

## Practical training of software engineering talent in *one integration and four layers mode*

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**ABSTRACT:** The rapid development of the software industry has put forward higher requirements for software industry practitioners. In order to strengthen the practical engineering and innovation ability of software professionals, an integrated practical training mode for fostering software engineering talent has been constructed from four aspects of university education: curriculum experimental redesign, internship, graduation project and competition. To ensure the effectiveness of the mode, an evaluation mechanism including quality assurance has also been built into the mode. Evidence collected of the mode's application at Hunan University of Arts and Science indicates improvement in cultivating software talent.

### INTRODUCTION

In recent years, the software industry in China has developed swiftly. According to the *12<sup>th</sup> Five-Year Plan for Software and Information Technology Services* by the Chinese Ministry of Industry and Information Technology, the total income of software business has been up to RMB (Chinese yuan) 180 million in 2011. As of 2015, the income of software and information technology services will approach RMB 400 million with an annual increase of more than 24.5% [1].

The rapid development of the software industry has imposed higher requirements on its employees, and the enhancement of practical ability, engineering ability and innovation ability of talent for software technology has become widely recognised by universities, enterprises and individuals. Several new educational approaches with strong emphasis on practical skills have been developed to address key problems in talent training [2-6].

Established in 1958, the Institute of Scientific and Technological Development is now at Hunan University of Arts and Science, which is a multi-disciplinary, full-time, ordinary university. Guided by the goal of *cultivating multi-level, practical and international talent* right from the beginning, the University has established an integrated practical training mode in the form of *one integration and four layers* based on the overall structure of practical training mode to satisfy the current strong demand by enterprises for engineering software talent. Conceived and designed within the practical training approach, it includes quality assurance measures for practical training and an evaluation mechanism of practical ability.

### PRACTICAL TRAINING MODE WITH *ONE INTEGRATION AND FOUR LAYERS*

#### Integrated Practical Training Content Mode with Four Layers

Designed with a top-down approach, the integrated practical training mode addresses the overall goal of practical ability cultivation in several sub-goals, to create a total plan for all the links in talent cultivation. Then, these sub-goals are implemented in practical training, which solidifies the practical training plan. Finally, the overall goal is realised by the accomplishment of all these sub-goals of practical ability in practical training. Figure 1 shows the content and corresponding goals of talent cultivation within the integrated practical training mode. The layers are as follows:

- **Curriculum experiment:** in the basic layer of the practical training mode, an environment is created to foster students' talent. The training content includes a basic experiment, an elective experiment and an extended experiment on campus. Students have good command of professional knowledge by combining classes with experiments.

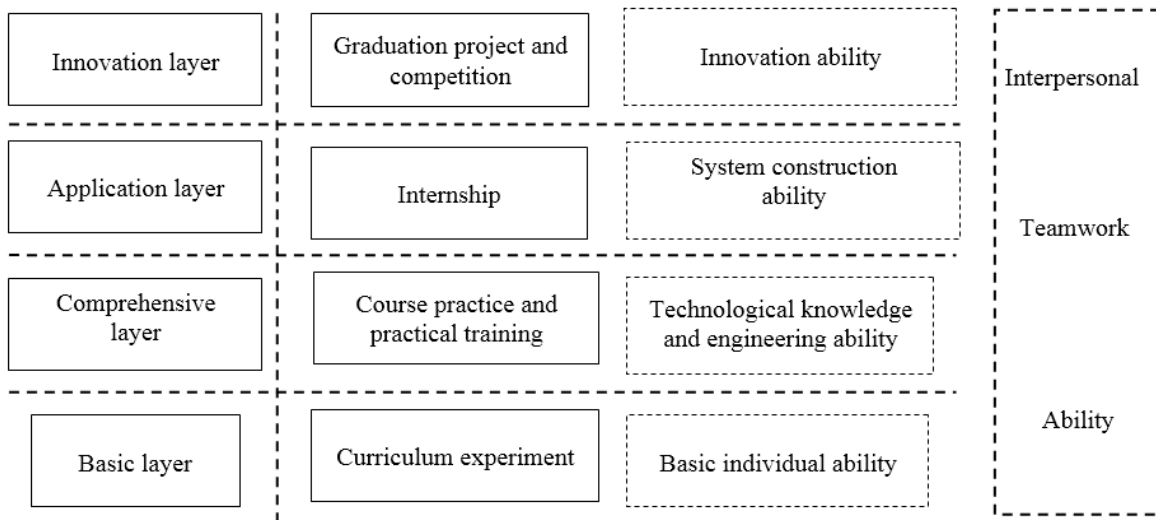


Figure 1: Content and goals of the integrated practical training mode.

- Curriculum practice and practice of school year: this is the second comprehensive layer in the practical training mode to broaden the abilities of students. The training content includes comprehensive professional practice on campus. The training for the overall process of project development is conducted for students from demand analysis, design, operation and test to stage reports by instructors invited from enterprises with real-life cases. On completion of this layer, the ability of students will be improved in several aspects of project planning, team organisation, work distribution, member communication, etc, and team spirit will also be cultivated.
- Internship: this is the third layer, the application layer in practical training mode, aiming at further enhancing the engineering ability of students. The training content is the enterprise practical training. The engineering ability, communication ability and social adaptation ability of students are enhanced by establishing multiple high-quality enterprise practical training bases for practice of upperclassman in the real-life enterprise environment led by real project managers in real project cases with work pressure, and also work opportunities.
- Graduation project and competition: this is the innovation layer in the practical training mode, mainly aimed at cultivating the research and innovation ability of students. Guided by instructors, students participate in software development at an internship enterprise and solve actual problems independently. They are expected to grasp the development method and technology of a software package and strive for innovation. In addition, students can learn management flow, improve their communication skills and observe work methods of enterprise and enterprise culture to shorten the adaptive phase after graduation. On completion of this layer, the comprehensive design ability, technology innovation ability, document writing ability, foreign language application ability and information retrieval ability of students will be improved.

Table 1 shows the reformulated practical training mode of software engineering major according to the cultivation goal of advanced software talents.

Table 1: Practical training mode of software engineering major.

Support mode of practical training	Practical training mode						Cultivation of engineering ability	Quality assurance mode of practical training
	Internship	Project practice	Comprehensive paper training	Discipline competition	Innovative practice	Innovative practice	Innovative ability Ability to process and mode construction Technology and engineering knowledge Scientific research ability Learning ability Practical ability	
	Practical training	C++ programming practice, software operative technology practice, software engineering tool and environmental practice, practical training of software engineering, project practice and scientific research training						
	Compulsory courses in software engineering major	Design and evaluation of user interface, software engineering tool and environment, theory and technology of software evolution, software configuration management, Linux programming environment, large-database technology, structure platform of software development, SOA theory and technology, analysis of software development case, principle and technology of analysis on software development case, software safety and technology, software security, fronts and innovation of software engineering, process and management of software outsourcing						

Main courses in software engineering major	Software engineering basis, software mode structure, organisation and management of software project, software test technology		
Foundation courses in software engineering major	C/C++ programming basis, information mode basis SSDI, computer mode basis SSI2, data structure, algorithm analysis and design, discrete mathematics		

The key to realising the above content in the practical training mode is to organise rationally the training plan and content in every school year, semester and learning stage according to the cultivation goal of software talent. By organically combining and connecting every practical link, a scientific and effective practice process can be constructed [7]. Hunan University of Arts and Science have further worked out the engineering ability cultivation mode for software talent as demonstrated in Figure 2:

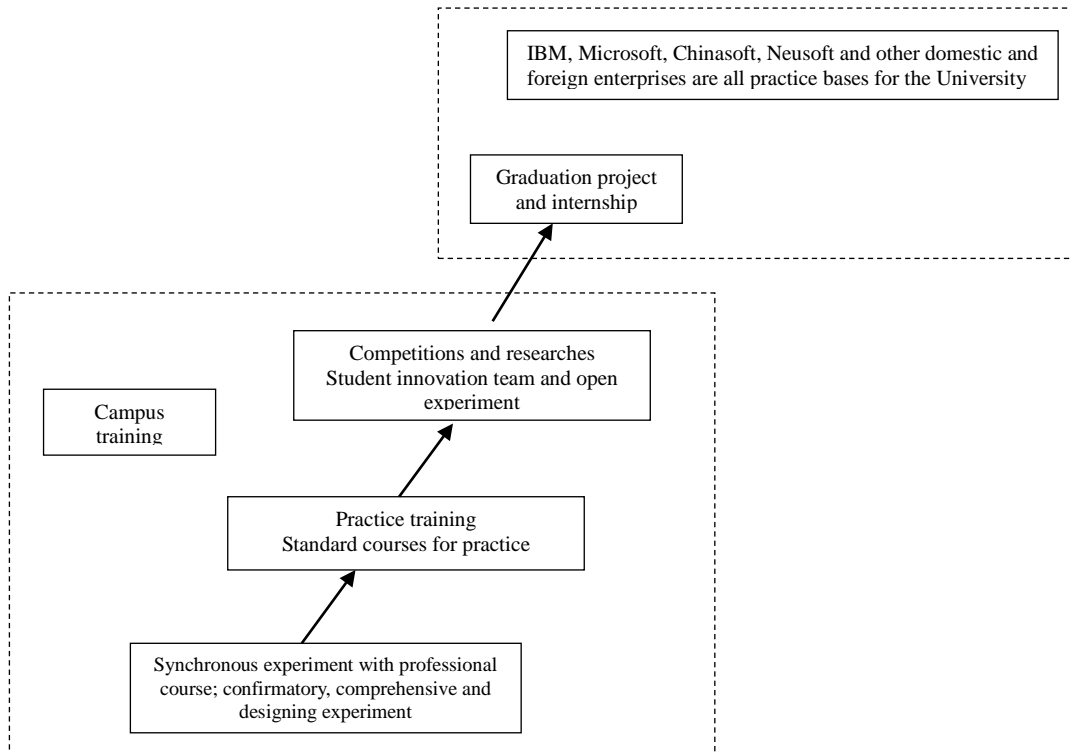


Figure 2: Engineering ability cultivation mode for software talents.

#### Evaluation Mechanism for Practice and Comprehensive Ability

A set of easy-to-operate evaluation measures must be established to ensure the effective implementation of the practical training mode for software engineering, so that all the abilities involved in practical training can be effectively evaluated. Evaluation ideas, structure and content should be determined according to different evaluation subjects and items, and more attention should be paid to the comprehensive ability, initiative and innovation of students.

The specific evaluation method is to evaluate individuals and groups in different practical training links. When determining the practice performance, teacher evaluation, practical ability, co-operative ability and practice reports can all be incorporated into the grading system as specific index entries in a certain proportion. In this way, the comprehensive rating evaluation of students can be more rational and scientific.

Firstly, the competency requirements of software talent, shown below, should be analysed:

- Comprehensive ability of industrial application and information demands
- Ability of logical thinking, scientific analysis method and engineering thought
- Ability to analyse, process and explain data
- Programming ability
- Ability of mode analysis
- Ability of mode design
- Cooperative and leading ability in team work
- Ability to know, abstract and establish model by engineering concept

- Good professional ethics and responsibilities
- Ability of expression, language and communication
- Humanistic quality
- Lifelong learning ability
- Ability to use modern technology and necessary tools

The evaluation mode includes all major evaluation items of students in all grades of software engineering major according to the competency requirements. Evaluation of the ability of students should combine university evaluation with enterprise evaluation. School evaluation is conducted by course assessment, theory tests, practical ability assessment, technology competitions, questionnaires, expert attendance, interviews and visits, etc. Enterprise evaluation pays more attention to the evaluation of actual problem-solving ability and comprehensive quality by assessing the completion condition of practical projects and evaluating the student's project development ability, interpersonal skill and teamwork ability. The assessment penetrates the whole process of practical training, including capability evaluation of students in experiments, practical training, internship, graduation projects and competitions.

#### Quality Assurance Mode in Practical Training

To ensure the orderly and standard operation of practical training, scientific and effective quality assurance and a management mode must be established for practical training. The quality assurance mode is composed of management mode, monitoring mode and feedback mode.

- Management mode for practical training: This mode is mainly responsible for the organisation and implementation of practical training with an administration centre and experiment practice centre as executive agencies. The educational administration office under the university administration centre is responsible for the planning and coordination of practical training activities, and the experiment practice centre for the organisation and monitoring of experimental and practical training. The cooperation between these two units can ensure the achievement of quality goal in practical training.
- Monitoring mode for practical training: this mode is responsible for the measurement and investigation of practical training quality, which can provide evidence for the decision-making of practical training management. Following training rules, the monitoring mode should develop activities by planning in an organised way in strict accordance with the evaluation programme. By gathering the required information of practical training in time, this mode can provide assurance for the management mode to command, coordinate and monitor practical training effectively. The monitoring of practical training is divided into three layers: university, department (school), and the teacher layer.

The monitoring of practical training quality is mainly conducted to see if the practical training mode satisfies the requirements of talent cultivation goals. The schedule and management mode for practical training links can ensure the normal operation of practical training. Moreover, the structure and quality of teacher group, conditions of practical training, evolution and research of practical training and quality conditions of training are also monitored.

The quality monitoring in practical training pays great attention to all documents (training outlines, instructions and prospectus) and relevant auxiliary materials in all practical training links, the management mode and evaluation methods, the teacher group and text materials reflecting training effects, including experimental reports, internship reports, course design and papers from graduation projects.

The quality monitoring of instructors in practical training mainly includes the preparation before practice sessions, ability to train in guidance and management, and the quality of instructor training.

- Feedback mode in practical training: this mode is mainly involved in feeding information back to the decision-making department responsible for practical training and principles for practical training operation. The feedback information in practical training can be collected in three ways.

Firstly, dynamic information about the practical training operation and static information about achievement quantity, and quality can be collected by overall evaluation.

Secondly, the ability and knowledge structure of students can be collected by special project investigation after every practical training link is completed.

Thirdly, comments and suggestions on practical training from teachers and students can be collected by questionnaire surveys or discussion fora.

After settling, classifying and analysing the information about practical training, relevant information should be sent to the decision-making department in time. This information can provide powerful evidence for the decision-making in practical training and further improvement of training quality for teachers.

## APPLICATION EFFECTS

The *one integration and four layers* practical training mode for software talent has been put into full operation among students of the software engineering major at Hunan University of Arts and Science. At present, the total number of students trained in this mode has been up to 600, and the training process and effects are positive:

- Good effect on talent cultivation: graduates cultivated in the new practical mode have strong innovation ability and can rapidly adapt to their work in job position.
- High social assessment and employment quality: most employers reflect that graduates from the Institute of Scientific and Technological Development are *diligent, innovative, good at team cooperation and strong in engineering practice*. The employment rate of students with a software engineering major that graduated from the Institute of Scientific and Technological Development, Hunan University of Arts and Science has been at 100% in recent years.
- Significant improvement in engineering ability of teachers: with this mode, the Institute realises training benefits to both students and teachers. The course in the software engineering major requires teachers to be a project manager with development experience. In practical training, teachers are not only lecturers in class, but also project managers. They are responsible for proposing project requirements, checking development schedules, monitoring development processes and evaluating software quality.

## CONCLUSIONS

The cultivation of engineering practice ability is always a bottleneck problem in the cultivation of software talent because of the lack of practical training, single training method and often unclear goals in the traditional talent cultivation mode. Combining the evolutionary achievements of practical training in software talent cultivation in recent years at Hunan University of Arts and Science, a practical training mode has been constructed in the form of *one integration and four layers*. The design of the practical training mode includes a practical ability evaluation mechanism and an assurance and management mode for training quality as support at the macro level. The mode has been used over the last four years, and the effects have been positive in regard to internal measures and student employability.

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