to their mastery, which is convenient for graded teaching [8]. The project "Automatic washing machine", according to the difficulty level, is divided into three topics: design 1, design 2 and design 3, and the training content of the topics is shown in Table 1.

In the past, when students first started programming, they felt overwhelmed and clueless. We improve programming efficiency by using programming aids, and the focus is placed on project flowchart. Drawing flowcharts before programming is equivalent to writing an outline of the front of the essay, first with the central idea of the essay, to determine the beginning, end and middle levels, followed by the words to fill the outline. Drawing a flowchart requires identifying the main idea, then the intermediate branches, and finally translating the flowchart into code using a programming language [9, 10]. Lead students to draw the flowchart of the project, introduce and discuss their design ideas, and the teacher will add comments and give a reference flowchart for comparison



(a) Hardware Platform (b) Virtual Simulation Platform

Fig. 2. Automatic washing machine project

Table 1. Automatic washing machine subject practical training content

Subjects	Practical training contents
Design 1	Basic operation of the washing machine, involving only the LED module, the button module and the motor module, with simple programming logic.
Design 2	On the basis of design 1, new LCD display and conditional judgment functions are added, increasing the difficulty by one level.
Design 3	On the basis of design 2, new voice broadcast and pause functions are added to increase the amount of logic operations and algorithm design.

to broaden students' ideas and develop their programming thinking and independent thinking skills.

2.3 Learning Effectiveness Assessment (Flipped Classroom)

Students' learning outcomes should be measured in a timely manner after the teaching is completed. The process can be implemented online (Voov Meeting is recommended) or offline, with students as the main focus, with reference to the flipped classroom format. Firstly, students present the production effect and practical training data as a group, highlighting the innovation points, then other groups ask questions and discuss the solution, and finally the teacher makes comments, affirming the merits of the solution and pointing out the unreasonable points of the solution. After the discussion, the teacher explains his or her practical training program and allows students to discuss and improve their own program. The assessment session should be based on the development of students' practical skills, and the main line is "project task" → "basic theory" → "project analysis", and the development idea is "problem formulation", "problem analysis" and "problem solving", so that students can analyze, discuss and complete the task to master the relevant theory and practical skills [11]. This teaching session serves as an assessment of students' performance and also provides a strong guarantee and basis for the next stage of offline practical training exercises.

2.4 Student Practical Training Exercises (Offline)

After students enter the practical training room, firstly, teachers should educate students on the safety of practical training, including rules of practical training room, safety management regulations of practical teaching place, code for students' practical training and safety operation procedures of practical training room; secondly, teachers should conduct demonstration teaching on the operation of practical training equipment, students start to be familiar with the operation of practical training equipment, teachers go around to guide and put forward improvement opinions in time; finally, after students master the operation of practical training equipment, they can continue to finish the rest of practical training contents. In the process of practical training, students should be guided to record relevant data timely and accurately, and before the end of the day's practical training, students are required to organize the data of practical training, analyze the results of practical training and make valid conclusions. After the practical training, students should organize the practical training materials and practical training tools and practical training equipment, and clean up the environmental hygiene of their personal work stations.

2.5 Assessment and Evaluation (Online + offline)

At present, the assessment standard of embedded system course practical training is basically based on students' attendance, practical training report and performance in the operation training process. Due to the large number of students in the class, it is difficult for teachers to know specifically the actual training and mastery of each student, and the assessment results are mostly subjective, which is not conducive to improving students' learning motivation [12]. The reform method of assessment is to evaluate each other within the group, and the group leader supervises and records the training of the group members to strengthen the assessment of the practice process; to explain and display in groups, and to review between groups to strengthen the assessment of design ideas; to reply the training results to strengthen the assessment of the training results, and to truly and comprehensively assess the performance of students, and to establish a diversified practice assessment evaluation method of the practice course, as shown in Table 2. Combined with the course attributes and objectives of the practical teaching, focusing on the cultivation of students' engineering practice ability, the final assessment of the course is determined to be online accounting for 30% of the total score and offline accounting for 70% of the total score.

Table 2. Appraisal table

Grade Composition	Percentage of grades	Assessment session
general performance	20%	Conceptualization of the solution, demonstration of the solution, discussion within the group, grade given by the group leader; Attendance and work attitude.
Design	20%	Flowchart design with complete design function and reasonable structure; Program design, to complete project metrics requirements.
Debugging	15%	Ability to correctly troubleshoot hardware circuits; Ability to debug software.
Reply and acceptance	20%	Explain the topic accurately and express the design function; Answer teacher questions correctly and whether the topic is completed independently.
Summary Report	25%	Whether the design content is complete, correct, and has the ability to summarize; Whether the practical training data preservation is valid and complete.

3 Analysis of the Implementation Effect

Through three years of research and practice of online and offline hybrid teaching for the embedded system practical training course, some results have been iterated as follows.

3.1 Built and Improved Online Digital Teaching Resources

Through the construction of online course platforms such as "Rain Classroom" and "China Student MOOC", the main body of teaching in this course is changed from teachers to students, so that the purpose and relevance of teaching is made clearer. Teachers publish the teaching contents, teaching tasks, teaching requirements, homework library, test paper library and operation of practical training equipment in the form of videos, audios, pictures and documents on the online teaching platform; students can learn independently online; teachers and students, students and students, teachers and teachers can carry out discussions and exchanges of relevant issues on the platform, etc. These provide a colorful educational environment and powerful learning tools for students' learning of the course, and build a new platform for independent, cooperative, and inquiry learning [13].

3.2 Improved Teaching Effectiveness

Through the implementation of online and offline hybrid teaching, students actively participate in the learning and practice of this practical training course, and the enthusiasm

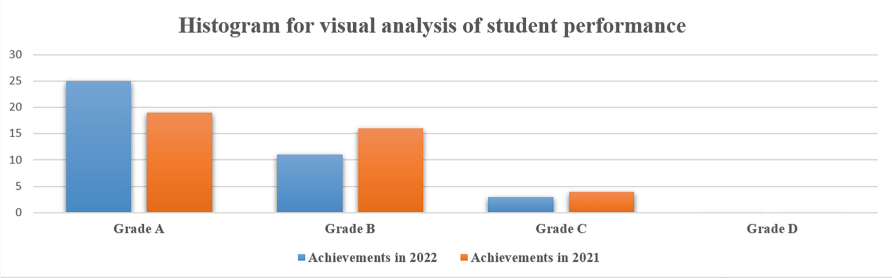


Fig. 3. Performance Analysis Histogram

and initiative of learning are obviously improved, and the teaching effect is significantly enhanced. After three years of teaching, students' performance has improved significantly compared with previous years. Taking Applied Electronics Technology Education as an example, the percentage of A grade in 2022 is 15% higher than that in 2021, and the number of A grade increased by 6; the percentage of C grade in 2022 is 2% lower than that in 2021, and the number of C grade decreased by 1; the histogram of visual analysis of grades is shown in Fig. 3, indicating that students' mastery of professional fundamentals has been effectively improved.

3.3 Improved Quality of Teaching and Learning

The course is implemented through a hybrid teaching approach of online virtual teaching and offline practice, so that students' engineering application and innovation abilities are also significantly improved. Since 2020, despite the impact of the COVID-19, teachers have been working hard to build the stage for students to demonstrate their skills. For instance, multiple students have achieved outstanding results, with Li Miaoxin of class 1812 of Applied Electronics Technology Education won one national second prize in the National Undergraduate Mechanical Innovation Competition; one gold medal (champion) in the China Undergraduate Engineering Practice and Innovation Ability Competition; one national second prize in the National Undergraduate Electronics Design Contest and two first prizes in Tianjin; one first prize in the Tianjin Emerging Engineering Competition and three other provincial awards, etc. Because of the above outstanding engineering practice ability, he won the national scholarship in 2022.

4 Conclusion

With the diversified and personalized teaching needs under the new form of "Internet + education", the embedded system practical training course in the Engineering Training Center of Tianjin University Of Technology And Education has reformed the traditional practical training teaching mode since 2020, relying on the online teaching platform and implementing a hybrid online and offline practical training teaching mode. Through the deep integration of information technology and practical courses, online and offline hybrid teaching has changed the presentation of the previous practical training course teaching contents, teachers' teaching methods, students' learning style and teacher-student interaction, and the implementation of a diversified assessment and evaluation mechanism has promoted students' enthusiasm and initiative in learning. The online and offline hybrid practical training teaching expands students' innovative thinking, improves the effect of practical training and enhances teaching quality.

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