Innovation in employment-oriented education for engineering professionals

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ABSTRACT: Educational reform in engineering courses is essential for improving the employment aptitude of engineering graduates and cultivating multi-talented graduates with professional skills and a theoretical foundation. By analysing problems in engineering education in the context of employment-orientation, this study proposes a CSTC (course, student, teacher, college) teaching model. The model has been applied to one class of engineering students, while another class's education continued to be based on the traditional model. Experiment results indicate that the attendance rate, mastery of basic knowledge, ability to obtain skill-oriented certificates and the employment rate of students in the CSTC teaching model have significantly improved. Thus, the CSTC teaching model has some significance and it is relevant to the teachers of engineering courses.

INTRODUCTION

Given the onset of the *knowledge economics age* and demands for national development transformation in China, society has a pressing need for skilled people [1]. An employment-oriented education mode has become an inevitable choice for numerous engineering colleges. The traditional engineering education mode suffers from an increasing number of hard to resolve problems that relate to globalisation, the innovation economy, engineering complexity and the need for human sustainable development. Students perform poorly in engineering practical ability, humanistic attitude, sustainable development capacity and cross-cultural communication competence.

Understanding future development trends in engineering education and cultivating personnel with professional talents, who are adaptive to social needs with strong competitiveness, are some of the most urgent problems that engineering colleges need to address. The challenge for engineering professional education is to undertake relevant educational reform and cultivate people who can adapt to social needs and complete successfully in the labour market [2].

PROBLEMS OF ENGINEERING PROFESSIONAL EDUCATION AGAINST THE BACKGROUND OF EMPLOYMENT-ORIENTED MODE

Lack of Good Linkage between Theoretical Courses and Practical Skills

First, many courses are focused on theory and have no practical characteristics. Colleges also offer numerous liberal education courses, professional basic courses, professional compulsory courses and professional elective courses. In reality, in order to complete the course, students concentrate most of their time and energy on qualification tests. Thus, the effects of the China specialty-cultivation plan are not realised. The teaching plans and course structures formulated by colleges do not provide students with a deep understanding of the field. Course setting based on the traditional framework and plan does not promote talent cultivation. The construction and reform of college courses may become futile, if the emphasis is only on the completion of plans and/or frameworks.

Second, professional engineering education does not support the connection between theoretical courses and practical applications. Theoretical courses and practicum differ in nature and function, but they are not opposites. However, colleges usually divide engineering courses into theoretical courses and practicum, selecting corresponding subjects and activities and, then, relocating them in unified training programmes. This practice makes teaching arrangements relatively clear and easy to implement. However, in terms of talent cultivation and student development, such a division cuts off the inner link between knowledge and skills. For example, many graduates possess the knowledge that matches the job, but they fail to be competent because they lack actual application and mastery.

Ambiguous Professional Engineering Education Concepts, Formalistic Cultivation Plan and Disintegrated Course Contents

Currently, the formalistic cultivation plan of professional engineering education, out-of-date course content and poor linkages between the course system and talent cultivation have become common problems. As such, the professional engineering education reform should concentrate on these key issues. A literature review reveals and, interviews with numerous colleges demonstrate, that the professional cultivation plans of several colleges resemble a castle in the air, because the reform ideas are not reflected in the actual professional engineering courses. Investigations on the present formalistic course setting indicate that integrity and continuity between courses are especially scarce. Nearly all engineering courses are divided into either a module form or block structure. In the traditional course structure, the only known linkage between courses is determined by the condition of preliminary knowledge. Thus, certain courses should be taken before other courses [3]. However, the unreasonable linkage between the course time in engineering majors hinders the real integration of course learning themes.

Lack of Excellent Teachers with double Qualifications and Weak Employment-oriented Teaching Ability

At present, an alarming number of teachers possess limited educational concepts and cannot adapt to the requirements of the times. Engineering majors lack excellent teachers with double qualification and distinguishing characteristics. Teachers are responsible for education that focuses on giving students a fish rather teaching them how to fish. The purpose of tests should be to assess students' ability to solve and analyse problems rather than load their memory with a few rules [4]. Considering the current limits in the time and form of written tests, evaluating students' ability to solve and analyse problems is challenging. Several teachers focus on passive acceptance and easy mastery, while neglecting application and practice, leading to the perpetual junior level of graduates. In addition, passive practice is a serious problem in engineering practice, which results in seriously inadequate abilities to solve actual problems and innovate [5]. Overall, the poor teaching ability of teachers and lack of excellent teachers with double qualifications, negatively affect students' initiative, enthusiasm, creativity and more importantly their active practice ability [6].

Utilitarian Trend to Student Cultivation Targets at Several Engineering Colleges

In recent years, the competitive employment market of college graduates has forced many engineering colleges to adopt an employment-oriented education mode. Although this mode is based on a scientific outlook on development and it adapts to the needs of the market economy, the mode continues to encounter problems in terms of concrete implementation. In employment-oriented engineering education practice, several colleges overemphasise the employment function and focus on the first time employment rate of graduates, which results in narrow and utilitarian educational objectives. Whether students can have essential professional judgments is the premise of engineering professional education. Even if students can master specialised theoretical knowledge, if they do not become reasonable choices for enterprises, what they have learned becomes useless.

At present, the assessment method of students in engineering colleges is the final examination, which is usually in written form. Several colleges adopt a comprehensive assessment method. The final examination, along with students' daily performance, assumes a specific percentage of total assessment. The final grade of a student comes from the integration of both. However, in their focus on employment orientation, a number of teachers are not strict with the final examination and daily assessment. They give students high scores to equip them with strong employment competitiveness. Moreover, the ineffective punishment in cases of student cheating contributes to the delay of their academic maturity.

PROPOSAL OF A CSTC TEACHING MODEL

On the basis of the aforementioned problems in the professional engineering teaching mode, this study proposes a CSTC (course, student, teacher, college) linkage teaching model, which is a teaching model linking the course, student, teacher and the college. This model applies technological innovation to engineering education in the context of employment orientation, realising a new leapfrog development in engineering education.

Talent Cultivation Targets of CSTC

The rapid development of modern science and technology paves the way to new technologies and materials in the engineering field, which requires high competencies of engineering students. Thus, the main talent cultivation targets of engineering education are improving comprehensive qualities and abilities of students in social interaction and public relations, and enhancing the match between students and social needs for talents.

Course System Construction of CSTC

Compiling a new scientific course system is crucial in cultivating students with employment-oriented innovative talent. By analysing the disciplinary characteristics of professional engineering education, this field is established by its own strong technicality, collaborative operation and a single-use orientation. Thus, cultivating students' professional skills

should be given emphasis in the teaching process. Engineering industries usually need to develop engineering materials by the interaction of labour and mechanical equipment, emphasising a need for employees with strong professional qualities. At the same time, the set course system should start from employment requirements, utilising practical training resources inside and outside university and cultivating students' theoretical foundations and professional operation skills. Overall, the course system should be designed to innovate engineering education courses and their settings, use a practical teaching type, enhance communication and cooperation between engineering majors and enterprises, and combine practical training teaching materials with actual practice. According to the above analysis, the specialised course setting for civil engineering (Road and Bridge) is presented in Table 1.

Table 1: Specialised course setting for civil engineering (Road and Bridge).

Professional core courses	Elective courses
Traffic Engineering	Design Principles of Steel Bridge
Roadbed Pavement	Bridge-culvert Hydrology
Road Survey and Design	Pre-stressed Bridge
Bridge Engineering	Bridge Computerised Calculation
Foundation Engineering	Construction
Soil Mechanics	Supervision
Engineering Geology	Typical Engineering Case Analysis
Engineering Economics	Engineering Practice
The mechanics of the three (Theoretical Mechanics, Mechanics of Materials, Structural Mechanics)	

Innovation in CSTC Pedagogy

With the current development of social economy and engineering technology, society proposes new demands for engineering education [7]. Engineering education talent training not only needs solid theoretical foundation, it also requires students to possess rich practical experiences. Therefore, the CSTC linkage teaching model is proposed and a course return to integrated-type engineering practice, including core course setting, situational teaching and theory-practice course model in detail.

Core course setting: courses are the core of students' professional ability cultivation and engineering students should possess strong professional abilities in particular. The core project courses of engineering education are guided by professional job demands for students, and are set around the professional main courses to help students correctly understand their achievements and problems in attitude, ability, knowledge, skill and other aspects, as well as mastering their learning method and improving learning outcomes. The professional teaching and cultivation targets directly aim at students' comprehensive ability and employment competitiveness.

Situational teaching: engineering majors have strong practical abilities, which lead to student difficulties when learning the theoretical knowledge. In teaching courses, a concrete scene or an environment corresponding to the teaching contents should be introduced or set up to induce students' emotional experience, make students understand and arouse their learning enthusiasm. In engineering specialty courses, such as structural geology, learners go to one geographic position where they receive relevant geological information of this particular position and expediently further their learning. A live-action introduction makes students actively think of the problems on the scene, improves student learning interest and explores students' active learning potential. Moreover, actual practice can deepen the students' understanding of business [4].

Theory-practice course model: course setting is directly related to whether students can be directly employed after graduation and their own follow-up development ability. The theory-practice course model involves: 1) students learning subject theories and mastering fundamental mathematics and physics knowledge and specialty basic knowledge at university, such as mathematics and physics basis and circuit principle; and 2) students engaging in practice training courses in enterprises to learn to think like an engineer and form perspectives as an engineer, including design ability, time cost, communication ability, and influences on society and the environment. In the theory-practice course model, subject courses and work experience are conducted alternatively and the non-technology skills and technology skills of students are improved equally.

Teacher Assessment System of CSTC

For the teacher assessment system within the CSTC model, an index is developed in terms of teachers' ethics, job performance, social service and research outcomes demonstrating professional skills. The model comprehensively considers the strategic objectives of university, students' responses and social responses, and transforms a unilateral perspective to a multi-dimensional one by overcoming the simple method and idea of the traditional assessment system. The reformed assessment emphasises the integration of qualitative and quantitative indices, static assessment, and dynamic monitoring, pays attention to the development of university and considers the implementation role of teachers. As such, the assessment system can be visible to students and effectively promote further improvement of

engineering professional teaching quality. Promoting the transformation of teachers and establishing a long-term incentive scheme can guarantee the effective implementation of CSTC teacher cultivation. The teacher assessment system of CSTC is formulated and can be implemented to unite the university development and teachers' self-development, determine the balance between teachers' competition and cooperation, and satisfy the psychological and physical requirements of students with respect, care and incentive. Fully exerting the activity and creativity of teachers can provide powerful support for the development of engineering colleges and universities.

EFFECTS OF THE CSTC TEACHING MODEL ON ENGINEERING EDUCATION

The CSTC linkage teaching model greatly influences engineering education. Taking civil engineering majors at the China Shijiazhuang Railway Institute as an example, two classes of 2010 were selected, with 36 students in each class. One is regarded as a regular (control) class and the other is the experimental class. The regular class adopted traditional teaching modes, whereas the experimental class adopted the CSTC linkage teaching model. After one learning cycle, the results indicate the following:

First, the course interest and activity of students in the experimental class were evidently improved. The class attendance rate of students in the experimental class was 97%, whereas that of students in the regular class was 86% (see Figure 1).

Figure 1: Comparison of attendance rates between two classes of 2010 in civil engineering majors.

Second, in the experimental class, the students' ability to master basic theoretical knowledge was improved. Figure 2 illustrates that only two students in the experimental class failed in the test and the entire class had a passing rate of 94.4%. In contrast, the passing rate of students in the regular class was 77.8%. At the same time, five students had a score of above 90 points in the experimental class, but only one student obtained above 90 points in the regular class.

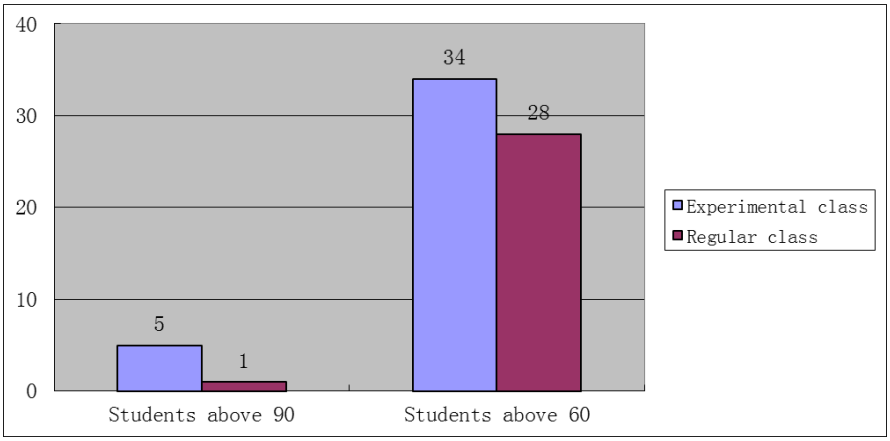

Figure 2: Comparison of students at each score interval between two classes of 2010 in civil engineering majors.

The comparison of students' ability to obtain proficiency certificates between two classes of 2010 in civil engineering majors is shown in Table 2.

Table 2: Comparison of students' ability to obtain proficiency certificates.

Number of proficiency certificates	None	1–3	Above 4
Experimental class	3	27	6
Regular class	11	24	1

Fourth, the employment rate of students in the experimental class was 86%, whereas that of students in the regular class was 65%.

In conclusion, students majoring in civil engineering at the China Shijiazhuang Railway Institute significantly improved their attendance rate, mastery of basic knowledge, ability to obtain skill-oriented certificates and employment rate by the Institute's CSTC teaching model. These results indicate that this teaching model improves students' comprehensive abilities, establishing an active significance to engineering course teaching.

CONCLUSIONS

Employment is an important issue in the lives of university graduates; hence, improving students' employment rate should be the top priority of each university [8]. The CSTC teaching model proposed in this article has significant teaching achievements and can greatly improve the basic knowledge, practical operation ability, learning interest and enthusiasm of students in courses, as well as developing the potential and employment rate of graduates. Therefore, engineering course teaching can produce comprehensive graduates and extend the main functions of professional engineering education in the context of employment orientation by following the CSTC linkage teaching model.

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