

## The SE-CDIO Based Chinese National Excellent Course Construction Experience of “Software Engineering” Course

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**Abstract.** This essay summarizes the experience of constructing “Software Engineering” course in Yunnan University into “Chinese National Excellent Course”, “National Excellent Resource Sharing Course” and “Resource Sharing Course in Chinese University” presented by our team based on SE-CDIO and gives the ideas and methods to construct the course.

### Introduction

SE-CDIO Talent Education Model <sup>[1]</sup> was proposed by Professor Li Tong, the leader of our education team. It has begun to practice in School of Software, Yunnan University since 2007. It combines the general principles of CDIO <sup>[2]</sup>, the specific national conditions of China and the characteristics of software engineering talent training with the software life cycle closely. Therefore, the new software engineering education model has been put forward. SE-CDIO realizes the organic combination of CDIO and software life cycle. In SE-CDIO, “SE” is the abbreviation of “Software Engineering”, “C” is “CONCEIVE software requirement”, “D” is “Software DESIGN”, “I” is “Software IMPLEMENT and testing” and “O” means “Software OPERATION + Industrialization + Marketing”, so that students can experience the whole procedure of theory, technology, production and application. <sup>[3-4]</sup>

Software Engineering is a discipline that develops large-scale software systems under the guidance of Engineering theories, principles, methods and techniques, and occupies a central position in the field of computer software. “Software Engineering” course is one of the core curriculums for senior computer majors in Yunnan University, which takes up a lot in computer majors. However, due to the strong abstraction and application of Software Engineering itself, there are many problems in the process of teaching and learning, resulting in unsatisfactory teaching effect. Therefore, how to improve the teaching level and quality of “Software Engineering” course is a topic widely discussed by many scholars at home and abroad. <sup>[5-8]</sup>

Over the years, our education team has been engaged in teaching and research related to “Software Engineering”. Specifically, the undertaken courses include “Software Engineering”, “Advanced Software Engineering”, “Software Engineering Methodology”, “Software Process”, “Software System Modeling and Design”, “Software Component Technology”, “Design Mode”, “Software Project Management”, “Software Testing Technology”, “Business Process Modeling” and “Requirement Engineering”.

Excellent course construction is a systematic project of a series of work, such as teaching content, methods, teacher and student training, and related policies. Excellent courses need to learn the advanced mode of education at home and abroad, and in the face of Chinese environment, make ourselves and our students understand the ability to solve practical problems.

In accordance with the requirements of personnel training of China National Demonstrative Software Institute, and combining SE-CDIO, our team has carried out deep-seated reform and

innovation on the course of “Software Engineering”. Through some means such as case teaching, heuristic teaching, research teaching, bilingual teaching, practical teaching, examination reform, the course has been constructed as an excellent course. With our efforts, the course has been awarded “Chinese National Excellent Course”, “National Excellent Resource Sharing Course” and “Resource Sharing Course in Chinese University” by the Ministry of Education of China.

## **Establish SE-CDIO Talent Training Mode to Combine Production, Teaching and Research Substantially and Highlight the Engineering Properties of Talent Training**

### **Defining the Training Objectives of Courses**

Guided by the general goal of training software engineering talent which is “Following the market demand, to train high-level, practical, compound and internationalized software engineers with international competitiveness” and carrying out the concept of “enhancing theoretical basis, emphasizing practical ability, stimulating innovative spirit and cultivating comprehensive quality”, the course has gradually got the idea of talent training into shape with years of education experience. It clearly puts forward that the way to construct double-qualified teachers and train software engineers with international competitiveness is to establish a talent training mode based on SE-CDIO, reform all-round education and use the teaching and practice model of “learning by doing”. It also establishes a hierarchical teaching system consisting of two core parts: theory and practice.

### **Reforming the Model of Talent Training**

Our team uses SE-CDIO Talent Education Model as guidance to integrate the basic concepts of SE-CDIO into the whole process of curriculum teaching and talent training, which comprehensively reflects the four keys of conception, design, implementation and operation. Through case teaching, discussion teaching, research teaching, bilingual teaching, practical teaching, examination reform and other means, the students are divided into teams to complete the research and development (R&D) a small project and put it into operation (some are simulated), so that students can learn by doing and learn in practice. The training of theoretical knowledge and practical ability is organically integrated to meet the requirements of SE-CDIO talent education objectives. R&D content should be organized according to relevant standards of software engineering to ensure better connection with industry and international and provide a solid foundation for students to face industry directly. In the whole process of talent cultivation, the principal position for students is fully embodied, and leading position for teachers is brought into full play. In this way, the educational concept of “student-centered, teacher-led” has been effectively implemented.

### **Innovating Practice Teaching Model**

The practical teaching of this course is divided into experiment in each chapter and SE-CDIO practice. SE-CDIO practice involves conceptual practice, designing practice, implemental practice and operational practice with basic form is to establish a project group. Each group is composed of 4-10 students, who can experience the roles of software engineering and the stages in software life cycle through actual project practice, master the mainstream development environment and tools, analyzing requirements, software architecture design, database design, interface design, algorithm design, code implementation, testing and put into operation. Students are demanded to develop according to user requirements and encouraged to innovate their thinking and choose the development process and tools independently. Teachers can simulate the actual working environment and constantly change the requirements during the development process, so that students can comprehend the concepts of iterative development, extreme programming, software refactoring and so on, use Object-oriented method to model, design and test the system to improve its usability, extendibility and maintainability. Eventually, the students are required to submit the software system which can be practically operated and the software documents which conform to the specifications, and make public dissertation. All the documents must be compiled in accordance with Chinese national standard “GB/T 8567-2006 Specification for Computer Software Documentation”.

## **Regarding the Integration of Production, Teaching and Research**

Our team has created a substantial relationship of combination between industry, teaching and research with the school-affiliated enterprise “Kunming Huaruan Information Engineering Co., Ltd.” as a platform for implementing SE-CDIO operation part (i.e. O). For the course, our team comes up with the idea that enterprise is the second classroom of the school and school is the human resource bank and pretreatment workshop of the enterprise. According to the needs of the enterprise, talent training should be people-oriented and personalized, and should be actualized by deepening the cooperation between the school and enterprise, improving the quality and level of practical teaching. Kunming Huaruan Information Engineering company provides students with a large number of practical projects matching the course content, opens the channels for application and marketing, realizes the real combination of production, teaching and research, and practices the concept of “learning by doing”.

In addition to the school-affiliated enterprise, we have also established 45 internship bases for domestic enterprises. 3 bases are in foreign places (1 in the United States and 2 in Japan); about 20 of them have served this course. “C” (conception) part and “D” (design) part should be finished in school. “I” (implementation) part is mainly done in school depend on the opinions in the enterprise, “O” (Operation) part mostly in enterprises (part of the operations which are simulated will be done in school). This forms a complete SE-CDIO talent training mode.

## **Use Original Textbooks and Teach Bilingually**

In order to cultivate internationally competitive software talents, improve students’ ability of international communication and impart the latest foreign technology to students so as to ensure that the teaching level is in step with the development level of international software engineering technology, our team has adopted the book *Software Engineering* edited by Professor Ian Sommerville, an eminent British software engineering expert, as the original textbook since 2002, and set a bilingual course. In addition, the course uses the technological information of well-known universities and companies abroad, and gives foreign R&D cases to make students understand the development of international new technologies.

## **Attach Great Importance to the Construction of Textbooks and Publish Original Textbooks in World-class Publishing Houses**

(1) The latest scientific research achievements obtained under the support of the Chinese National Natural Science Foundation have been compiled into an English academic monograph, *An Approach to Modelling Software Evolution Processes*, published by Springer, a world-class academic publishing house, and used in undergraduate education. This is the first academic monograph systematically discussing the software evolution process in the world, which has an important impact on the research and teaching of software engineering and has attracted extensive attention of relevant scholars at both home and abroad.

(2) The domestic edition of the monograph mentioned above was published by Tsinghua University Press in August 2008. It has been used as a reference book for the course “Software Engineering” in Software Process part, which gives the latest scientific research achievements directly access to undergraduate education.

(3) The textbooks *An Introduction to Software Engineering* and *Operating System—The CDIO Approach* were published by Science Press in February 2012. They have been used as reference books for software engineering and operating system courses in many universities in China.

(4) The academic monograph *Concurrent Development Process of Software* was published by Science Press in August 2003. It was considered by reviewers as “the first academic monograph in China to discuss the concurrent development of software” and has been used as a reference book for the course of “Software Engineering”.

(5) The textbook *Operating System Analysis and Design*, published by Yunnan University Press,

won the Yunnan Provincial Excellent Textbook Award in May 2002. It provides Unix operating system kernel analysis as a case to implement case teaching.

(6) The textbook *Java—The Object-Oriented Programming Language* was published by Yunnan University Press in August 1997. It has been used as a reference book for Java programming in practice under SE-CDIO.

(7) The textbook *Computer Professional English: Practical Document Writing* was published by Tsinghua University Press in January 2009. It provides practical English documents related to software engineering and has been used as a reference book for document writing under SE-CDIO.

### **Innovate the Examination by Drawing on the Assessment Methods of First-class Foreign Engineering Universities**

The examination should be reformed boldly and discreetly by drawing lessons from the assessment methods of the first-class engineering universities in foreign countries. Our “Software Engineering” course uses the method of combining project practice with closed-book examination to evaluate students’ engineering level and ability objectively, promote the improvement of students’ professional quality and practical ability and overcomes the drawbacks of traditional examination which emphasizes papers but neglects abilities.

The proportion of the final grade is as follows.

(1) Homework (non-experimental traditional homework) and classroom performance accounted for 10%.

(2) Mid-term closed-book examinations accounted for 20%.

(3) Practical achievements accounted for 70% (20% in experiments and 50% in SE-CDIO practice).

The specific scoring ratio of SE-CDIO practice (also known as large assignments) is (calculated by 100 points): C (20%), D (20%), I (20%), O (20%), word expression and document (10%), report quality and oral presentation ability (10%).

### **Create Abundant Stereo Teaching Resources, Build a Virtual Environment for Laboratory and Curriculum**

As early as twenty years ago, our team began to develop computer-aided teaching system. In 1996, multimedia teaching system OSCAI and electronic wallchart system OSCEF was developed to implement multimedia teaching. The separation of teaching and examination was realized by using automatic question-setting system. With the advancement of technology, since 2002, our team has re-developed a new computer-aided teaching system with new technologies. We collected, collated and self-made a number of Internet teaching resources with independent intellectual property rights and applied them in teaching, forming abundant stereo teaching resources which makes a complete system, rich diversity and virtual laboratory. The system conforms to 4 “no boundary”: no time boundary for independent learning of students, no space boundary for communication between teachers and students, no classroom and laboratory boundary for homework and experiments, and no campus boundary for research results sharing.

Our team has developed several course websites and related computer-aided multimedia teaching systems based on Internet. The websites for both undergraduate “Software Engineering” and graduate “Advanced Software Engineering” course are a sisterhood, providing students with a broader space for learning and communication. On the e-learning platform of Yunnan University, the sharing resources of excellent courses have been built. The website of the resources are listed below:

Undergraduate “Software Engineering” course:

<http://elearning.ynu.edu.cn/eol/jpk/course/layout/page/index.jsp?courseId=1255>

Graduate “Advanced Software Engineering” course:

<http://elearning.ynu.edu.cn/eol/jpk/course/layout/page/index.jsp?courseId=1860>

In 2007, this course became a provincial excellent course in Yunnan Province.

In June 2010, this course was awarded “National Excellent Course - Software Engineering” (High Edu. Department Document [2010] No. 14). Then in May 2013, awarded “Resource Sharing Course in Chinese University - Software Engineering” in Chinese National Teaching Quality Project (High Edu. Department Document [2013] No. 26). And in October 2013, awarded “Chinese National Excellent Resource Sharing Course - Software Engineering” in Chinese National Teaching Quality Project (High Edu. Department Document [2013] No. 115). Course website:

[http://www.icourses.cn/sCourse/course\\_4381.html](http://www.icourses.cn/sCourse/course_4381.html)

In 2012, this course constructed the sharing resources of Software Engineering provincial excellent resource sharing course on the platform of Yunnan University Teaching Resources and E-learning Center. The website:

<http://www.ynce.net/jpkc/Default.aspx?ID=179>

The teaching website mainly consists of multimedia teaching service area, virtual discussion room, software engineering resource service area and retrieval system. The concept renewal promotes the development of digital teaching system and achieves the transformation of the relationship between teaching and learning. It transforms one-way “teaching and learning” into multi-way interactive and autonomous teaching and practice, which makes learning space for students expand rapidly and changes the limitations of students’ relying solely on teachers to acquire knowledge in the past. In the “course discussion area”, students can ask questions, comment on the lecture content, talk about learning experience and consult with teachers about difficulties; teachers can respond to discussions from students in a timely manner. Online students can also carry out discussions with each other, publish exercises, and even can upload homework or experimental reports and express their opinions through the website. Under the new teaching mode, teachers are no longer simple “teachers” who teach their own views, but also "guides" who help students acquire knowledge and conduct research from various aspects. Linear knowledge teaching has become a tridimensional and multidirectional learning practice, which makes the gradual transition from simple teaching to interactive discussion come true. By using multimedia and e-teaching, the abstract teaching content becomes more vivid and the teaching effect is efficiently improved.

### **Enhance Practice Part, Strengthen Practice Teaching**

Our practice teaching is divided into two parts: experiment for each chapter and SE-CDIO practice. The experiments are mainly validation experiments, focusing on solving the problem of theoretical knowledge mastery; relying on cases and a small number of comprehensive experiments and designing experiments to solve the transition from experiment to development.

SE-CDIO practice carries out research and development of Engineering projects, focusing on solving development and engineering problems. It consists of three intersectional training units, namely engineering teaching, engineering practice and enterprise cooperation. Engineering teaching focuses on teachers’ teaching and guidance to students; engineering practice focuses on students’ hands-on work; enterprise cooperation focuses on enterprises’ participation in teaching and guidance to students, and experience of students in enterprises. SE-CDIO practice constitutes a practice mode with “conception—designing—implementation—operation” as the main line, gradually cultivating ability of integrating theory with practice, development, engineering and innovation for students.

In SE-CDIO practice, 20 projects have been set up for students to choose. Our team introduced the latest technology of industry into the course, including the latest technology such as “Concurrent Software Architecture Design”, “Software System Development Based on Multi-Core”, which ensured that the teaching content could keep pace with the international advanced technology.

### **Implement Research-oriented Teaching to Make Research Promote Teaching**

Our team has been engaged in research in the direction of “software engineering” for a long time. There are more than 20 scientific research projects at or above the provincial level which are

conducted by the author and implemented by us. In addition, we have categorized the scientific research results based on their contents as topics for discussion in or after class to encourage students to question the existing results and provide students with the remaining questions for further research. In this way, the research achievements can be reflected and be brought into undergraduate teaching so that the understanding of students to the course can be deepened; using practice to condense research project, the research-oriented teaching ideas have been practiced, so that students can greatly improve their research ability, practical ability and knowledge field.

### **Implement Case Teaching to Enrich Teaching Content and Mobilize Learning Enthusiasm of the Students**

The traditional teaching mode mainly teaches theoretical knowledge, and students are lack of perceptual and practical comprehension to the knowledge. In order to solve this problem, our team has organized several research projects and projects of Kunming Huaruan Information Engineering Co., Ltd. as cases, collected some classical teaching cases from abroad and provided them to students as learning materials to implement case teaching. Some cases are explained by teacher in class, and others are submitted to students for analysis and discussion. The teacher can raise some questions for students to discuss whether the project is successful or not, what aspects it conforms to the idea of software engineering, what aspects it violates the basic principles of software engineering, how to improve and so on, and give their own opinions about solutions, which can mobilize enthusiasm of the students in learning and enrich the teaching content.

After years of efforts, we have built a case base with a certain scale, including software evolution process supporting tools, general security supporting platform, CASE system for parallel software development, PKI network information security software system based on secure operating system, Linux application software development tools, game software, waste management and tracking system, rescue service system, air traffic control system. With it, a solid foundation for further practicing SE-CDIO talent training mode has been laid.

### **Implement Discussion-based Teaching to Establish a Smooth Communication Mechanism between Teachers and Students, and Strengthen Teaching Interaction**

By means of oral presentation, oral defense, teacher comment and network communication, students can have a speech, comment, discussion and teachers give summary, which can offer more opportunities for students to use their brain and mouth, guide them to think deeply, cultivate their abilities of communication, presentation, innovation and team spirit, and bring their subjective initiative into full play.

### **Conclusion**

The practice of “Software Engineering” course teaching based on SE-CDIO in our college shows that this teaching method can stimulate learning enthusiasm, broaden innovative thinking, train professional ability, cooperation ability and perseverance in solving problems, and cultivate self-confidence and sense of responsibility for students. Meanwhile, it also promotes the teaching research and team building for teachers, and substantially improves the overall teaching quality of the major. Of course, the teaching model based on SE-CDIO still faces many challenges, hence it needs to be further studied and explored.

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