

Teaching Reform of Embedded ARM System Based on Project-driven Engineering

Peng Wang, Zhigang Lv, Bin Lei, Xiang Hua, Xiaoyan Li, Xiaobin Li

*School of Electronics and Information Engineering,
Xi'an Technological University, Xi'an 710021, Shaanxi, China*

Abstract

On the basis of introducing embedded systems, the implementation process of embedded systems teaching reform and practice was finished in planning of Xi'an Technological University's outstanding talent training project. Through the analysis of the current problems in embedded teaching and characteristics of teaching, a project-driven teaching and training model for embedded systems was proposed, in which how the specific engineering project is introduced into the curriculum system and training system in an embedded system is discussed. It is proved that the project-based embedded systems driven teaching training model can effectively solve the difficulty of teaching, improve students' engineering practice ability and it can perfect the system of the embedded system teaching.

Key words: PROJECT-DRIVEN, EMBEDDED SYSTEMS, TEACHING MODEL, CURRICULUM SYSTEM

1. Introduction

With the development of teaching, embedded system, based on the 32-bit ARM microprocessor, is becoming a professional application-oriented institution of higher learning electrical engineering, from which students' comprehensive and innovative ability and employment rate are increased[1, 2]. Embedded system is an excellent carrier, which can train integrative competence of hardware and software. From the Computing Curricula 2001 of IEEE / CS, we can see that the embedded system course is one of the key disciplines of Computer Engineering course, which also takes the

hardware and software co-design as a high-level elective course[3]. The catalog of Colorado state university's embedded system certification course includes "Introduction to real-time embedded systems", "Embedded Systems Design", "Embedded Systems Engineering" and so on[4, 5].

The course has many obvious traits, such as enormous knowledge contents, high integrity, high requirements for students' practical ability, which has brought difficulties and challenges to its teaching [6]. In order to improve students' practical application ability as the goal of the project, to summarize the teaching experience and

to construct a teaching-mode to adapt social's need of embedded systems, embedded systems teaching mode must be reformed.

The embedded system course in the University of Washington, named "Introduction to Embedded System Design", basically includes the contents of the above three courses[7]. Some related major in Electronic information engineering college of Xi'an Technological University, such as automation, communications, and electronic information, has been included the "Embedded Systems Principles and Applications" in the compulsory courses scope. This paper quests the teaching reform of embedded systems teaching contents and practical teaching mode by analyzing the shortcomings of traditional teaching methods for embedded systems.

2. Characteristics of embedded system course

2.1. Key points of embedded system teaching reform

Before the implementation of outstanding talent cultivation plan of Xi'an Technological University, the embedded system teaching has the following main problems:

(1) The traditional experimental teaching method belongs to force-feeding teaching, which causes the students lack of subjective initiative. So it is difficult to meet the needs of embedded system experiments' design ability and comprehensiveness.

(2) Subject to the restrictions of training plan, the arrangement of the theory and experiment teaching is difficult to ensure universal coverage course content. Classroom theory teaching and experiment science are lack of comprehensiveness and far from experimental teaching, so that knowledge is difficult to grasp thoroughly.

(3) Theoretical education need to consolidate and improve.

2.2. Teaching characteristics of embedded systems

Embedded system is the combination of the advanced computer technology, electronic technology and other industries. Therefore, it is a technology-intensive and integration system of innovative knowledge. Embedded system teaching has the following three features:

Embedded system integrates software and hardware technology and needs co-design of hardware and software, which also involves electronics, computer, automatic control and other related professional knowledge. Embedded system teaching has a feature of comprehensiveness.

Embedded system practical-in highly needs theory integrate with practice for students to understand embedded systems courses deeply. It also helps to enhance students' innovation consciousness. Thus it can be seen that embedded systems teaching has a feature of practical.

Application is the key part in embedded system, which should integrate the engineering practical cases into teaching and promote learning practical ability. Therefore, embedded teaching system has a very strong nature of the application.

3. The knowledge system of the embedded system

3.1. The knowledge of embedded systems course

Embedded system, based on computer, is defined as a kind of special computer system, in which software and hardware can be cut out. So, embedded system can be used in some strict requirements area such as high reliability, low cost, low volume and low power consumption. Embedded system involves contents from hardware to software, which can be divided into four levels. The knowledge system of the embedded system is shown in figure 1.

(1) In hardware level, embedded system includes processor architecture design, embedded interface technology design, the hardware circuit design, PCB-board design and so on. Board Support Package BSP is corresponded to the Hardware Abstraction Layer HAL, providing operating system a unified interface.

(2) In operating system level, embedded system includes the design of embedded operating system, optimization, transplanting technology, application technology and so on.

(3) In middleware level, embedded system includes middleware and optimization technology.

(4) In application level, embedded system involves specific domain knowledge.

3.2. Teaching goals of embedded course

Embedded system course is designed to enable students to master the basic principles of embedded system software and hardware, and take the basic process of embedded system project development into practice. It focus on training the applied engineering and technical personnel who can solve problems of the field of embedded system and have the practical ability of analysis design, debugging and running.

The course in Xi'an Technological University mainly introduces the ARM7 microprocessor, whose contents include the ARM microprocessor kernel, assembly instructions and assembler programming of ARM, chip peripherals and interface technology, C language design, the embedded operating system and so on.

Embedded system course require students have the base of some prerequisite course, such as analog electronic technology, digital electronic technology, computer composition principle, microcomputer principle and interface technology, C language programming, software technology foundation and so on. The embedded system course of Xi'an Technological University mainly introduces the ARM7 microprocessor,

including the ARM microprocessor kernel, ARM assembly instruction and the assembly program design, chip peripherals and interface technology, C language design of the embedded system and embedded operating system, etc. In addition, embedded systems development also should master a variety of programming languages, which include embedded system-specific cross compiler and cross-debugging techniques.

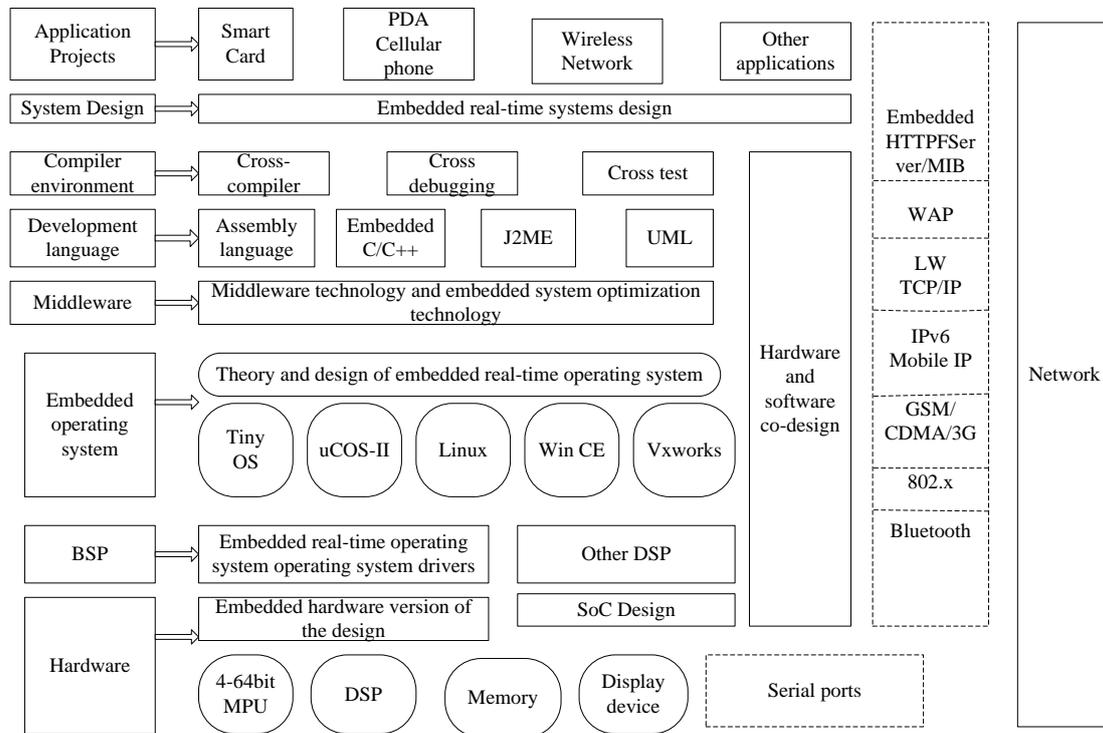


Figure 1. The knowledge system of the embedded system

4. Teaching reform methods of embedded system

4.1. Reform of project-driven teaching mode

Practice teaching is the core in the embedded system teaching and cultivating student's perfect practical ability is another key of embedded system teaching. Take typical engineering projects as the object, from which we can decomposing and extracting the theoretical knowledge and practical knowledge. Infiltrate them into the theory and practice of teaching as well. In this way, we can produce application of high-level innovative talents with solid theoretical basis and engineering practice ability. Research should focus on the following aspects:

1. The project is introduced into the course teaching in which curriculum system is arranged scientifically, from the shallow to the deep. So, integrating theory and practice can be associated together.

2. Practice content and level, based on project, is arranged scientifically from establishing a comprehensive training system, from which a gradual way to improve students' practical ability and creativity is formed.

3. Through establishing scientific embedded system teaching mode, we can apply the forefront of new technologies to the teaching theory, and narrow the distance between students and engineering applications.

4.2. Reform of project-driven teaching system

Embedded System is a very comprehensive curriculum, which covers many contents. In the traditional teaching method, practice is applied after learning theory, which makes students often in learning objective blind position. If we can introduce the projects into the teaching, the abstract theory will be transformed into the image of a practical case, which yields twice the result with half the effort.

Engineer pedagogics

Because of the practicality and applicability of embedded system course, it is very suitable for the teaching process introduced by projects.

According to the combination among the embedded system subjects, we can divide the subjects into five levels, as shown in Figure 2.

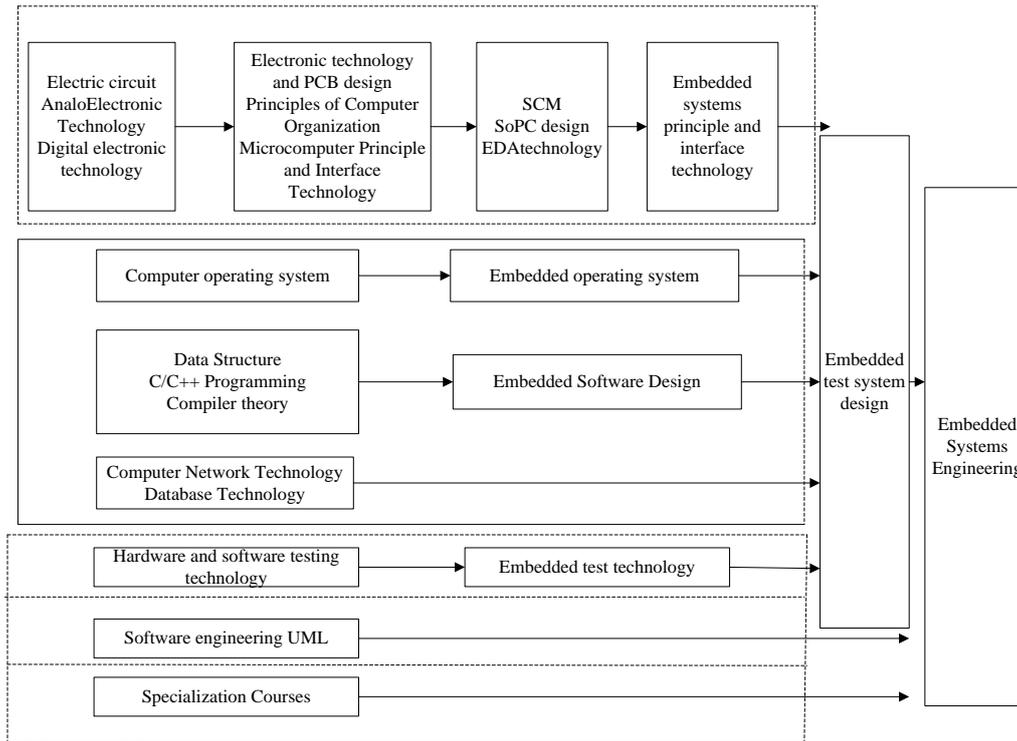


Figure 2. Background difference image

The arrows in the Figure indicate the order of the relationship among curriculums, representing that courses take each other as the foundation and have the nature of before and after the following.

1 In the hardware level, it begins from the foundation of electronic technology, and gradually goes deep into the theory involved in the embedded system hardware knowledge system.

2. In the computer software level, embedded system covers computer-related knowledge and skills, such as transition from the operating system principles to embedded operating systems, the transition from C / C ++ programming, data structures and other program design to embedded software design.

3 In test level, because it is crucial to ensure product quality, the embedded system testing programs should be set up.

4 In project management level, the development of embedded systems products is a systematic project. Therefore developers need to master the theory and tools of software engineering, UML and other engineering development.

5 In domain knowledge level, embedded system should be combined with the application field such as combing a set-top with digital

television technology and technical standards. 3G products should be combined with wireless communication technology.

This course selects some typical embedded system projects, which decomposed according to the course syllabus, after that, extracts the knowledge points covered in each project and forms the corresponding teaching cases, summarizes these items to obtain the project description and project requirements, eventually. Before the implementation of teaching, hand out the project description introduction to students, guarantee them have a general understanding of these projects in advance, and then combined with the teaching case, to explain the relevant knowledge. Finally, students can implement these projects by themselves according to project requirements, which will make the knowledge achieve mastery through a comprehensive study and improve the ability of engineering practice. As shown in Figure 3.

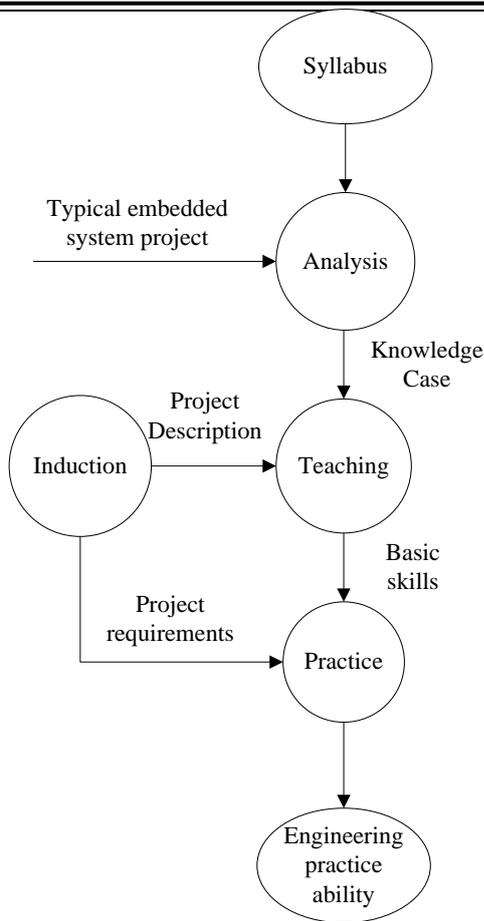


Figure 3. The sketch of project into teaching

4.3. The reform of training practice driven by engineering project

Embedded system course has a strong practicality, which is one of the most important part in the embedded system teaching. So it's necessary to study how to analyze the characteristics of the embedded system industry talent demand and development trend according to the actual demand of enterprise. On the basic of the students' mastered knowledge, that basic concepts and basic rule of the embedded system, stand out the development of engineering

application ability and build a comprehensive training system.

The system aim to enhance the students' engineering practice ability and implement the combination of multi-level, inside and outside class and around the school considering all the practice link while the students at the school , so that each segment of training form an organic system with the characteristic of mutual cohesion and gradual deepening.

The implementation of combination of multi-level is a typical embedded systems engineering projects combined with theory teaching, decomposing the function to each practice link, making the content of experiments, practice, design, and training to be an organic whole, which involved in embedded system teaching, therefore, students can complete embedded systems projects, progressively and deeply .

Take the embedded system project" The computer room environment monitoring system based on ARM" as an example, can be broken down into four levels as shown in figure 4 ,namely the theoretical teaching, curriculum experiment, curriculum design and graduation project. The final three levels involved in practice teaching, gradual deepening of each other, and the curriculum experiment laid the foundation for the latter two links; Simple information inquiry system designed on Curriculum design does not use an embedded operating system, but only integrated with some related curriculum design together, implement the spanning from basic verification experiment to the comprehensive experiments; Graduation design is based on the curriculum design of the introduction of embedded Linux operating system, and design a fully functional information query system, complete the spanning from comprehensive experiments of expansion to the research on innovative experiment. As shown in Figure 4.

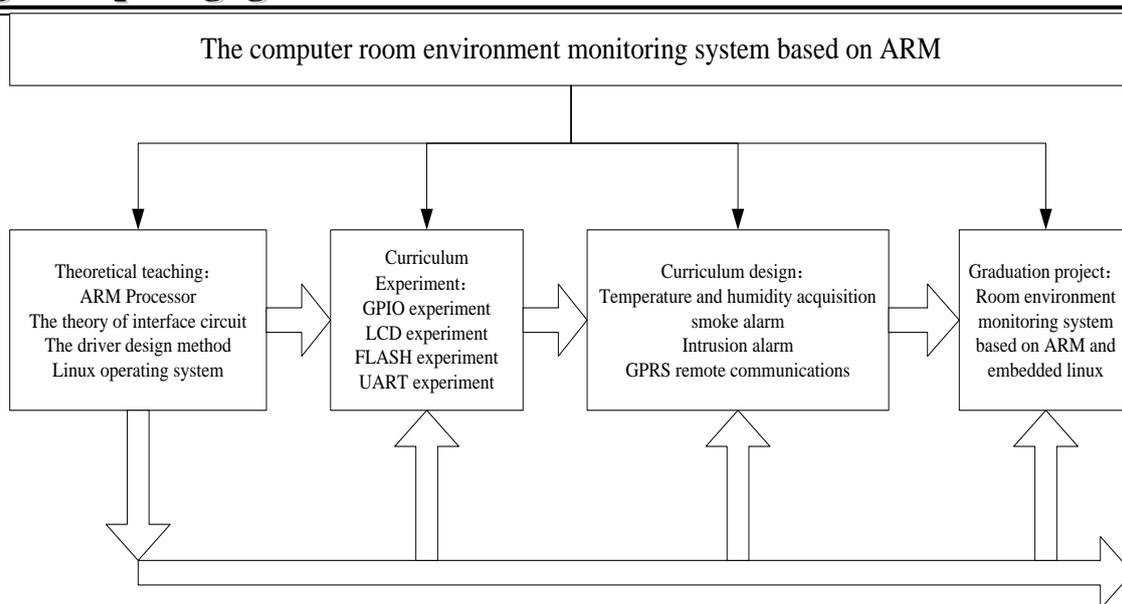


Figure 4. Examples of embedded systems project training stratified

To cultivate the students' practical ability, rely on classroom demonstration experiment and curriculum experiment, merely, is not enough. Therefore, we can adopt the way of lesson internal and external and establish open embedded system laboratory and innovation lab, etc, providing students with extracurricular practice platform, to supplement the shortage of the in-class experiment lesson.

And also can encourage students to build a project team according to their interest, then each group will have a relatively simple embedded system test board, purchased or provided by the school, and have after-school training with teachers' regularly guidance.

5. Conclusions

With the rapid development of the theory and technology of embedded system, teaching teams are guided under outstanding talent training plan in Xi'an Technological University to carry out teaching pattern reform and practice of the embedded system. In the end, the experiences of teaching reform are got in an all-round way. From the teaching practice, project, as the center of the embedded system teaching model, can effectively shorten the distance between the students and the practical application in engineering. It can cultivate students' ability of independent thinking and innovation research. In order to achieve the desired effect in implementing this model, teaching staff should have comprehensive ability, especially the high practice ability. We should establish the mechanism of teachers' practical ability to improve embedded system and update their knowledge system constantly. Therefore, it

can make embedded teaching system develop into a new level.

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