Exploring the Reform of Flipped Classroom Teaching Based on SPOC

-- A Case Study of "ARM Embedded System Architecture"

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Abstract: This study, centered around the "ARM Embedded System Architecture" course, compares traditional teaching methods with the practical effects of a flipped classroom approach based on Small Private Online Courses (SPOC). The analysis of the current teaching situation reveals shortcomings in traditional lecture-based teaching methods concerning student engagement and effectiveness. Therefore, this research focuses on implementing a hybrid teaching model based on SPOC for flipped classrooms, using the Learning APP as a platform. Through comparative experiments between the experimental and control groups, the study collects data on students' learning status, knowledge mastery, and assignment performance. The use of the Learning APP extensively records students' learning trajectories. The results indicate that the SPOC-based flipped classroom model exhibits significant advantages in enhancing student engagement, deepening knowledge internalization, and promoting practical application. This research provides empirical support for the promotion of digitalization and innovative teaching models in higher education, offering insights into the construction of a more flexible and effective educational system.

Keywords: ARM Embedded System; SPOC-based Flipped Classroom; Higher Education Innovation.

1. Introduction

The 20th Congress of the Communist Party of China explicitly put forward the goal of "promoting educational digitization, building a learning society for all, and becoming a learning-oriented nation," emphasizing the comprehensive improvement of the quality of talent development and the cultivation of outstanding innovative talents. It is evident that educational digitization has gradually become a crucial breakthrough for China to explore new paths and shape new advantages in educational development. One of the most typical platforms for digital education is Massive Open Online Courses (MOOC), characterized by connecting learners worldwide and providing high flexibility in course selection. MOOC participants can freely choose courses of interest and, upon successful completion, obtain certificates[1]. MOOC originated in 2008 and experienced massive development until 2012. However, from 2013 onwards, MOOC faced a severe issue of participant dropout, with less than 10% of registered learners completing the courses. The root cause lies in the lack of motivation among registered learners, despite the free access to learning resources. In recent years, with the emergence of online learning platforms such as Yuanfudao, MOOC, and Xuexitong, students in higher education institutions are no longer limited to traditional classroom teaching. With scholars continuously exploring teaching reforms, a new teaching model, Small Private Online Courses (SPOC), has gradually entered university classrooms. The SPOC course model can be understood as SPOC=MOOC+Classroom, aiming to integrate the advantages of flipped classrooms and MOOC, realizing a blended teaching mode of online and offline.

2. Analysis of Current Teaching Situation

Our school offers a course titled "ARM Embedded System Architecture" in the Internet of Things (IoT) program, with a planned duration of 64 instructional hours. The course primarily focuses on the ARM architecture's Cortex-A9 embedded processor, utilizing the Exynos4418 chip as the main control chip. Students learn about embedded microprocessor architecture, common ARM assembly instructions, development environment setup, GPIO drivers, interrupt systems, DMA control, PWM timers, ADC conversion, and other related topics. Practical programming is conducted using experimental kits in our school's laboratory, making it a course that combines theory with hands-on practice.

The course has prerequisites such as "C Language Programming" and "Microcontroller Principles" and is an elective, but due to the widespread application of embedded systems, especially in IoT devices, about two-thirds of students in the major choose to enroll. However, given the course's theoretical depth, the traditional "lecture-style" teaching method, even with in-class training and a full-week practical session at the end of the course, might result in passive knowledge absorption by students. This can hinder their enthusiasm for learning and the overall effectiveness of the practical sessions.

3. Flipped Classroom Teaching Based on SPOC

The essence of educational reform is a change in traditional teaching and learning methods. It aims to shift from the teacher-centered, lecture-based approach where teachers dominate the classroom and students passively listen to a new teaching philosophy centered around students, making them the subjects of learning[2]. The "student-centered" teaching model has been a focus of educators worldwide in recent years, with the "flipped classroom" emerging as one of the most prevalent new classroom models in educational reform research[3].

The application of the flipped classroom transforms the traditional "lecture-based" teaching approach. It emphasizes driving students towards autonomous learning. The process involves teachers assigning pre-class learning tasks through educational platforms. Students, organized in groups, independently study key concepts before class, completing assigned tasks. In-class activities led by the teacher include group discussions, one-minute presentations, Q&A sessions, brainstorming, fostering interactive exchanges, and addressing challenges students encountered during pre-class learning. This approach harnesses students' subjective initiative in learning, embodying the teaching philosophy of "student-centered, teacher-guided"[4].

In the current context of abundant internet information, implementing the flipped classroom is more accessible than ever. Therefore, contemplating how to better utilize modern network platform technologies for the organic integration of Internet+flipped classrooms has become a hot topic in course reforms across universities. This paper proposes using the course "ARM Embedded System Architecture" as an example, employing flipped classroom teaching reform based on Small Private Online Courses (SPOC). Centered around the flipped classroom concept, leveraging the Learning APP as a platform, and aiming to enhance students' subjective initiative in learning, the paper explores a new set of teaching ideas and methods.

4. Application of SPOC Teaching Model Using "ARM Embedded System Architecture" as an Example

4.1. Research Framework

In this study, the hybrid flipped classroom teaching model will be practically applied to the course "ARM Embedded System Architecture." The research will focus on two classes from the 20th cohort of the Internet of Things (IoT) major, referred to as Experimental Class A (20 IoT Undergraduate A) and Control Class B (20 IoT Undergraduate B).

Control Class A will follow the traditional classroom teaching approach, where theoretical knowledge is delivered during class time, challenging topics are highlighted, and in-class exercises are conducted to provide practice. Homework assignments will be given after the class.

Experimental Class B, on the other hand, will implement the proposed SPOC-based flipped classroom teaching model. Students will be grouped, and pre-class tasks will be assigned via the Learning APP for group completion. During the class, the teacher will present practical and applied problems, leading students in group discussions, brainstorming sessions, and Q&A activities to deepen their understanding of the topics. Following the discussions, groups will engage in in-class practical exercises. Post-class, assignments of varying difficulty levels will be given through the Learning APP, to be completed by the student groups.

The entire learning process for both Class A and Class B will be documented through the Learning APP, capturing learning status, knowledge mastery, assignment scores, practical exercise results, exam scores, and student feedback. Comparative analysis of the quantitative data from both classes will be conducted to derive comprehensive research conclusions.

4.2. Preliminary Preparation

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1. Construction of Teaching Resources:

Upload micro-course resources on Chaoxing Learning APP, including course PPTs, teaching outlines, and lesson plans.

Pre-enter pre-class learning tasks and post-class assignments into the corresponding course resources on Chaoxing Learning APP.

2. Student Grouping:

Pre-group students in the experimental class 20 IoT Undergraduate B to ensure organized and well-distributed learning tasks.

3. Topic Resources on Chaoxing Learning APP:

Enter discussion topics into Chaoxing Learning APP to adequately prepare for course guidance and interaction.

4. Student Training:

Conduct pre-training for students on how to effectively use the Chaoxing Learning APP, covering operational guidance, accessing micro-course resources, and completing pre-class and post-class assignments.

Ensure students are well-equipped to smoothly participate in the course and make the most of teaching resources.

4.3. Implementation Phase

This study adopts an experimental control method, using the "PWM Timer" in the Embedded Systems Design course as the teaching content. Control group Class A adopts traditional teaching methods, while the experimental group Class B adopts a SPOC-based flipped classroom hybrid teaching model. The implementation process of the SPOC-based flipped classroom hybrid teaching model is as follows.

4.3.1. Pre-class Preparation and Design

Pre-class self-study arrangement is a crucial step in the design of the SPOC-based flipped classroom teaching. By reasonably mobilizing students' learning enthusiasm and providing them with pre-arranged learning tasks, students can familiarize themselves with basic classroom knowledge, ensuring the smooth implementation of flipped classroom teaching. Pre-class arrangements are mainly conducted through the Learning APP. The instructor uploads micro-lecture videos related to the course's key points on Learning APP, adhering to the SPOC concept. Each video covers 2-3 new knowledge points per class, with each video lasting within ten minutes. Students are encouraged to keep their learning time for watching videos within half an hour. For example, in the "PWM Timer" class, core knowledge points include "Principle of PWM Timer" and "Control Registers of PWM Timer." After students complete the video-watching task, learning groups are required to finish some pre-class assignments within a specified time. If groups encounter challenging questions that cannot be resolved through group discussion, they can post them on the discussion forum on Learning APP. Other groups' students can participate in the discussion. If a student solves a problem raised in the forum, both the problem-solving group and the group that posted the question receive certain bonus points. The bonus point data can be exported from Learning APP records for subsequent scoring.

4.3.2. Flipped Classroom

While pre-class learning allows students to become familiar with classroom knowledge, it may not guarantee a thorough understanding and application of knowledge to solve practical engineering problems in embedded development[6]. Therefore, in the offline classroom teaching segment, the flipped classroom teaching model is employed. The experimental class is no longer confined to traditional lecture-style teaching but introduces brainstorming and group discussions. The instructor initially introduces the knowledge points for the class, then raises some key questions that students presented during pre-study, such as: "What steps are required to use the PCLK clock to output a PWM waveform?" The instructor guides the students in discussing these questions, and finally summarizes the discussion. Additionally, because the course "ARM Embedded System Architecture" emphasizes practical development, in-class practical training is necessary. The instructor can propose a specific engineering problem in class, sparking group discussions among students, for example: "How to configure PWM-related registers to achieve a 50% duty cycle for a 100Hz buzzer beep." Finally, based on the discussion plans of each group, in-class practical training is conducted using the embedded development experimental kit provided by the school, programming based on the Exynos4418 chip. The instructor assists from the side, realizing a "student-centered, teacher-guided" approach. The flipped classroom allows students' learning experiences to undergo a process of "seeing the mountain as a mountain, seeing the mountain not as a mountain, seeing the mountain still as a mountain," facilitating a profound understanding of classroom knowledge.

4.3.3. Enhance Students' Comprehensive Problem-Solving Abilities After Class

Taking "PWM Timer Driving Buzzer to Play Music" as an example, students in the flipped classroom can already achieve driving the Exynos4418 chip to control the buzzer to emit a sound with a certain duty cycle. Therefore, post-class assignments are designed to be more comprehensive. For instance, students can control the buzzer's beep frequency with a certain duty cycle to achieve changes in pitch. With pitch changes, students can play music. However, each group of students needs to independently research the pitch of each note. The ultimate task is to combine PWM timer programming and buzzer playback to perform the song "Two Tigers." Through this task, students can deepen their understanding of PWM timer knowledge and programming abilities.

5. Summary

The flipped classroom teaching model based on SPOC has shown positive teaching outcomes in the "ARM Embedded System Architecture" course. By comparing traditional classroom teaching with the SPOC flipped classroom teaching model, we can clearly see its significant effects in enhancing students' autonomy in learning, deepening internalization of knowledge, and promoting practical application.

Firstly, the SPOC teaching model, using the Learning APP, achieves blended learning both online and offline, allowing students to independently learn through watching micro-lecture videos during the preview stage. This not only enhances students' autonomy in learning but also makes the learning process more flexible, aiding students in better grasping foundational knowledge. Secondly, the implementation of the flipped classroom process places more emphasis on internalizing knowledge. By introducing practical problems, organizing group discussions, and brainstorming in-class activities, teachers successfully guide students in in-depth thinking and discussions. This interactive teaching model encourages students to understand and apply knowledge more profoundly, making it more conducive to the internalization and mastery of knowledge compared to the traditional passive reception method.

Furthermore, the SPOC flipped classroom records students' learning progress, knowledge mastery, homework scores, and other data through the Learning APP, providing strong support for the evaluation of teaching effectiveness. This digital record and analysis provide teachers with a more comprehensive understanding of students' learning situations, facilitating the timely identification of problems and targeted guidance.

Overall, the SPOC-based flipped classroom teaching model injects new vitality into the teaching reform of the "ARM Embedded System Architecture" course, achieving significant teaching outcomes. The successful practice of this teaching model provides valuable experience for the teaching reform of other related courses, laying a solid foundation for the construction of a more innovative and effective education system.

References

[1] Xu Bibo, Li Tian, Shi Xi. Analysis of Learning Motivation in MOOCs, Flipped Classroom, and SPOCs and Its Educational Implications[J]. China Electric Education. Vol. 09 (2017), p. 47-52+61.

[2] Jiang Qin. Application and Research of SPOC Teaching Model in Online Teaching—Taking the Course "Embedded Development" as an Example [J]. Computer Products and Circulation. Vol. 09 (2020), p. 207-208.

[3] Su Lina. A Study on the Impact of the "SPOC+ Separate Classroom" Teaching Model on the Autonomous Learning Ability of Clinical Undergraduate Nursing Interns[J]. Western Quality Education. Vol. 09 (2023) No. 22, p. 135-138.

[4] Song Kai; Yan Liping. Construction of Practical System for Computer Major Courses in the Background of New Engineering[J]. Fujian Computer. Vol. 39 (2023) No. 01:107-112.

[5] Wang Li; Su Bo; Cui Lizhi; Zhao Yunji; Yang Lingxiao; Gao Ruxin. Teaching Reform of "Single-Chip Microcomputer" Course under the Background of New Engineering[J]. Modernization of Education. Vol. 6 (2019) No. 77, p. 61-63+80.

[6] Song Kai; Yan Liping. Construction of Practical System for Computer Major Courses in the Background of New Engineering[J]. Fujian Computer. Vol. 39 (2023) No. 01, p. 107-112.