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# Course Construction and Practice of Embedded Computing for New Engineering Education

Dongxin Wen[1, a], Hongwei Liu[1, b], Yanjun Shu[1, c] and Danyan Luo[1, d]

[1]School of Computer Science, Harbin Institute of Technology, China

[a] wdongxin@hit.edu.cn. [b] Liuhw@hit.edu.cn, [c] yjshu@hit.edu.cn, [d] luody@hit.edu.cn

**Abstract.** Facing the reform and development of the New Engineering Education, the paper combines the Embedded Computing course construction and practice. The course of Embedded Computing is an elective course for postgraduates majoring in Computer Science in Harbin University of technology. Under the guidance of the education direction for Emerging Engineering Education, it must be strengthened the construction and practice of the course. This paper combines the traditional teaching mode with the online teaching mode, the theoretical content driven by problems with DIY practice, and adopts a diversified evaluation system. Through the curriculum reforms, the students' learning enthusiasm has been actively mobilized, and the teaching quality has been significantly improved. This paper can provide reference for reform of talent training in our teaching courses.

**Keywords:** New Engineering Education; Embedded Computing Course; Online Resources; Problem Driven; DIY Practice; Diversified Evaluation System.

## 1. Introduction

In February 2017, the Ministry of Education issued a notice on the research and practice of "New Engineering" by the Higher Education Department of the Ministry of Education. The notice clarified the basic connotation of "New Engineering", namely the new concept of engineering education, the new structure of disciplines and majors, the new model of talent cultivation, the new quality of education and teaching, and the new system of classified development [1]. New Engineering is a direction for the reform of engineering education in universities. It is based on national strategic development and international competitive situation. The first-class engineering talents from this cultivation meet the needs of the new era. It is an exploration that promotes the reform of higher education system. At the 2020 New Engineering Further Deepening Seminar, the “Π plan” in Harbin Institute of Technology for New Engineering was announced. The plan pointed out that higher engineering education emphasizes the cultivation of elite talents with broad knowledge, multiple abilities, and good comprehensive qualities [2]. It not only requires students to have in-depth professional knowledge and abilities, but also requires them to have various engineering abilities, including expression ability, practical ability, communication ability, organizational and management abilities, etc. “Π-type" talent is a composite leading talent with relevant industry knowledge and experience. They have both professional knowledge and industrial experience.

The course "Embedded Computing Technology" starts from the overall system. It discusses the design methods and technologies of modern embedded computing systems. The course describes the problems that need to be solved in design based on the quantitative goals of performance, power, energy consumption, and cost. This course is an important theoretical course in chip design. This course analyzes different embedded architectures through a large number of embedded examples. It discusses various advanced technologies in the field of embedded computing. It provides a detailed introduction to the design techniques and methods of embedded systems such as embedded network communication, reconfigurable systems, software-hardware collaborative design, security, and program analysis.

Currently, the teaching content of our courses generally exists as follows problem. The teaching content failed to reflect the latest developments, lack of examples based on real-life problems, and limited use of modern information. The achievements brought about by technological development have not been well reflected in the teaching content [3]. To change this situation, we apply for the task of cultivating talents in our teaching by experienced teachers.

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The team members of this project have been engaged in professional teaching and research for a long time. They own rich professional knowledge and comprehensive course content. They can provide sufficient guidance on course construction in the project. The team members of this project have strong engineering abilities. They are able to help students to solve problem in practice by combining their own learning experience. The members have the ability to integrate educational information resources on online education platforms. They deploy of the platform rapidly and provide strong technical support in teaching modes. The laboratory can also provide a practical environment and equipment for the research of this project.

## 2. Course Construction for New Engineering

Facing the reform and development of the new industry, higher education should timely adjust talent cultivation strategies, optimize curriculum systems, and reform talent cultivation modes based on the needs of talent cultivation in new engineering disciplines [4].

### 2.1 Cultivation of interdisciplinary comprehensive quality talents

The new engineering education emphasizes the integration of knowledge, skills, and methods from different disciplines. It is the goal of cultivating students' comprehensive qualities. Embedded systems have been widely applied in various fields, such as the Internet of Things, automobiles, medical equipment, industrial control, etc. The embedded computing technology course is a technology and system that applies computer science and engineering knowledge to hardware systems. This course combines the disciplines of electronic information, automation, and computer science for interdisciplinary course construction.

### 2.2 Importance of the practical abilities

New Engineering emphasizes the cultivation of students' practical abilities in curriculum education. A student-centered approach to cultivate independent practice among students are provided [5]. Embedded computing technology is a highly practical course with a certain theoretical foundation. It is necessary to participate in hands-on practical activities. A practical environment is provided to set up practical activities in the course. It combines theory with practice to strengthen the cultivation of students' practical abilities. Students' ability of independently think and solve problems can be improved in the practical process.

### 2.3 Importance of the innovation ability

In order to adapt to the development of society, New Engineering emphasizes the cultivation of students' innovative abilities. Under the background of new engineering, according to the characteristics of engineering college students, we should cultivate high-level engineering talents with innovative practice ability to meet the needs of enterprises [6]. The research on the cultivation of innovation and entrepreneurship ability among college students in project-based teaching aims to improve the engineering practice ability of applied postgraduate programs [7]. Innovation is the driving force behind human development and technological progress. In the practical process of embedded computing technology courses, attention should be paid to cultivating students' innovative abilities. The course teaching can encourage them to be good at using different methods to solve problems, bravely trying, questioning. Students must take responsibility, think carefully about problems and analyze results.

### 2.4 Development of personalized education

In the context of new engineering disciplines, it is required that talent cultivation in higher engineering education should develop in a diversified direction [8]. New Engineering emphasizes the development of personalized education. It allows every student to find the areas of their interest and to achieve education that fully develops their personality. In the assessment of learning abilities, teaching modes, program design, different tasks are assigned in the course based on students' interests and their abilities. Discussion sessions are arranged to give students time and space to express their personal opinions.

# 3. Course Practice for New Engineering

The course practice can form a cognitive system that integrates knowledge thinking, theoretical practice, and ability literacy for engineering students [9]. It integrates various teaching methods such as online and offline integration, problem driven learning, etc.

## 3.1 Course Teaching Class Groups Established

The teaching class group is the basic unit of course learning. This course fully utilizes the powerful functions of QQ groups to assist teaching, including teachers uploading PPT courseware, electronic teaching materials. Students can sign in, communicate and interact on QQ platform. The electronic materials include integrated knowledge expansion from multiple disciplines and diverse teaching activities. That can link various disciplines together.

## 3.2 Problems-driven of Teaching Content Designed

In the context of the new engineering discipline, curriculum introduction is carried out through interdisciplinary teaching content. It guides students to think, cooperate and explore. Good problems-driven are comprehensiveness, openness and hierarchy. This mode can promote thinking development through guiding questions. The design and application problem-driven can adapt to the cultivation of students' comprehensive abilities and the development of personalized education in the new engineering field.

## 3.3 Application of online teaching platforms

Digitalization is a catalyst for the ideal transformation of higher education [10]. On-Line learning environment survey also suggests that students' actual experience on-line exceeds their preferred classroom environment in terms of students' reflective thinking, interactivity and peer support [11]. An online teaching platform for the course is used to meet various teaching needs. Following exploration and operational process, the platform provides teaching assistants for teachers and students. The platform includes homework， tutoring learning， teaching videos, questions and answers. It can also provide online face-to-face education mode for teachers and students.

## 3.4 DIY Course Practice

New engineering education emphasizes the cultivation of practical abilities. The improvement of students' hands-on ability is crucial for their future development. The course teaching is mainly based on the project model. In order to ensure the successful implementation of the project teaching through the study of teachers' guidance and the combination of online and offline, the goal of talent training is guaranteed [12]. DIY is a good practical education mode to provide opportunities for students to learn and practice independently. At DIY students' problem-solving abilities can be improved, and their innovative thinking can be stimulated. Course practice should be based on tasks, topics, and projects to achieve tasks driven approaches. The valuable task is closely related to subject knowledge in social life. The tasks are a treasure trove of materials for subject practical issues, as well as the design origin of subject practical teaching. Students can choose the task which one they like to do.

## 3.5 Diversified assessment and evaluation

The current construction of the new economy and the rapid development of "new engineering" urgently require composite talents with teamwork ability [13]. To meet the training mode, diversified assessment and evaluation combines comprehensive abilities and personalization of students in the new engineering background. It can evaluate the learning effectiveness of students from different perspectives fairly. Diversified assessment and evaluation can use professional skill evaluation tools to evaluate the level of individual abilities in project team work.

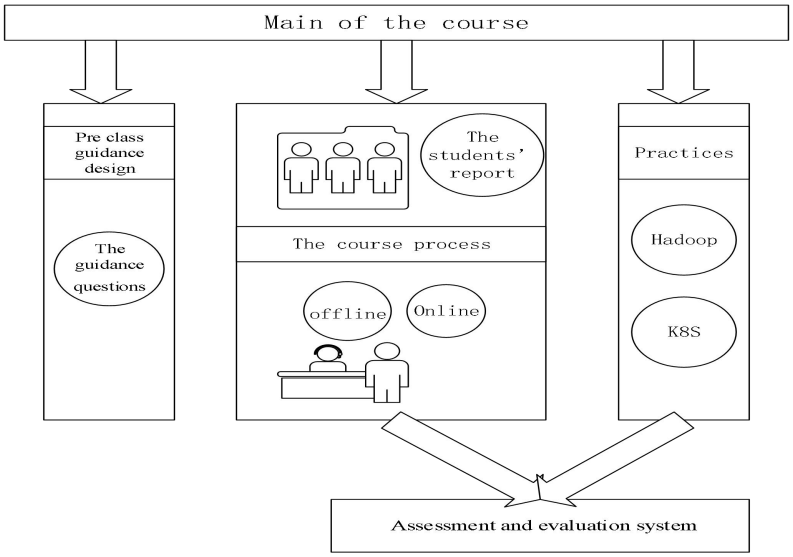


Fig. 1 Course Construction and Practice

The construction and practice of this course include the following aspects: course content construction; design of course teaching form; assessment and evaluation system. The course content includes three parts: pre class guidance, in class content, and post class practice. The teacher's teaching of in-class content is divided into two modes: online and offline. The assessment and evaluation adopts a diversified cumulative scoring form. The course construction and practice content is shown in Figure 1 [14].

## 4. "Embedded Computing Technology" Course Construction and Practice

### 4.1 Pre class guidance designed

The course adopts problem-driven pre-class guidance and forms a complete knowledge system through modular learning, as shown in Table 1.

### 4.2 Course Content Designed

1) Modular theoretical system

This course modularizes the teaching content and links it with relevant professional basic courses. So it is easy for students to learn themselves in weak areas.

Table 1 Problems-driven designed

| Preview questions | Introduce content （Key technologies） |
|---|---|
| What are the embedded systems you are familiar with; What are its characteristics; | Embedded computing |
| List the functions and types of processors that you are familiar with; | Microprocessor |
| What are the challenges of comparing embedded programming with general-purpose programming technology; | Embedded programming design |
| The difference between real-time operating systems and general-purpose operating systems; | Processes and operating systems |
| What is the purpose of introducing multiprocessor technology; | Multiprocessor architecture |
| How to design software on a multiprocessor system;； | Multiprocessor software |
| What are the differences between collaborative design and general computer layered abstract design. | Software/Hardware Collaborative Design |

2) Application of teaching content

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This course is not limited to specific textbooks. In order to expand the scope of student reading and realize the number of application examples, literature, the technology is involved and combined in the course.

3) Diversified teaching forms

This course introduces application demonstrations, problem scenarios, case-based teaching, and modular methods in classroom teaching. This enriches teaching formats and expands student thinking. Simultaneously adopting a combination of online and offline teaching modes, activities and questions about the course can be organized and answered at any time.

4) Engineering of teaching issues

In this course, engineering tasks are added. The tasks combine with Hadoop, a distributed software framework that excels in parallel processing. That can cultivate students' ability to choose optimization applications to solve problems in different distributed scenarios. Students do some practice on the Kubernetes—open source software project container orchestration platform. Containerization is automatically completed in deployment, management, and expansion.

5) Diversified teaching assessment

This course establishes a fair and objective evaluation system from the perspectives of student personalization and curriculum diversification. Talent evaluation is conducted through assessments of both theoretical level and engineering ability.

6) Comprehensive student training

This course aims to create opportunities for students, provide a communication platform. It can improve students’ practical activities through these engineering tasks and enhance the cultivation of students' all-round abilities through group activities.

### 4.3 Practice designed after class

The new engineering discipline not only requires students to have in-depth professional knowledge and abilities, but also requires them to possess various engineering related abilities. In order to improve students' practical abilities, the course has set project-based experimental questions in the practical stage including algorithm questions and system questions. For example, to design and implement typical software-hardware collaborative synthesis algorithms, a simple attendance machine system based on Raspberry Pi are suitable topic selection.

### 4.4 Construction of Course Teaching Forms

In recent years, the Ministry of Education has called for the vigorous development of online education. In order to better seize opportunities and innovate on diverse online platforms, the course adopts a teaching form that integrates online education with traditional education.

1) QQ group for teaching classes

The electronic teaching materials such as PPT courseware and explanations can be uploaded. Online tutoring, communication and interaction can be conducted in QQ group.

2) Preparation of teaching resources

The teaching resources include electronic textbooks, course introductions, electronic courseware, and teaching designs, etc. In teaching design, it corresponds to the problems to be solved in each lecture and a list of related content. It also provides a certain number of valuable references to achieve the teaching goal of combining basic standards with optimal standards.

3) Two teaching methods for online teaching: live and recorded

The group classroom and Tencent Meeting in QQ can serve as teaching software for live teaching on line. The group classroom function in QQ is specifically designed to optimize remote teaching services. Tencent Meeting can also be used for remote audio and video conferences. Online document collaboration, screen sharing, and other activities can be completed with various stages of the class. In order to avoid network failures and congestion, the Chaoxing teaching software can be used to conduct classroom teaching activities in the form of recorded broadcasts to ensure normal teaching progress. Micro videos of courses can be watched repeatedly. This is meaningful and easier for students to learn at any time.

### 4.5 Construction of assessment and evaluation system

The final grade of the course is composed：attendance score，peer evaluation score，PPT report and practical reports. Among them, attendance assessment accounts for 15%, peer evaluation accounts for 5%, PPT report accounts for 50%, and submitting practical report accounts for 30%. The mutual evaluation in the assessment is the score of each student's PPT learning report, which is an objective evaluation of the contribution of student participation in group activities.

In the construction and practice of the "Embedded Computing Technology" course with the strategy of cultivating talents in the new engineering, we adhere to the design of teaching centered on student as the purpose. Autonomous learning is the fundamental way to acquire and update knowledge, and it is also a basic quality of an individual. The role of teachers is important factor that affects the effectiveness of large-scale education. Teachers should become guides for learning, integrators of resources, listeners of emotions, and judges of grades. The teachers should respect the differences of students and provide space for their individual development by establishing flexible and diverse evaluation criteria.

The course construction and practice adhere to the concept of cultivating diversified and innovative outstanding engineering and technology talents. They provide strong talent support for the industrial development in China and international competition.

## 5. Course Construction and Practical Achievement

In the context of the new engineering discipline, combined with the characteristics of Harbin Institute of Technology, new methods and ideas have been proposed. More leading talents with professional knowledge and experience are emerging in engineering colleges. So we must strengthen curriculum construction, reform education modes, strengthen practical links, rebuild a fair evaluation system.

1) Online and offline, integrated teaching:

In recent years, the Ministry of Education has called for the vigorous development of online education. We have seized opportunities, and bravely explored and innovated on diverse online platforms;

2) Student presentations, exciting and diverse:

The teaching content has added a student presentation section to improve students' expression, communication, and organizational skills;

3) Hands on practice, practical experience strengthened:

The new engineering discipline not only requires students to have in-depth professional knowledge and abilities, but also requires them to possess various engineering related abilities;

4) Fairness and impartiality, assessment and evaluation:

The teachers have established a fair and objective evaluation system for the perspectives of student personalization and curriculum diversification.

5) Teaching research report:

In this report we state a summary of teaching experience in this semester, a summary of student practical achievements, and an analysis of student feedback information;

6) Shared digital resources:

Electronic textbooks, electronic courseware, instructional design, and other resources;

7) Subject competitions

We have organized subject competitions several times, such as student design competition.

8) Management system designed

In the course DIY practice, students have designed and implemented a facial recognition based management system [15] [16]. The management system is divided into two parts: front-end and back-end. The front-end includes interface and information display. The backend is divided into a facial recognition module for identity recognition, a database module for stored information, and a system security design module. After further testing and improvement, this system has been applied as an access control system to various units and it has great practical value.

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The evaluation of the embedded computing technology course was excellent in the 2023 spring semester, with a student satisfaction rate of 100%.

## 6. Summary

The construction and practice of embedded computing technology course under the new engineering discipline is an educational project based on national strategic development and international competitive situation. It is a reform project of university engineering education proposed to cultivate first-class engineering talents that meet the needs of the new era. It is an exploration and attempt to comprehensively promote the reform of the higher education system. In the field of the construction and practice of embedded computing technology course research, students can possess in-depth professional knowledge and abilities. They can become composite leading talents with various engineering related abilities. Through the curriculum reforms, the students' learning enthusiasm has been actively mobilized, and the teaching quality has been significantly improved. This can provide reference for talent training in our teaching courses.

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