REFORMATION AND PRACTICE OF OPERATING SYSTEM COURSE BASED ON CDIO TEACHING MODE

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ABSTRACT

The content of Operating System course is highly theoretical and closely related to applicatio n. It emphasizes on cultivating students' ability of engineering practice. The traditional learnin g mode places great emphasis on theoretical knowledge learning, but ignores the practical a pplication of capacity-building. In connection with the characteristics and problems of Operati ng System course, CDIO teaching ideas were introduced into the course teaching. Teaching and learning method based problem-solving as well as organization based on project were u sed as the principles of the course. In this way, theories were studied in practice and practic e was guided by theories. Students were guided to explore actively and solve problems to im prove their practical ability, innovation ability and team spirit. A "strong kernel, soft shell" cour se schema was established. Students were supported to master the basic knowledge of oper ating system and obtain development capacity through team project design. Teaching metho ds of active learning and practice were implemented. Students were led from passive to activ e exploration by a variety of learning styles such as project/problem based learning, inquiry-b ased learning, research & teaching fusion learning, case teaching, etc. CDIO real training pla tform was created. Basic knowledge, personal capacity, team collaboration and social enviro nment were fused in together similar to real enterprise and social environments to train stude nts with quality practice and deepen their understanding of theoretical knowledge. Teaching t eam with school teachers and company experts who complemented each other was formed t o help students to acquire knowledge and enhance their general engineering. Theory & pract ice assessment was implemented. Basic knowledge, basic personal capacity, interpersonal c apacity and system construction capacity of student were included in course assessment. St udents' career capacity of team collaboration, communication exchange and language expre ssion was trained in this assessment. Students' practical and research learning ability can be reflected throughout the assessment results. At last, the training objective of high-level appli cation-oriented talents was achieved.

KEYWORDS

Operating System; CDIO; teaching reform; Standards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 11

0 INTRODUCTIONS

As a professional degree course, Operating System (Hereinafter OS) plays an important role in curriculum system of computer-related specialty. Principles & Applications of OS is the basic knowledge for students. It is an important channel for students to understand the computer system, the interaction between users and computer system, as well as the design and development of application systems. The course content of OS is highly theoretical and closely related to application. It emphasized on cultivating students' ability of engineering practice. It involves theory, algorithms, technology, implementation, and applications and y are difficult for students to grasp. Traditional OS teaching placed great emphasis on theoretical knowledge learning, but ignored the practical application of capacity-building. In connection with these problems, CDIO teaching ideas were introduced into the reform and practice of OS course. Top design of teaching, learning and examination was given according to CDIO syllabus. Curriculum was organized and teaching methods were updated for practice teaching effectiveness. The reform of OS can cultivate students' knowledge, ability and stimulate students' interest. In this way, qualified software talents were trained.

1 CONCEPTIONS OF CDIO TEACHING MODE

In the new century, the scientific and technical knowledge expanded rapidly, engineering education didn't get sufficient attention and cannot meet the demand of the industry. As a result, industry has found that engineering graduates lack many abilities needed in real-world engineering situations. There is still a gap between engineering education and industrial needs for engineers. CDIO means conceive, design, implementation, operation, it is based on product research, operation, maintenance and abandonment of the product life cycle as the carrier, and establishes an integrative curriculum connected to each other to help the students study engineering in a proactive and practical way. Based on the current status that less attention to the practice and much importance to the theory in engineering education, CDIO engineering educational model trains the students ' ability of engineering not only academic ability, but also lifelong learning skills, team skills and system capabilities, with the whole process of conceiving, designing, implementing and operating as the carrier.

Computer OS is the most indispensable, common and important system software which is most closely to the computer hardware in a computer system. As the connecting bridge between the computer hardware and software, OS not only can manage a variety of hardware and software resources effectively, but also provides an interface for high-level application software operation and services. To master the principle, method and application of design of computer OS, we need to pay attention to the training of students ' knowledge, but also to students' ability of engineering practice, ability to detect problems, analyze and solve problems, their innovation ability and capacity of systems analysis, design, and practice. And these abilities fully meet the competence requirements of CDIO syllabus. Therefore, CDIO talents training model has a strong significance for the reform of OS course.

2 CURRENT SITUATION OF OS COURSE

At present, the traditional teaching model of OS course has the following main problems.

First, the theory lags behind the process of teaching practice, the result is not satisfactory. Large numbers of concepts and complex principles were involved in OS curriculum. Limited by teaching hours, traditional teaching mode often focuses on the explanation of theoretical knowledge, but ignores the cultivation of students' ability of innovation and engineering practice. Experimental practice was usually arranged in fewer hours for the simulation or verification of OS principle and implementation. It lacks of designed and comprehensive experiments and project design. Simply running ready-made programs is not enough for students to understand theoretical knowledge intensively in the classroom to achieve the teaching objective.

Second, the content is isolated and lacks of integration within knowledge. OS is a systematic course. It is necessary to integrate programming, data structures, computer architecture, and other related knowledge to help students establish concepts of system. In order to understand the essence of OS better, principles of OS must be analyzed from the perspective of system development. Traditional teaching mode tends to explain OS alone with complicated concepts. In this mode, it is hard for the students to get things organized.

Third, the content is boring and difficult to understand, and it is away from practical applications. OS is the computer's brain. Its working principles and concepts reflect the human wisdom and philosophy of life, such as queuing theory, the banker's algorithm and so on. Traditional teaching mode often teaches OS concepts in isolation and far away from the application context. Many textbooks and lectures are seldom associated with practical application. Students tend to get tired of learning after finding a lot of concepts and principles too abstract to grasp. Thus the teaching effect was affected.

Finally, teaching content is old and lack of updates. With the continuous changes and improvements of multi-channel, multi-core, micro-kernel, embedded, distributed and multi-processor OS, many other mainstream OS appear, such as Unix, Linux, Windows, Mac, Solaris, iOS, Android and so on. But current teaching contents are far behind the latest research and technical development. It is very urgent to include these different OS principles, techniques and applications in teaching to meet the development of theory and technology.

3 OS TEACHING PROCESS BASED ON CDIO TEACHING MODE

In CDIO teaching process, teaching team was composed of teachers from OS course and the associated courses. Team members teach students collaboratively to train their professional knowledge and CDIO ability, emphasize the integration and comprehensive curriculum. The four stages of teaching process based on CDIO teaching mode are teaching conceive, teaching design, teaching implementation and teaching operation.

At the conceive stage, teaching goals of OS based on the CDIO syllabus were determined. Integrated teaching team was formed according to the ability and curriculum needs. The teaching content, learning effect and division of labor was further clarified through the discussions within the teaching team members. They are based on the current educational infrastructure and students ' ability and on the CDIO engineering educational philosophy as well as the CDIO-CMM models. A "strong kernel, soft shell" course schema integrated with programming, data structures, computer architecture and other related knowledge was established. Advanced techniques such as multi-core processors and Android mobile OS were increased to keep pace with the times and reflect the latest research results in the field. Team project designs were added to help students to grasp the basic knowledge of OS and have some development capabilities.

At the design stage, team members discussed the teaching plan and requests proposed by each member. They discussed course content, teaching hour distribution and the way of cooperation. In order to ensure learning effects, they designed teaching case and related practice project, discussed teaching method and means, evaluated teaching effect, defined teaching risk and management strategy, and optimized teaching process. Teaching methods such as team learning, case studies, field studies and simulation training were used to combine theoretical teaching and practical application. Multimedia and bilingual teaching were complemented to make the content easily understood. Course races were actively carried out to stimulate students' interest in learning. As a result, students' ability of innovation and engineering practice were improved.

At the implementation stage, the teaching team members collected data, wrote handouts, compiled teaching media and teaching tools collaboratively, built teaching cases, inspected teaching facilities, implemented project prototypes, discussed the problems and difficulties encountered in this stage and then resolved them jointly. Multi-level and multi-grade practice system was constructed in order to enhance students' learning motivation and improve their innovation ability. Labs and projects were run through OS teaching. Team project design instruction was written. CDIO learning objectives, critical theory analysis and issues discussed with the students were taken as its' core contents. Students were trained with high quality practice to deepen their understanding of theoretical knowledge and improve their innovation ability. An independent learning platform was built to lead students from passive to active exploration.

At the operation stage, the teaching team members taught OS course in a cooperative way in accordance with the teaching process design, guided the integrative learning of students. Training platform based on the cooperation with enterprises was built to improve students' ability of engineering. Course evaluation based on capability maturity model is used which emphasized both theory and practice. The teaching team members assessed and discussed learning condition and learning effect during the whole process, detected problems timely and improved the following teaching.

4 REFORM PRACTICES IN OS COURSE BASED ON CDIO TEACHING MODE

4.1 CDIO Teaching Conceive

At teaching conceive stage, the teaching objectives based on CDIO syllabus were determined, "strong core, soft shell" curriculum was built under the OS CDIO objectives. The teaching teams were formed according to the needs of the curriculum.

4.1.1 Teaching Objectives of OS Course

According to CDIO syllabus, "broad fundamentals, high capacity and high quality" was determined as the teaching objectives of OS course which was both theoretical and practical. First, enhance students' basic knowledge and help students develop a professional and complete theoretical system, foster students' ability of systems design and analysis for innovative thinking and practical ability. Second, have the students to fully comprehend the composition, structure, function and applications of OS through the conceive, design, implementation and operation stage of a certain OS project, improve students' large-system software development capabilities to meet the future need for software analysis and development, lay the foundation for students' participation in life-cycle project development combined with industry needs.

4.1.2 Integrated Teaching Team

Combined with OS course and other related professional courses, integrated teaching teams with strong practice engineering were set up to serve students. The team is composed of doctoral supervisor, Professor, Associate Professor and experimenters. At present, teachers with senior professional titles account for 67%, Professors account for 50% in our team. Teachers were sent to the enterprise to receive engineering training and gain practical experience. Firm engineers with experience and theory were invited to school as part time teachers. Teaching team composed of school teachers and enterprise experts was formed to assume students' responsibilities of acquiring knowledge and enhancing general engineering.

4.1.3 "Strong Kernel, Soft Shell" Course Schema

First, the selected contents of "strong kernel, soft shell" were established to attract students (as shown in Figure 1). "Strong kernel" covered core knowledge of relatively stable method and principle. "Soft shell" was constituted of knowledge that can be extended, evolved and adjusted according to needs of courses. "Strong kernel" contents include the role of the OS on the computer system, multi-programming system, processor management, memory management, and so on. All students are required to master these contents based on their levels. "Soft shell" contents include device management, file system, network OS, Unix, Windows NT, Linux, multi-core processor management. Students can determine its availability as well as the depths independently in accordance with their own characteristics.

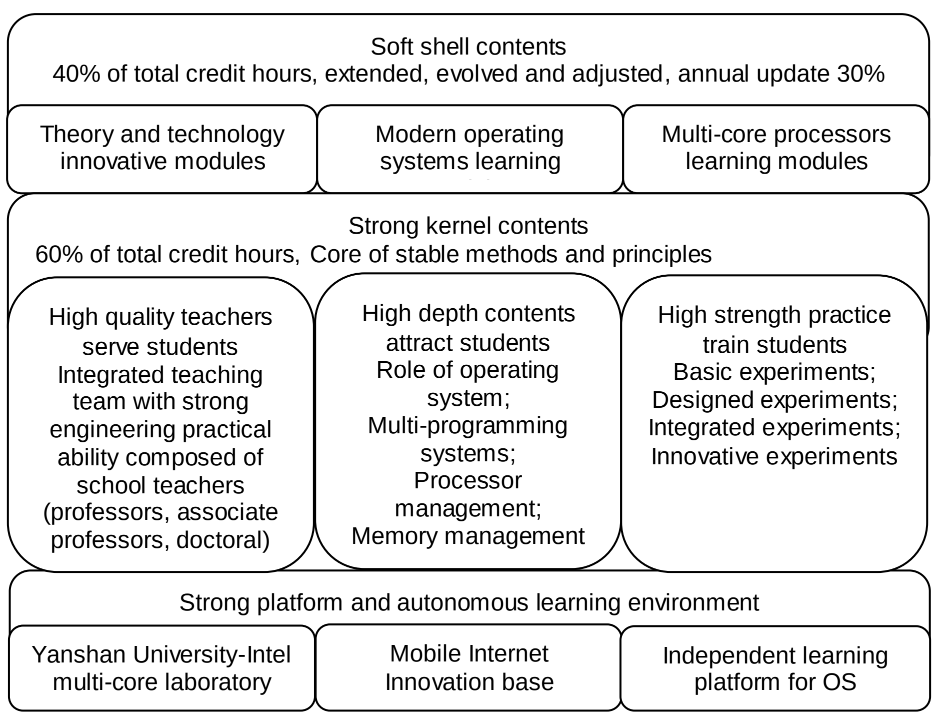

Figure 1 "Strong kernel, soft shell" course construction

Second, contents that reflected the latest research results and technological applications were increased. Course contents for multi-core processor were added to enrich students with prior knowledge. "Mutual promotion and resource sharing" curriculum was constructed systematically. Mobile OS based on Android were introduced to have students be familiar with cutting-edge knowledge. Students were taught how to develop basic and advanced applications with Android SDK to promote the popularity of Android mobile application development.

Third, team project design of OS was added. Students were trained synthetically and systematically with one-week project design to cultivate their abilities of comprehensive application, teamwork, independent thinking, solving problem and technology document writing. At last, they can master both basic knowledge and development technique of OS and have some development capacities.

4.2 CDIO Teaching Design

At the design stage, students were cultivated with varied teaching methods and flexible teaching strategies to arouse their interest and desire in learning.

First, students were trained with a variety of teaching methods and flexible teaching strategies. Idea of “broad fundamentals, high capacity and high quality” was taken as guideline to rely on professional resources and environment. Variety teaching forms such as case type, inquiry type, experiment type, discussion type, collaborative type and action research type were used. Cross teaching, free selection, network teaching and independent learning were adopted to guide students from passive accept to active exploration and inspire students’ learning interests and desire. Students studied not only in hearing and seeing, but also in thinking, asking, practicing and doing. Vivid examples were explained to students on the emphases and difficulties of the course to allow students to remember and put it away. In class, students were guided with questions to mobilize their enthusiasm and cultivate their good habit of initiative thinking. In practice, students' team spirits were trained through grouping design with the full materials prepared by special tutors. Collaborative learning of was encouraged to improve their level of basic theory and teaching ability. Students' ability to solve concrete problems was cultivated with teaching methods such as team learning, case teaching, field study and simulated training by increasing practice hours and credits.

Second, CAI multimedia courseware was combined with traditional blackboard teaching to assist students in flexible way. The parts that are important and difficult were taught on traditional Blackboard to emphasize the process of thinking and understanding and attract students' attention. The parts that are not interesting and hard to understand were showed by CAI courseware to deepen students' understanding in vivid and facilitate way.

Third, unconscious and unobstructed bilingual teaching was introduced to enrich students with high level teaching. English teaching material of “Applied Operating System Concept” was chosen as supportive materials. Specialized English was used naturally and properly in classed and exams to allow students to recognize the meaning of English in OS course. English is no longer the obstacle for students to understand the course contents.

Fourth, OS competitions were carried out to inspire students. Students were positively organized to participate in domestic and international competitions. At the same time, OS knowledge contests were carried out regularly in order to encourage students' mastery of knowledge. The enthusiasm of students was mobilized and an effective feedback mechanism between teachers and students was established by summing up the learning situation of students and giving awards to the outstanding students.

4.3 CDIO Teaching Implementation

4.3.1 Multi-level and Multi-grade Practice System Construction

At the implementation stage, multi-level and multi-grade practice system was constructed in order to enhance students' learning motivation and improve their innovation ability. Labs and projects deepen students' understanding of OS theory and classical algorithms, train students to solve practical problems with theoretical knowledge in engineering practice. By learning objective, learners were divided into three types: terminal users, programmers and system designers. According to the level of each type, four types of experiment were designed in order from easy to difficult level: basic experiments, designed experiments, integrated and innovative experiments.

Basic experiments include process scheduler, scheduling, storage management, and so on. It can enhance students' understanding of basic concepts and core knowledge of OS. It is the minimum difficulty degree experiment and the basis for follow-up experiments. Students were allowed to select the OS they are interested in from the lists provided by teachers. Open source OS are recommended, such as Linux OS for personal computers or Android OS for mobile. Students are familiar with certain OS and configuration, user commands, Shell language, structure of OS, and so on. Students were asked to simulate some of the classic OS algorithms, such as multi-process concurrency and scheduling, intercrosses communication, storage space allocation and recovery, to understand OS principles and algorithms deeply.

Most of the designed experiments were combined with scientific research or practical application. According to the given design requirements, students were required to design complete task with theory knowledge including shared memory process synchronization, document management and the allocation of disk space to store and recycle. Thus develops their abilities to analyze and solve problems and capabilities of systems analysis and design.

Integrated experiments are based on modern mainstream OS that students were required to study, such as Linux OS for personal computer or Android OS for mobile phone. Students mastered achieved technology, module design method and skills through deep analysis for OS kernel, modification and design of scheduling algorithm, drive program, and file system. Students' capacity of system thinking, knowledge exploring and innovation in experiment were trained through case repetition and module replacing experiment. It is difficult to have practice at this stage. Not all students have the ability to do the practice. It is only available to those who have interests in research on specific OS.

Innovation experiments are open practice including innovative designing or projects related to OS done by students with unlimited experimental form and scope. Students can select research topics and build team freely to finish OS project design freely by group. Students' teamwork ability was trained as well as the system ability to conceive, design, implement and operate. CDIO learning objectives, critical theory analysis and consideration, issues discussed with the students were taken as core content of it. Students were trained with high quality practice to deepen their understanding of theoretical knowledge.

4.3.2 OS Curriculum Design Guide Book

Supported by Hebei province teaching reform project and Yanshan University curriculum and textbook construction project, we summarized our experience to compile the "Operating

System curriculum design guide book". The guide book includes design purpose, task, development environment, technology, and tools and duration, basic functional requirements, operating requirements, score and acceptance standard, basic design steps, content requirements of design manual, operation instruction for users, references, technical guidance, instances and technology problem. Subjects about scheduling & interrupts and system management of multi-threaded I/O oriented multi-nuclear processor were added. This book has over 30,000 words. It can meet the needs of teachers and students in different levels. It can reflect the guiding role of "learning, imitation, improvement and innovation" for students in curriculum design. It features specific topics, positive demands, proper guidance, issues forecasts, and strict acceptance. At last, it helps us to achieve our goals of enable, useful and handy.

4.3.3 Autonomous Learning Platform Development

Supported by Yanshan University courses construction project, teaching resources such as curricula, textbooks, reference books and experiment guide book were integrated to develop a platform including networking, stereo and student-centered OS autonomous learning. Platform integrated learning, guidance, answering questions, discussion, self-test, submitting and modifying a job and realized a lot of practical activities of teaching, guidance, answering questions, operations, submitting and checking on network. Online discussions and answering the classroom enhances the communication between students to students, and students to teachers for interactive learning. Prepared by the research group of exercise and examination system with complete test database, automatic scoring, can test students' mastery of the knowledge; Online submission and grading enhance students'' understanding and practical situations. Platform since 2006 runs very well, it creates excellent teachers teaching, students learning environment, has won the national software registration, Ministry of education, the ninth national multimedia educational software Contest award of excellence.

4.4 CDIO Teaching Operation

At the operation stage, basic knowledge, personal skills and team-work were combined with social environments relied on "Yanshan University-Intel multi-core technology laboratory" and "Yanshan University-Ministry of industry and information mobile Internet innovation education base". The course evaluation based on capability maturity was adopted to improve students' ability of engineering practice.

4.4.1 Training Platforms Based on Cooperation with Enterprises

Training platforms based on cooperation with enterprises were created as practice teaching base of OS course. In 2006, Yanshan University was admitted to "multi-core technology courses" college program founded by Intel Corporation-the leading processor manufacturer and created a "Yanshan University-Intel multi-core technology laboratory". In 2012, the "mobile Internet innovation base" cooperated with the Ministry of industry and information technology was founded. A practical course project "Android operating system and programming" was built successfully between Google and Yanshan University in September 2011. Google Company appropriated 40,000 yuan to support our school. The real cases and practical teaching system were prepared to motivate students with actual needs and to stimulate students' interest and desire. Students were encouraged to learn course combined with research of synchronization. Their practice was guided with theory and their theory was verified by practice.

4.4.2 Course Evaluation Based on Capability Maturity

Taken OS course as the key process areas, CMM capability maturity model was adopted as course evaluation model to strengthen students' test of basic knowledge and skills. At the same time, practical abilities, skills, social practice, teamwork and innovation competencies were set into course assessment to evaluate students' ability more scientifically.

First, change the curriculum evaluation indicators. OS design work was taken as an important part of the final grade. OS curriculum project was set as one-week project practice to promote students' deeper understanding of OS and strengthen their practical ability. Project design scores were assessed through oral defense by submitting project report to train students' career capacity of team collaboration, communication exchange and language expression. The assessment results can reflect students' practice capacity and exploratory and creative learning capacity. Score assessment for students run through the whole teaching process to improve students' consciousness and initiative of learning.

Second, multiple evaluation methods were introduced. Contents, process and head covering were realized through quiz, homework and final exam to focus on students' learning outcomes and learning processes. Curriculum design score was given in three parts: teachers' evaluations, peer response within the group and self-evaluation. Student's personality and diversity was considered through identifying practice projects with students, encouraging students who progressed faster and setting higher requirements on students with good grades. Practice in recent ten years proved that evaluation results can improve students' learning motivation, enhance their cognitive development, recognize their innovative ability and achieve the training goal of "broad fundamentals, high capacity and high quality".

5 CONCLUSIONS

CDIO is the main line in our syllabus. It includes professional knowledge, personal and professional skills, teamwork and interpersonal communication skills to emphasize students' theoretical basics and cultivate their abilities of theory application, team work and system control. With the constant high demands for computer OS, CDIO comes at the right time for teaching reform. A teaching team with strong engineering practice capacities was constructed. "Strong kernel, soft shell" course schema which integrated the knowledge of programming, data structures etc. was established to help students understand the essence of OS and build up concepts of system. Advanced applications such as multi-core processors and Android OS were integrated to keep pace with the times. We have formed a teaching team with strong engineering practice, establishes the course schema of "Strong kernel, soft shell". Real training environment is created for the system of CDIO. Experiments and project designs is taken as core and teaching methods of active learning and practice are adopted to reach the courses teaching goal and improve students' learning interests and CDIO capacity with satisfactory results. "Research and practice on curriculum module for multi-core processor" got Yanshan University Teaching Award in 2008, Hebei provincial teaching achievement award in 2009. Students guided by Professor Shen Limin won third prize in "Challenge Cup" college students' extracurricular science and technology competition of Hebei province in 2011. We got 1 third prize, 2 excellence Awards of the second Chinese College students Android application development challenge in North China in 2011. We got 1 first prize, 2 second prizes and 2 third prizes in the computer application competition of "Tianyi Cup" in 2012. OS teaching reform has laid firmer theories and practice foundation for follow-up courses such as Linux development environments, embedded systems, parallel computing curriculum. Our experience has been applied in the Northeast University at Qinhuangdao, Daqing Petroleum Institute, Hebei Normal University and other universities. The reform has been highly appraised by experts and becomes more and more popular among the students.

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