Exploration and practice of college-enterprise co-operative teaching of a civil engineering major

Wei Gu†, Wei Cai‡ & Jun Li‡

Jiaxing Vocational Technology College, Jiaxing, Zhejiang, People's Republic of China†
Ningbo University of Technology, Ningbo, Zhejiang, People's Republic of China‡

ABSTRACT: The objective of this study was to investigate the reform of the practical teaching of a civil engineering major. A new system for training students to be innovative and have practical ability was developed and college-enterprise co-operation, which is at the heart of the new system, is described in this article. For the civil engineering major at Ningbo University of Technology, the training goals, standards, methods and execution plans are presented and discussed here. A specialised agency to manage the co-operative teaching between college and enterprise was created, and a double tutorial system involving both enterprise and college teachers, as well as quality assurance, were determined and implemented. The results show that the approach was innovative, of high quality and provided an engineering vision for civil engineering undergraduates. The results of this study may be beneficial in research that is attempting to improve the teaching of engineering students.

INTRODUCTION

Training applied innovative talent is the term used to describe an education aimed at developing students with scientific literacy who are innovative, with practical abilities and have been formally educated in the theoretical content of a discipline augmented by practical engineering training [1]. Such training should be subordinated to national strategy, serve the local economy and promote enterprise development [2]. School-enterprise co-operation is one of the most important methods by which to achieve such training [3]. Given this situation, how to establish a training system for applied innovative talent has become an important research topic in engineering education.

Ningbo University of Technology (NBUT) was one of the first universities to launch *A Plan for the Education and Training of Outstanding Engineers*. The implementation plan for outstanding engineers is in line with the strategic orientation of NBUT, whose guiding principle is to produce talented graduates with practical ability. Ningbo University of Technology is dedicated to serving the local economy and society, and is aiming to build the institution into being a top technical and engineering university with distinct characteristics; the better to serve locally and nationally.

Co-operation between schools and enterprises is an important way for students to acquire practical skills at Chinese universities and it is good for the development of doubly capable teaching staff, i.e. staff who can operate in academia and enterprise [4].

Civil engineering at NBUT is nationally recognised and it provides excellent training, where the emphasis is on practical ability with an orientation toward support of the local economy. The work reported in this article describes and analyses the college-enterprise co-operation system of the civil engineering major at NBUT.

TEACHING METHODS

Given the aim of fostering innovative talent who have abilities in applying knowledge, a new school-enterprise co-operation mechanism was established in order to produce a large number of talented, innovative civil engineers. The roadmap for this work is shown in Figure 1.

Training Goal

The goal is to develop students with good, overall quality in science and engineering into top-class, innovative civil engineers displaying acceptable practical ability and global vision. The applied innovative personnel in civil engineering are certified professional civil engineers with good, demonstrable applied innovative ability.

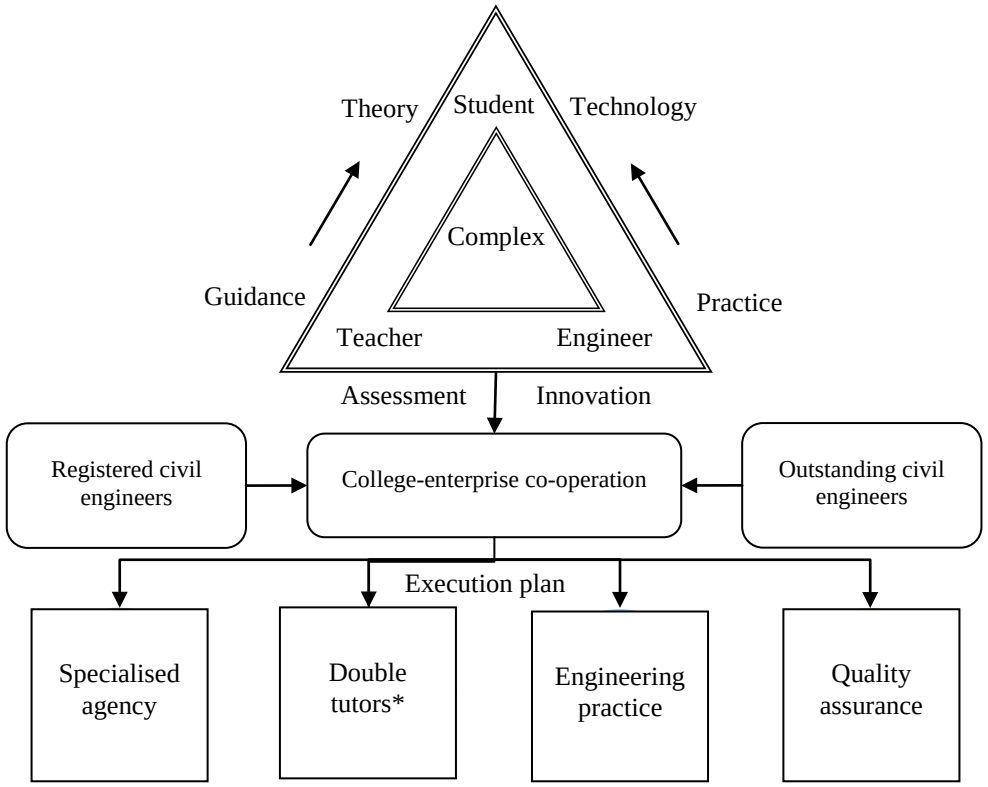

Figure 1: The roadmap for training civil engineering students.

Based on the building vocational certificate system, a new training mode was set up for civil engineering students skilled in construction and design with a strong management ability. This is referred to as *skilled construction*, so that students are familiar with modern construction methods and technology; *skilled design*, so that students have analytical and design skills; and *strong management*, so that students develop good communication, leadership and project management.

Training Mechanism

Building on the long-term and stable industry-academic-research co-operation between NBUT and local industry, a new school and enterprise joint training mechanism was established according to the mantra, *three united, two participants, one goal*, to enhance the role of industrial firms in student training.

Three united means NBUT and industry jointly decide the training standard, training process and the quality evaluation system for students. *Two participants* means industry is heavily involved with NBUT in the training and appraisal of students. For example, NBUT's civil engineering students fully employed by a local construction enterprise achieve a win-win situation for NBUT and the enterprise.

Ningbo University of Technology also provides a co-operation platform for the research, product design, manufacturing applications and personnel training, based at the University's Architecture Design Institute and laboratory. *One goal* is the production of innovative and practically skilled graduates.

Training Content

Civil engineering students improve their applied innovative abilities by learning in an enterprise; therefore:

- Engineering knowledge and ability is strengthened. Combined with engineering practices, civil engineering students learn construction techniques and management. Also, students develop an intimate knowledge of safety regulations, quality assurance and equipment operation.

- Great attention must be paid to linking theory with practice. Civil engineering students should be familiar with construction drawings and technical data, building draft plans, construction budgets, project accounts and inspections.

- Civil engineering students should apply new technology, materials and construction methods. The students are encouraged to analyse and solve engineering problems.

- Communication ability and occupational interactions are improved. Through participation in the enterprise, students come into contact with the working units of the enterprise, which improves their social inter-communication and group co-operation.

Execution Plan

The focus is on training students to master the basic structural theory and design methods, as well as the advanced construction technology and project management skills. These should be supported by outstanding foreign language and computer skills. Guided by a *pan-engineering* idea, in responding to enterprise demands, the curriculum was updated to reform the technical training, project design and graduation project, to enhance innovative abilities [5]. It was necessary to combine extramural study with the campus programme [6]. Students' engineering abilities increase through training, course learning and the graduation project, based on actual conditions in an enterprise, with difficulty ranging from elementary to hard.

Civil engineering students should be conscientious about gaining experience. Students should work independently and follow closely operating instructions, with the guidance of school and enterprise teachers. The graduation project should comply with the training targets and the research aims.

Teaching experience in enterprises improves students' co-operative ability and studies. Deepening engineering educational reform fundamentally changes the teaching methods, from prescriptive teaching to inquiry teaching.

ORGANISATION AND OPERATION OF THE CO-OPERATIVE TEACHING MODE

In recent years, NBUT has deepened the reform of education and teaching, including engineering education. Meanwhile, a fruitful platform for school and enterprise co-operation has been developed based on the civil engineering major, as shown in Figure 2.

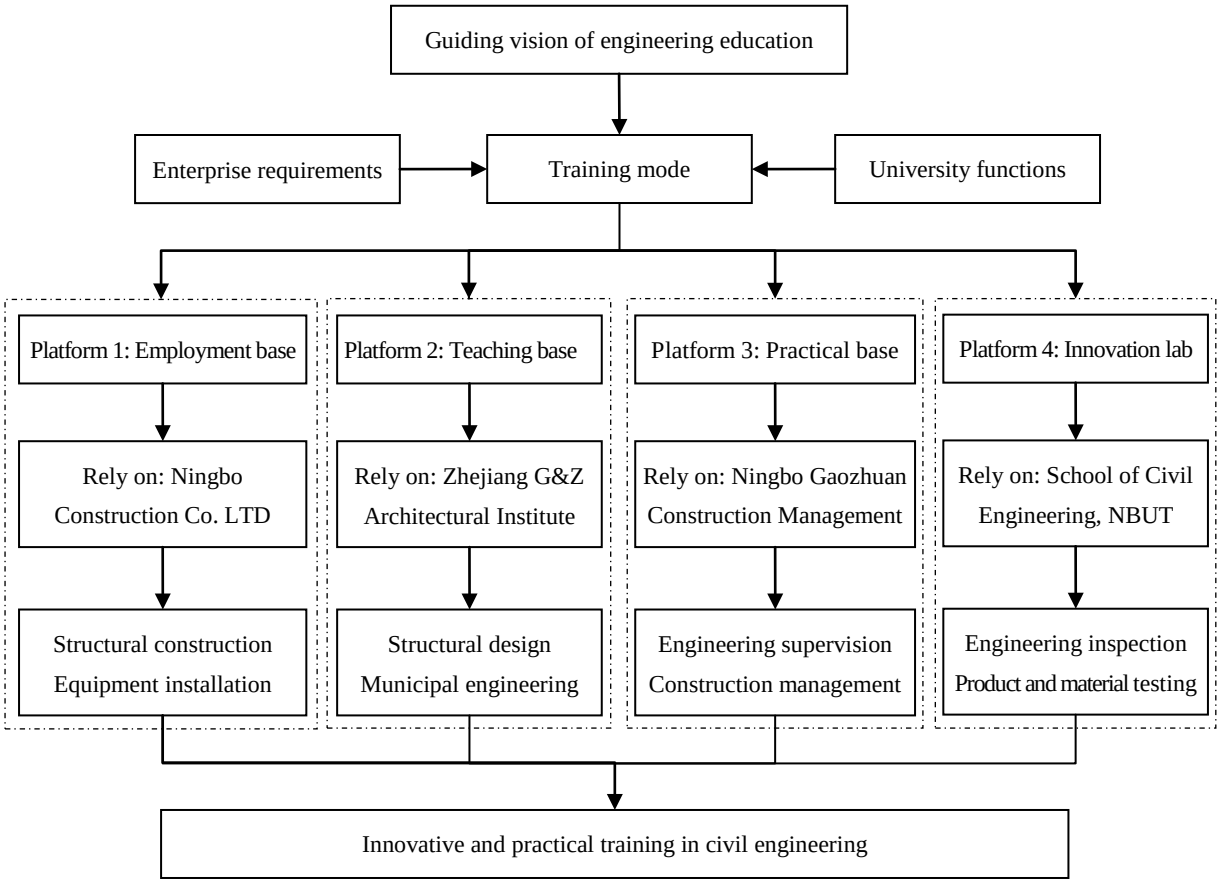

Figure 2: A new system of applied innovative training.

Organisational Management Institutions

Relying on the building trade associations, a supervision board and working group were formed as the specialised agency responsible for the applied innovative training programme. The board provides guidance for the strategic alliance between the school and enterprises, and also organises and evaluates the teaching content. An education centre for applied innovative training for civil engineering was formed, with full-time professionals responsible for the work in the enterprises. They organise the teaching and the workplace, as well as maintaining the equipment.

Teaching Team

An excellent teaching team has been assembled to improve the quality of civil engineering education. Industry experts with a civil engineering background were invited to review and modify the training plans. Excellent engineers were appointed as part-time teachers. Teachers lacking practical experience and young teachers were sent out to local construction enterprises to gain practical experience.

Double Tutor System - Enterprises and College

Teachers for the co-operative teaching mode are selected from the university teaching staff. This education mode aims to combine theoretical knowledge with practical engineering experience, which requires strengthening the teaching team through teachers who have an engineering background. According to the co-operative agreement, enterprise teachers are appointed regularly from major construction projects. They combine advanced theory with rich experience to provide guidance in conjunction with the university teachers.

Engineering Practice

It is most important that attention is paid to the practical ability of civil engineering students. The emphasis is on innovation, with particular focus on knowledge and practical engineering ability. The ideal situation would be to learn through doing and doing through learning as a way to inspire civil engineering students.

Quality Assurance

According to the agreement, NBUT, construction enterprises and students should define the duties and establish responsibilities. The NBUT is responsible for student selection, school teacher assignment and support for students regarding engineering theory. Enterprises are responsible for assigning students and enterprise teachers, as well as for monitoring quality. Civil engineering students should obey the university rules and the rules of the enterprise. Students should maintain a daily planner and ensure the completion of all tasks.

TEACHING EFFECT

The system discussed has been applied in practice and it has achieved very good results. The NBUT civil engineering students have enjoyed significant success in various contests, such as winning the *Challenge Cup* National Undergraduate Curricula Academic Science and Technology Works race, National Undergraduate Structural Design Contest, as well as four second prizes and two third prizes from the Zhejiang Province Challenge Cup Competition of Science and Technology, which attracted the attention of news media [7].

The civil engineering students have undertaken work on big construction projects, such as Hangzhou Bay Bridge, Zhoushan Mainland-Island Linking Project and the Ningbo International Financial Services Centre. Through working in enterprises, the capacity of civil engineering students was significantly enhanced [8]. The results show that this mode of training promotes holistic education, as well as the students' civil engineering abilities.

CONCLUSIONS

The framework for a new training system was outlined in this article, and the major methods were presented and discussed. Experience has shown that this system improves innovative ability and quality. This framework was designed to help educators develop effective engineering education programmes. As well, it provides an outline of a basic civil engineering curriculum unit and of curriculum options.

ACKNOWLEDGEMENT

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REFERENCES

1. Lin, J., On the professional training program of *a plan for educating and training outstanding engineers*. *Tsinghua J. of Educ.*, 32, **2**, 47-55 (2011).
2. Cao, L., Practice teaching program of training excellent engineer according to the qualification system. *J. of Architecture Educ. in Institution of Higher Learning*, 20, **3**, 30-34 (2011).
3. Chen, J. and Liang, Q., The research of training model of excellence engineer in teaching university of applied civil engineering. *China Construction Educ.*, 6, **11-12**, 35-39 (2010).
4. Xia, J. and Wu, J., Study on practice teaching in education of excellent civil engineering engineer. *J. of Zhejiang University of Science and Technol.*, 22, **5**, 387-391 (2010).

5. Li, Z., Liu, J. and Shang, J., The training and research of the excellent engineers in the civil engineering. *J. of Tianjin Institute of Urban Construction*, 19, **1**, 72-76 (2013).
6. Peng, G., A probe into the practice teaching reform of civil engineering specialty in local universities-a case study of Zhengjiang University of Technology. *Theory and Practice of Educ.*, 33, **36**, 15-17 (2013).
7. Cai, W., Gu, W., Zhu, L., Lv, W. and Dong S., Training engineering undergraduates in building environment and energy. *World Trans. on Engng. and Technol. Educ.*, 11, **4**, 480-483 (2013).
8. Ding, J., A study of deepening school-enterprise cooperation mechanism in civil engineering vocational colleges. *China Higher Educ.*, 28, **5**, 98-101 (2012).