

Exploration and Practice of Cultivating Software Development Ability for Undergraduates*

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Abstract—Good software development ability is the core ability for software engineering specialty in application-oriented universities. Based on OBE (Outcomes-Based Education), this paper introduced some reform ideas of how to improve the development ability. Set up a curriculum group stress on development ability cultivating, which integrate with industry standard and competition etc. Construct a training pyramid to enhance students' innovation practice ability. Results showed all these reforms have a good effect on improving specialty belonging and employability.

Keywords—OBE, curriculum group, software development ability, certificate, competition

I. INTRODUCTION

Software industry is an important indicator of national comprehensive competitiveness, especially innovation. With the rapid development of information technology, the demand for software development and software testing talents is increasing rapidly [1]. Good software development ability and innovative ability are the key to cultivating software engineering profession in application-oriented universities. How to improve students' core professional ability and enhance students' interesting of specialty is the primary problem to be solved in universities and colleges.

Based on OBE (Outcome-Based Education), we have established a curriculum group with software development ability as the core professional ability. OBE focus on "Student-Centered, Outcomes Oriented and Continuous Improvement". The main goal of teaching design and implementation for OBE is to ensure that students achieve specific learning outcomes [2]. Based on OBE, we adjust our curriculum system and set up a curriculum group integrating with the industry standard. We also establish a closed loop of "evaluation → feedback → improvement" to form a continuous improvement mechanism. During the teaching, we adopt "project driven" and pay attention to the cultivation of "development ability" and "innovative practice" ability. The purpose is to create a good learning atmosphere, let students better understand and use the learned knowledge to solve actual problems

***Funding:** This paper is supported by the First-class undergraduate profession building of Shanghai under Grant No. A30NH221903-0313.

II. OBE-BASED CURRICULUM SYSTEM REFORM

A. The curriculum group stress on software development

Since its establishment in 2005, the software engineering major of our university has continuously made good achievements in teacher construction, experimental environment, student competition and innovation and so on. In 2010, it was approved as a "national characteristics specialty of China"; in 2011, it was rated as "085 connotation construction" in Shanghai, and in 2020, it was approved as "First-class undergraduate specialty building in Shanghai". OBE emphasizes the following four issues [3]:

(1) What learning outcomes do we want our students to achieve? (2) Why should we let students achieve such learning results? (3) How can we effectively help students achieve these learning outcomes? (4) How do we know that students have achieved these learning outcomes?

Our reform focus on these four issues of OBE. Software development ability is the core professional ability of software engineering major in application-oriented universities. We must cultivate students' software development ability vigorously. In our school, we sort out the curriculum system and set up a curriculum group with software development ability as the core professional ability, shown as in Fig.1.

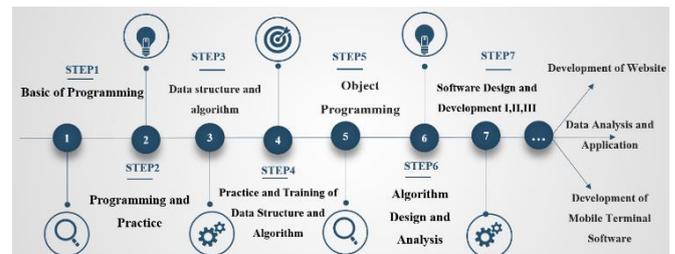


Fig. 1 The curriculum group stress on software development

The main line strengthens the development foundation, the curriculum like Basic of Programming, Programming and Practice, Data Structure and Algorithm, Software Design and Development I, II, III etc. The branch lines meet the diversified needs for the rapid development of the software industry, like Development of Website, Data Analysis and Application, Development of Mobile Terminal Software.

Students can choose two directions according to their interests and specialties. In the curriculum group, we organically integrate the knowledge and ability points of industry standard, competition and employment interview. High-trust certificates and competitions not only test the effect of teaching and learning, but also stimulate students' interest and curiosity in programming.

B. Integrate industry standards

The "China Qualification Certificate of Computer and Software Technology Proficiency (ruankao for short)" is a national certificate examination for IT industry [4]. It is the only qualification examination for professional titles in the IT industry in China. It has high authority, strong professionalism, pays attention to knowledge and skills of IT industry. Among ruankao, the "software design engineer", "software testing engineer" and "programmer" can well investigate students' software development ability.

CSP (Certified Software Professional) is a software capability certification that launched by China Computer Society (CCF), in conjunction with famous universities and IT enterprises. It focuses on the programming ability of software developers to actual problems [5]. It has become an important standard to measure the algorithm design and software programming ability of college students.

Based on the consideration of credibility and operability (students' economic perspective), we organically integrate the ruankao of "software design engineer", "software testing engineer", "programmer" and CSP certificate into courses teaching and practice. Relevant courses are required to include corresponding knowledge points and ability points according to the knowledge and ability points involved in the ruankao, CSP, contest and employment interview etc. Exercises, quiz, assignments, examinations and demonstration examples in the course adopt directly the real examination questions of previous years.

For example, in our curriculum group, with the support of PTA platform [6], "Basic of Programming" curriculum has designed a teaching mode of "Getting Started" → "Improving Application" → "In-depth Practice" with gradual progress and spiral rise. The "Getting Started" phase adopts online assessment, the "Improving Application" phase uses computer assessment, and the "In-depth Practice" part combines the method of certificate and competition extension evaluation to conduct all-round assessment of relevant courses.

The two courses of "data structure and algorithm" and "algorithm design and analysis" further consolidate students' algorithm foundation. According to students' level, hierarchical tasks are arranged, including basic questions, improvement questions and challenge questions. Software design and development I, II and III are three practical courses to improve the ability of software development step by step, which are arranged in three summer semesters with immersion centralized project practice in the laboratory during 2-3 weeks. From simple to complex, from front-end

and back-end to comprehensive project development, students' software development ability is progressing slowly and continuously.

Assessment is a very important part for the curriculum group. We make explicit criteria for course assessment and emphasizes the process assessment. Let students know what exactly they must complete and submit and how they can get high score.

In order to motivate students attend the certificate, students who obtain the ruankao qualification can apply for a course exemption from designated courses and obtain corresponding credit. Similarly, if the CSP score reaches more than 200, students can also apply for a course exemption from the approved course and obtain corresponding credit.

In this way, course teaching, examination and certificate complement and support each other. Since 2014, more and more students have signed up for the ruankao and CSP certification every year, and the passing rate of programmers is as high as 70%. In 2019, 47 students obtained programmer certificate and 15 got the software design engineer. Partial students who got the ruankao qualification are shown in Table 1.

Table 1 Partial students got the ruankao qualification

班级	学号	姓名	层次级别	上午成绩	下午成绩
17 软工 A1	20171115008	陈**	软件设计师	61.00	60.00
17 软工 A1	20171113235	李*	软件设计师	66.00	62.00
17 软工 A1	20171113239	戴**	软件设计师	57.00	67.00
17 软工 A1	20171113225	张**	软件设计师	58.00	67.00
17 软工 A1	20171113216	秦**	软件设计师	61.00	58.00
17 软工 A3	20171113420	金*	软件设计师	53.00	57.00
17 软工 A2	20171113341	黄**	软件设计师	47.00	52.00
17 软工 A2	20171113340	王**	软件设计师	49.00	59.00
17 软工 A2	20171113328	王**	软件设计师	52.00	50.00
17 软工 A2	20171113316	单*	软件评测师	53.00	61.00
17 软工 A1	20171113218	吴**	程序员	52.00	58.00
17 软工 A3	20171113420	金*	程序员	53.00	57.00
17 软工 A2	20171113301	王**	程序员	60.00	63.00
17 软工 A3	20171113421	刘**	程序员	60.00	61.00
17 软工 A3	20171113430	龚**	程序员	56.00	57.00
17 软工 A3	20171113423	倪**	程序员	53.00	61.00
17 软工 A3	20171113433	苏**	程序员	50.00	56.00
17 软工 A1	20171113234	宗**	程序员	47.00	50.00
17 软工 A1	20171115030	袁**	程序员	48.00	55.00
17 软工 A1	20171113237	王**	程序员	53.00	63.00

Our school is one of the CSP certificate examination site. In recent years, some students have obtained high scores of more than 300. The curriculum group integrate with industry standard has improved the students software development ability and the practical ability of most students. This reform can help students get a high value certificate, but do not need to make extra efforts to prepare the certificate, and do not need to spend a lot of extra money for training.

C. Cultivating innovative ability

Promoting learning through competition and paying attention to the cultivation of innovative practical ability. We

guide and organize students to participate in various competitions, from school competitions to national competitions, optimize and upgrade level by level.

First, students have freshmen contest on the freshmen year, followed by the "programming contest", the "Blue Bridge Cup", ACM/ICPC and CSP, and then "Challenge Cup, Internet+, ruankao and outsourcing competition etc. We also guide students to attend college students' innovation and entrepreneurship project. The training pyramid of innovation ability is shown as Fig.2. From programming to comprehensive competition and project practice, teachers act as coaches and excellent students act as teaching assistants. In the process of preparing for the competition, students' programming skills, algorithm ability, learning interest and software development ability rise spirally with time.

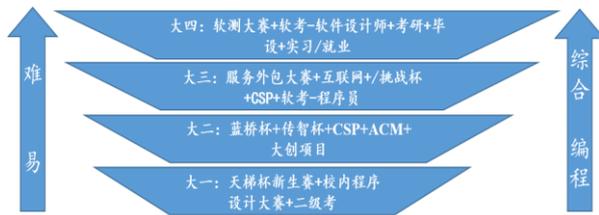


Fig.2 The training pyramid of innovation ability



Fig.3 Some programming competition awards

The student competition has achieved remarkable results and has won the first, second and third prizes in national and

provincial competitions for many times. Some programming competition awards are shown as Fig. 3.

III. THE APPLICATION OF REFORM

This reform has been explored and practice for nearly 9 years since 2013 in our school. We have trained more than 800 students of software engineer major, who work actively in all fields, realize self-worth and create value for society.

The curriculum reform stress on core ability of software development, which mainly solves three problems:

First, courses content taught by colleges and universities cannot keep up with the rapid development of IT industry;

Second, students only pay attention to high scores, but weak software development practical ability;

Third, it stimulates students' interest and curiosity in programming, and enhance their major belonging.

The curriculum group adopts the combination of "ability oriented", "problem oriented" and "project driven" teaching methods. With the help of online teaching platforms (PTA, chaoxing, MOOC [7], and chuanzhi etc.), online and offline blended teaching is carried out. The three-dimensional and all-round evaluation of relevant courses is carried out by combining classroom questions, online tests, practical tests, final exams, and competition extension evaluation.

In the process of education and teaching, engineers' values, professional ethics and industry feelings are integrated into the teaching, so that all kinds of courses and ideological and political courses go hand in hand, forming a synergistic effect.

While paying attention to strengthening students' software development ability, we cultivate students' craftsman spirit of excellence, and stimulate students' feelings of serving the country with science and technology and their mission.

Through the process of learning, practice, competition and certificate, students transform professional knowledge and skills into their own logical thinking and professional ability.

Promoting learning by certificate, promoting learning by competition. Good atmosphere of learning has been formed in the competition. Most students study hard, have a good atmosphere of study and enhance significantly their competitiveness.

Some class were selected as the school's "excellent study demonstration class", "top ten online classes" and "advanced class". Liang, a student of software engineering major in 2023, won the bronze medal in the Website Design and Development Project of the 2022 World Skills Competition, and achieved a breakthrough of zero medal in this project in China.

Enterprises have high satisfaction with our graduates. Some students are promoted to project manager after one or two year; Some students have founded an IT company

cooperate; Some students have been employed by well-known enterprises and get high salary, such as Baidu, TikTok, bilibili and so on.

Software engineering graduates have strong entrepreneurial ability. For example, the "yunbian technology company" jointly founded by five software engineering graduates enjoys high reputation and popularity in the industry on Shanghai. At present, it has two brands of "yunbian campus" and "yunbian government affairs", and has provided wechat platform construction and technical support for more than 300 government institutions such as "Shanghai release", "Shanghai Education", "Youth Shanghai" etc. The 2019 graduate yearly salary reached 50w after working for more than one year, and student He, a 2021 graduate, works for Baidu, and student Zhang, 2022 graduate, works for TikTok, student Gu, a 2022 graduate, serving for bilibili.

This reform not only improves students' software development ability, but also can increase greatly the competitiveness of employment and job selection by getting corresponding certificates. The software engineering in our school is also more and more popular with students and parents. In recent years, the enrollment rate and enrollment score have significantly improved, ranking first in our school.

IV. SUMMARY

Based on OBE, this paper introduced a cultivation scheme reform for application-oriented universities. Combine with the

industry standard, a curriculum group is set up with software development ability as the core ability. And a training pyramid of innovation ability is constructed. Promoting learning by certificate, promoting learning by competition. Highly recognized certificates and competitions not only test the effect of teaching and learning, but also stimulate students' interest and curiosity in programming.

Results showed this reform have improved the teaching quality and achieved great success. Hope these reform ideas can have some reference value for software engineering specialty construction.

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