

Teaching Reform of the Single-chip Microcomputer Curriculum based on PBL

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Abstract—This paper has proposed a teaching reform method for the curriculum ‘Single-chip Microcomputer Applied Technology’ based on the concept of PBL. The improvement includes choosing the suitable SCM chips (MSP430), designing the pattern of the PBL class, and using the circuit simulation software, such as Proteus 8 and IAR, and MOOCs to promote students’ enthusiasm. A contrast experiment of two classes was done for one semester in the biomedical engineering major of Shanghai University of Medicine & Health Sciences. The results of the experiment showed that PBL class performed better in encouraging excellent and middle-leveled students to learn by themselves. With the help of the improved class and the different educational technological tools, the population of high-score (80-10) students in the PBL class is over 50% more than the ones receive the traditional course.

Keywords—single-chip microcomputer; curriculum reform; PBL; circuit simulation

I. INTRODUCTION

The “Single-chip Microcomputer Applied Technology” is a classical course for many engineering majors, such as electronic engineering, communication and biomedical engineering, etc. The single-chip microcomputer, short for SCM, is the important basic knowledge for studying the embedded system and microcomputer principle. However, previous studies show that there are several drawbacks which often occur in teaching and learning this course [1-2]. First, the class hour is not enough for practice. The class period for theory teaching is generally far more than the one for doing the experiment. Second, students lack experimental conditions and tools for learning by themselves in spare time. Third, the traditional teaching mode made students passive to receive knowledge from the teacher, but a better way to master the SCM is to read more codes and developing the hardware individually or in teamwork. The PBL (Problem Based Learning) mode has been considered as an effective way for helping students learning by themselves. It is generally adopted in the medical course teaching while rarely seen in the engineering class. Therefore, in order to solve the problems above, a teaching reform for the single-chip microcomputer curriculum based on the PBL method is suggested in this paper.

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II. DESIGN OF CURRICULUM REFORM

A. The Course Content

The Course “Single-chip Microcomputer Applied Technology” is designed to introduce the structure and working principle of the common SCM and help students achieve the ability to develop software and hardware based on it [3]. In Chinese Universities, the most popular SCM for the study includes MCS-51, MSP430, AVR and PIC. MCS-51 SCM has simple structures while the developing work is relatively easy. But its disadvantage in performance made it be used rarely. MSP430 is a product of Texas Instrument and famous for its better performance in use with excellent power control. In the SCM course for the biomedical engineering major of Shanghai University of Medicine & Health Sciences, it has been chosen as the study object as it plays an important role in medical instrument design and manufacture. It means that the MSP430 single-chip microcomputer also meets the spirit of the cultivating talents program.

TABLE I. THE CONTENTS AND CLASS HOUR OF CURRICULUM

No.	Title of Unit	Theory Hours	Practice Hours
1	CPU and I/O	2	-
2	Display technology	4	2
3	Keyboard input	4	-
4	Timer	4	2
5	A/D converter	4	-
6	D/A converter	4	-
7	Real-time clock	2	-
8	Serial communication	4	-
		Total	28
			4

According to the basic structure and working principle of MSP430, the content of the curriculum can be divided into 8 parts as shown in Table I. The second column shows the titles of each unit, including CPU and I/O, Display technology, Keyboard input, Timer, A/D, D/A converter, Real-time clock and Serial communication. The third one gives the class period for both theory studying and experiment.

Obviously, there are only 32 class periods for this course in the cultivating program. This situation just reflects that the class hour is not enough for practice, and the class period for theory teaching is generally far more than the one for doing experiment. In order to gain a better effect, students should spend more time on self-learning. The urgent problem is how

to improve the students' enthusiasm and make a better arrangement of time plan in and out of class.

B. The PBL Mode Used in Teaching Reform

The PBL mode is oriented in McMaster University in Canada. Its core idea is to let students explore and research the studying contents by finding, announcing and solving problems individually [4-5]. In contrast, PBL is different from traditional class, which is carried by teachers' lecture and directions. PBL suggests that the problems can lead and drive the learners to study positively. The general mode is like: face the designative state, find and solve problems, and get to know the new knowledge, strategy and attitude during the process above.

In the reform of the curriculum "Single-chip Microcomputer Applied Technology", we critically obeyed the principle of running a PBL class. For each unit, prepared materials which contain the theory and application of every SCM module are sent to students before class. The materials were written in the form of stories, news or micro novels. Students must read them very carefully to find what they were not familiar or something they are interested in. All the things they find should be listed in the form of questions, which would be the homework to complete in their spare time.

The characters of the problem based learning can be described in three aspects.

- The role of both the teacher and students are changed. Teachers play a role as tutors or assistants. They supply the situation with problems, give examples, and stay away from students' discussion gradually. During the studying procedure, teachers should also be the cooperating researchers to join the learning procedure and evaluate their effectiveness. At the same time, students are not only participants, but leaders. They are encouraged to be positive, do research and solve problems from the essentials of the questions.
- Posing questions are not in fixed structures. The purpose is to supply a challenging questionnaire atmosphere. The information source is from the students. They collect, prepare and combine most of the information by themselves. The knowledge should rarely be given by teachers. [6]
- The final goal of the PBL is not only to gain knowledge and find the solutions to questions, but even to let students master how to live and find the meanings of life. The PBL respects the special character of every student's learning method, realizes the inner value of studying and release the students' talent during learning. Basically, the PBL mixes the exploration on questions and finding the sense together in order to integrate both of them.

III. IMPORTANT ACTIONS IN THE TEACHING PROCESS

Different from the traditional teaching mode, PBL course prefer to let students do more independent work, of which the achievement can be shared to teammates in class. In this

curriculum reform procedure, circuit simulation software and MOOC are employed in the course schedule. First, we use Proteus and IAR Embedded Workbench to help students build an engineering platform to make programs and test. Then, they can get the necessary principles of SCM from the MOOC which is designed and built by teachers from Shanghai University of Medicine & Health Sciences. The details about these educational technologies are discussed below.

A. Circuit Simulation

In common course of the single-chip microcomputer, students' opportunity to do practice is not enough. Most of the experiments must be done with special designed experimental boxes in the laboratory. As a result, they cannot spend much time on practice, or even get no chance to design what they plan to do. The EDA software has given a solution to these situations. For example, Proteus 8 is a famous circuit design and simulation tool. It contains a lot of common electronic components, such as single-chip microcomputer, crystal, resistance, capacitors and other components. We use Proteus 8 to design the SCM platform for the experiment, include I/O, keyboard, display (LED, 7-seg digital LED, LCD screen), timer, serial communication, A/D, D/A and so on. Take the I/O port experiment for example, the circuit layout is shown in Fig. 1. The SCM chip MSP430FXXX in the figure can run with a *.hex file produced by the IAR. When the circuit diagram is ready, the SCM should be clicked twice and the hex file should be imported in the pop-up windows. And then the program written by students is loaded into MSP430.

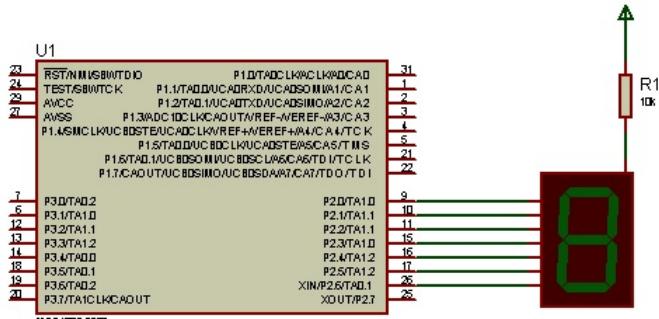


Fig. 1. Example of a SCM simulation in Proteus.

IAR Embedded Workbench has a special version for MSP430 developing. Students can make C program in IAR, which support both the real chips and their surrounding circuit on the kit board and simulating circuit layout placed in EDA software, such as Proteus 8. The IAR also supports ASM, C++ and other program languages. Something should be noticed is that IAR cannot export *.hex files directly. Students should modify some settings in the Fig. 2. In this way, when students compile the code, IAR will make it into a *.hex file. As referred above, it can be loaded to SCM in Proteus 8.

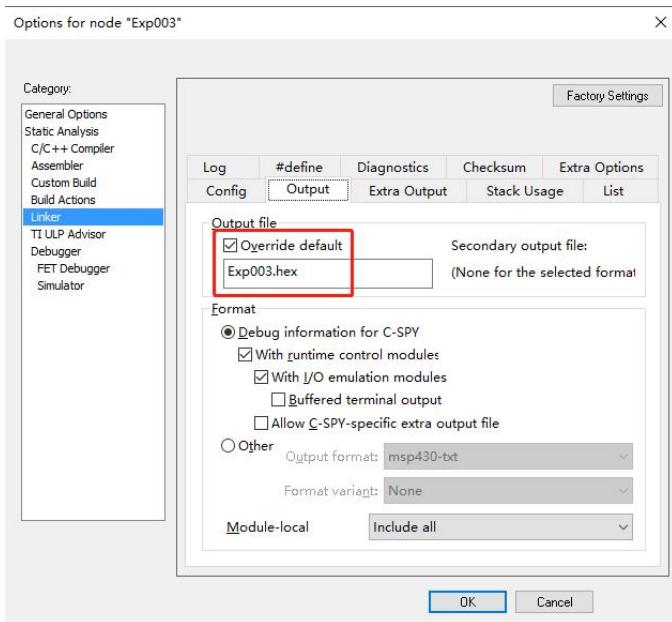


Fig. 2. IAR settings for the form hex file

B. MOOC of Single-chip Microcomputer

Previous researches show that MOOC can offer great help to promote students' self-learning. MOOC also plays an important role in assisting PBL curriculum. Especially, it can be helpful to integrate key points of knowledge, supply extra information to expand students' view, and allow them to study anywhere and anytime as they wish.

The MOOC used in this reform project is made by the teachers who used to teach the curriculum of "Single-chip Microcomputer Applied Technology". It is open to registered visitors on 'www.chaoxing.com'. This online course has 13 chapters, chapter 1-12 show the theory and principle of MSP430, and the last chapter tells how to do all the experiments with a laboratory box or circuit simulation software. In each chapter, the main content is in the form of video which is given by professional teachers. One chapter contains 3-6 lessons. Besides, a test will appear after watching the video of one lesson. There are 4-6 exercises in each test. The MOOC system can correct answers automatically and record the scores in background processing. After completing all the chapters, the system can also prepare a final examination for online test.

The system also support a series of functions for assisting teaching and learning, such as checking attendance, calculating everyday scores and exporting statistic report. Besides, the online course supplies several ways of improving teaching quality:

- Discussing area. In each lesson, there is a discussing area for students leaving messages about questions or doubts they meet when watch videos or do exercise. Both the teachers and students have rights in this area. They can answer others' questions or raise new relative questions free.

- Questionnaire. In order to control the educational quality, teachers should collect students' advice and suggestions on learning and teaching regularly. The MOOC system supplies the function of online questionnaire to help teachers make one in convenience. And it can do the statistics and show the diagram or tables directly.
- Quick answer. Teachers can set a quick answer competition with the online system, to make the class atmosphere more relaxed and positive. Before starting the quick answer, students must install the APP which connects to the online course in their smart phone. When teachers distribute the subjects on the web, the APP can receive these messages, and show them to students in real time.
- Public notice. A good MOOC should be arranged in rules, so that each activity about studying should be sent to students in time. Therefore, the system supports real-time communicating by the APP. Teachers can easily sent public notice to everyone in the same class.
- Homework. The MOOC system can also allow students do homework online. Teachers prepare the homework through the internet, and then sent homework notice to all the class. They usually set the deadline, which can stop the students from submitting out-of-date homework.

IV. EXPERIMENT

In order to compare the PBL method and the traditional teaching mode, an experiment was done in two classes of the biomedical engineering major in Shanghai University of Medicine & Health Sciences. The two classes were named class A and B. For keeping justice and getting rid of the disturbing facts, the same teacher was employed to teach the course 'Single-chip Microcomputer Applied Technology' in the same semester. PBL method was adopted in class A, while the teacher carried on the curriculum in the traditional way. The number of students in class A and B were 32 and 28 separately. Before the experiment, the average marks of the two classes were almost in the same level. The final examinations for the two were held at the same time, and they used the same paper.

The average scores of the two-class appeared significant difference. The full mark was 100, and the quality to pass was above 60. The score distributions of the two classes are shown in Fig. 3 and Fig. 4 separately. The X label is students' scores; the Y label is the students' quantity.

From the two diagrams, some interesting phenomenon can be found: (1) Students in class A performed better in high score band (80-100), the number was 18 while class B had only 12. The leading percent reached 50%. It told that PBL method could strengthen the excellent students' initiative in self-learning and supplied a better chance to find what they were interested in and gained the solutions. (2) The middle score band (60-79) of the two-class appeared almost the same state. The population rate is 13:16. The results may suggest that different teaching method had affected middle-level

students' performance in study SCM. (3) However, the quantity of students who failed examination in class A was more than that in class B. And the number of the difference was 7. It was a relatively large number. That may mean these failed students lacked enthusiasm and willingness to learn by themselves.

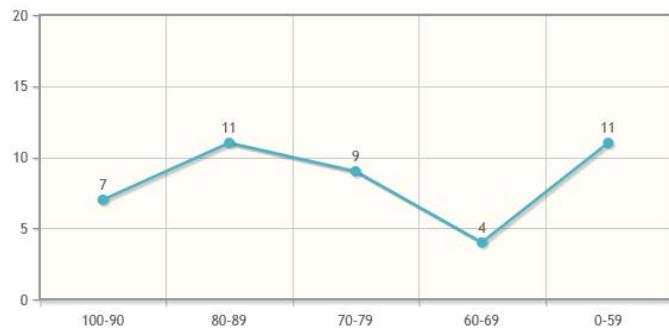


Fig. 3. Score of Class A in the PBL method

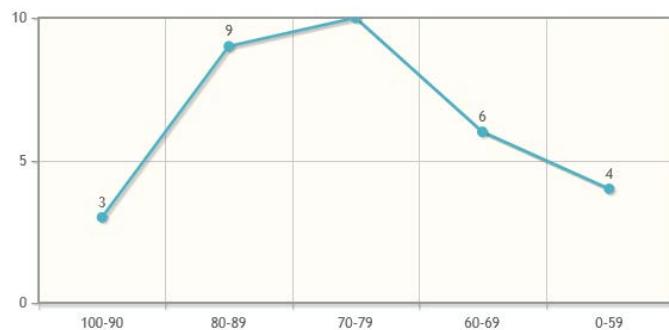


Fig. 4. Score of Class B in the traditional way

V. CONCLUSION

In this paper, a teaching reform method of the curriculum 'Single-chip Microcomputer Applied Technology' based on PBL is proposed. According to the current disadvantages of this course, such as lack of practice hours, absence of students' learning enthusiasm, the reform employed the circuit simulation software and MOOC to improve the situation. The simulation software can help students study SCM lessons wherever and whenever they want. And the MOOC can be a useful assistant to make students' self-learning more systematic. After one semester teaching experiment, we found that the new teaching mode can promote excellent and middle-level students to perform better in SCM study. But something detailed to be improved should be considered to make the students who did poorly in the exam more confident and positive to accept the PBL class.

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