Civil engineering education based on work-integrated learning in China

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ABSTRACT: Work-integrated learning aims to improve personnel training, economic efficiency in enterprises and the employability of graduates. However, this practice has proved to be inadequate for civil engineering in China. Presented in this article are the results of analyses carried out of the current problems of work-integrated learning in civil engineering. Within this context, a series of measures to resolve the problems is proposed and discussed. The measures have, in practice, proved to be effective and the study can provide guidance for similar cases.

INTRODUCTION

Civil engineering is taught in more than 400 universities in China, with more than 300,000 students [1]. Civil engineering includes construction technology, underground engineering, bridge engineering, road engineering and geotechnical engineering. Most universities that provide a civil engineering major offer two or more professional courses. At many universities, civil engineering is a new major and has been in place since 2002. Unfortunately, the teaching experience of those universities is often limited.

Given fierce market competition, the requirement for practical ability in civil engineering graduates has grown and the question of how to improve students' practical ability has become a very real problem for universities. Practical training cannot be achieved without the participation of enterprises. Therefore, work-integrated learning is the inevitable choice for higher education by which to meet the needs of economic and social development.

ORIGIN OF WORK-INTEGRATED LEARNING

The evolution of work-learning can be traced back to 1903 and the *sandwich education* in Sunderland Technical College's Engineering Department [2][3]. After the British *sandwich education mode*, the main idea of which was to alternate academic study with industrial training, the University of Cincinnati in 1906 started a co-operative education programme for engineering students [4][5]. Since then, people have paid more attention to work-learning in higher education [6-8].

In 1983, the World Council and Assembly for Cooperative Education was founded, and renamed in 1991 as the World Association for Cooperative Education (WACE) [9]. The WACE is the only international professional organisation dedicated to developing, expanding, branding and advocating co-operative and work-integrated education programmes within industry and educational institutions. The concept of work-integrated learning was officially formed after discussions in 2000, during which WACE decided to change the name *co-operative education* to *work-integrated learning*, so that the relationship between work and learning within higher education could be more easily understood [10].

THE STATUS OF WORK-INTEGRATED LEARNING IN CIVIL ENGINEERING IN CHINA

Work-integrated learning in civil engineering is a systematic process, and requires co-ordination and co-operation between universities, enterprises and students. In China, where work-integrated learning is put into practice, there are many difficulties that must be confronted. These problems stem from the three bodies involved, viz. universities, enterprises and students.

Universities pay more attention to theory and rarely concern themselves with the skill requirements of enterprises in the areas of production, management and services. Sometimes, university work-integrated learning schemes both in practical content and scheduling do not meet the requirements of enterprises.

Enterprises lack enthusiasm for work-integrated learning programmes because there is no direct economic benefit. In most cases, companies passively accept trainees. Because the trainees are all new, they need more human resources management. Many businesses provide students with internship positions, but there is a lack of management support. Even more common is for businesses to regard students as cheap labour. Hence, internships become a way for enterprises to employ short-term staff, which compromises a student's development.

One characteristic of work-integrated learning is the effective combination of work and learning. Such programmes allow the students to obtain theory, and to receive occupational training by work experience to assist them in beginning their careers. Students are the biggest beneficiary of work-integrated learning. At the same time, it is down to the student to achieve good results. However, some students only work mechanically; sometimes, they simply regard work as learning or learning as work and are unable to link up work and learning organically. Such students have no clear purpose in studying. All of these factors make it difficult to obtain good results in work-integrated learning.

STRATEGY OF WORK-INTEGRATED LEARNING IN CIVIL ENGINEERING

A professional personnel training scheme includes not only the core content, but also the focus and difficulty of the other components. Personnel training schemes should include such necessary elements as a curriculum system, teaching content, teaching methods and practical teaching. Personnel training should begin by considering the economic and social goals, followed by planning and optimisation. Effective mechanisms, whereby enterprises participate in developing a training plan lay the foundation for the long-term co-operation between enterprises and the university. The flow chart for developing professional personnel training in civil engineering is shown in Figure 1.

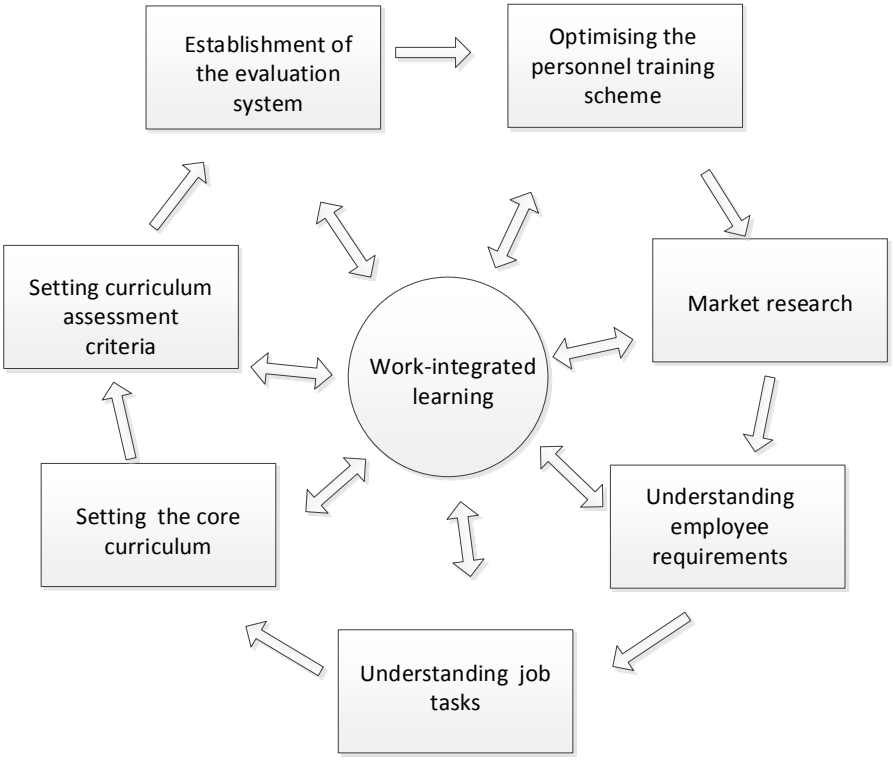

Figure 1: Flow chart of the construction of a personnel training system.

The construction of a civil engineering curriculum must be developed through market research. Teachers should determine the curriculum based on the required knowledge, abilities and qualities required for employability, with a focus on ability and quality.

The teaching team needs to understand the civil engineering industry, and should be able to analyse typical tasks and understand the scope of business after consulting industry experts. This should be so for teachers and students. On this basis the main courses can be determined.

A curriculum standard prescribes the nature, objectives, content, learning objectives and implementation of a course and, it is, therefore, essential that a curriculum standard be developed for professional personnel training. A curriculum standard must address the following objectives:

- Course objectives must reflect the primary work in the field of civil engineering.
- The course content and standards must match civil engineering standards.
- The teaching should combine theoretical and practical knowledge.

The formulation of course standards needs the participation of experts and engineers from the enterprise. The enterprise's technical standards must be reflected in the curriculum. Furthermore, the curriculum assessment objectives should be consistent with the occupational assessment objectives.

For teaching, one of the enterprise's typical projects should be chosen first, so that the teaching reflects an actual situation. Next, the teaching content should be developed jointly by the university and the enterprise. At the end of the course, graduates, as well as the enterprise, could provide feedback to evaluate the teaching content and the process, enabling teaching content to be adjusted accordingly. The process is shown in Figure 2.

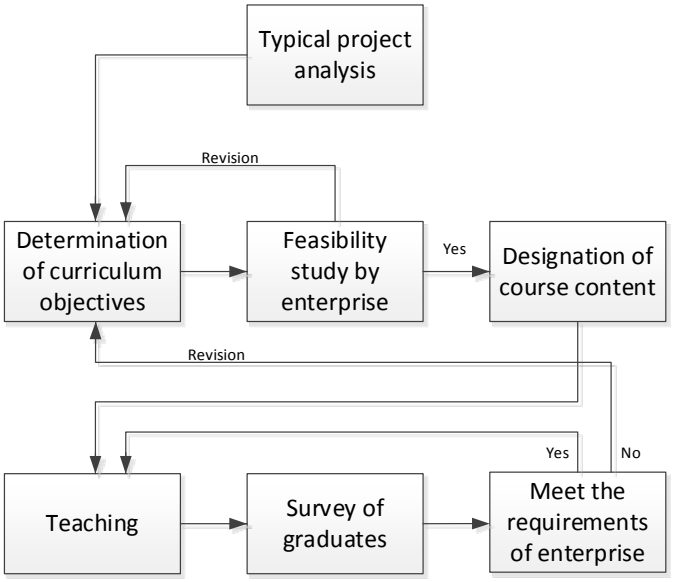

Figure 2: Flow chart of course implementation.

The positions required by the enterprises should be made known during the construction phase. The curriculum would, then, reflect the requirements by the enterprise for specific qualities and skills. Therefore, informed by communication with enterprises, the core curriculum and evaluation system also can be determined.

The construction of a practical teaching system should focus on the professional training objectives of civil engineering. Knowledge and ability cannot be acquired without practice; therefore, it is important to design the practical teaching which enables students to better grasp the professional skills required in their field.

Teaching evaluation should include that of the teachers; students' self-evaluation; peer evaluation and evaluation by the enterprise. The teacher evaluation should reflect the students' mastery of knowledge. The students' self-evaluation is, as the term suggests, students evaluating themselves. Peer evaluation involves teammates evaluating each other. Enterprise evaluation is carried out using criteria set by the enterprise. Attention should be paid to the students' employability and graduate promotion possibilities. The teaching process needs to be evaluated so that the programme can be improved.

In order to verify the work-integrated learning strategy, a tracking survey has been conducted on some of the students in the 2009-10 graduating class of the Civil Engineering Department at the Luoyang Institute of Science and Technology. The co-operating enterprises of civil engineering at the Luoyang Institute of Science and Technology are the China Railway Tunnel Group, the China Railway 15th Bureau Group Corporation and five other enterprises. During each semester, the co-operating enterprises were invited to analyse the teaching objectives and critique the curriculum. The revised curriculum was designed in conjunction with the co-operating enterprises.

There were 112 students in the 2009-10 graduating class in civil engineering, whose specialty was underground engineering. These students were investigated regarding work-integrated learning. The results are shown in Table 1.

From Table 1, it can be observed that the students are satisfied with work-integrated learning and their employability is good. Five co-operating enterprises were also satisfied with work-integrated learning. Indeed, some enterprises have benefited from it. For example, there were eight outstanding students who signed job contracts with the China Railway 15th Bureau Group Corporation after their internships. The China Railway Tunnel Group obtained a useful patent based on the work of students and teachers. Work-integrated learning programmes have proved to be beneficial for the development of students, universities and enterprises based upon five years of tracking of students and enterprises.

Table 1: Results of the investigation of work-integrated learning.

Investigation items	Yes/No
Whether the theoretical curriculum is reasonable or not.	102/10
Whether the practical curriculum is reasonable or not.	106/6
Are you satisfied with the teaching in class?	102/10
Are you satisfied with the practical teaching in the enterprise?	108/4
Did you find related work or not?	103/9

CONCLUSIONS

Work-integrated learning enabled civil engineering students to acquire practical knowledge and skills and make them more employable. A professional personnel-training scheme that better meets the needs of the market and encourages teaching through *learning by doing* can play an active role in sustaining student development. Participating businesses also acquire more potentiality in terms of human resources and innovation, which are beneficial for maintaining and enhancing market competitiveness.

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