Practice of Training Building Industrialization Talents under the Background of New Engineering by Course Reconstruction

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Abstract. Targets of training building industrialization talents under the background of new engineering are to develop the engineering practice ability, innovation ability and cross-border ability. As a part of traditional civil engineering comprehensive experiment course, bending experiment of reinforced concrete (RC) beam was reconstructed based on PC project in this paper. By simulating the stakeholders in the actual project, students' autonomous learning ability is well stimulated. Both traditional professional knowledge and expanded professional knowledge were involved in the new mode. Practice of this paper demonstrate that higher education should be student-centered and design of reconstructed course should conform to the most typical engineering project.

1. Introduction
The fourth industrial revolution puts forward new requirements for the higher education. And higher education for traditional engineering has actively begun to explore the construction of new engineering [1]. In China, “Fudan Consensus”, “Tianda Action” and “Beijing Guide” have been formed to guide the construction of new engineering since February 2017 [2, 3]. The new engineering requires a shift from passive adaptation services to active lead development, from relative division of specialties to cross-border integration, from emphasis on knowledge to engineering ability. Meanwhile, the new-type building industrialization ushered in a period of strategic opportunities. Its distinctive features include standardized design, factory production, assembly construction, integrated decoration, information management and intelligent application [4]. From the perspective of talent training, the requirements of the two are very similar. Therefore, targets of training building industrialization talents under the background of new engineering can be summarized as engineering practice ability, innovation ability and cross-border ability.

Take a complete life cycle of one building for example, it includes perceived need, feasibility study, design and engineering, procurement and construction, start-up for occupancy, operation and maintenance, and disposal of this building [5]. The whole process involves in so much professional knowledge that higher education could not provide very systematic education for each aspect, paradoxically. For traditional civil engineering specialty with engineering design and construction knowledge as the core, extended knowledge such as modern information technology, engineering management, engineering laws and economics must be put on the agenda to meet the needs of the sustainable development of the construction industry. It means that the civil engineering professional curriculum system needs to be reformed and extended.
Bending experiment of reinforced concrete (RC) beam is the most important part of traditional civil engineering comprehensive experiment course. Previous teaching was for professional knowledge. From the perspective of the life cycle of prefabricated buildings, students were given the roles of owner, supervision, production, construction and acceptance. Practice of training prefabricated construction talents under the background of new engineering was carried out by simulating real civil engineering projects in this paper. This kind of mode stimulated most students' independent learning ability. Results indicated that engineering practice ability, innovation ability and cross-border ability were all trained.

2. Course Design
Take the bending experiment of RC beam as the object of course reconstruction, as shown in figure 1. The object is prefabricated concrete (PC) project, which means that the entire implementation process contains the steps of design, produce, transport, construction and operation [6]. For this course, there are six specific steps: (1) The owner formulates the project requirements according to actual situation of the structural laboratory, including the maximum building height, span and load conditions; (2) According to the information provided by the owner and the current specifications, the designer modulates the reinforcement, concrete strength grade and specific dimensions, ensuring that the ultimate bearing capacity and serviceability limit state are met; (3) The producer is responsible for designing and assembling the formwork, preparing the designed concrete, forming the steel bar cage, pouring the beam and its subsequent cure; (4) During step 3, the supervisor will test the moisture content of sand and stone, the material mechanical properties of reinforcement and concrete, and is responsible for the quality control of the entire production process according to supervision rules; (5) The constructor installs concrete beams and various sensors, debug strain measuring instruments, displacement measuring instruments and pressure sensors; (6) Finally, all of the roles are involved in the bending test of PC beams. Each student should submit a test report, which is also the most important part of the previous professional knowledge of this course. In addition, each student needs to share experience including the problems and solutions encountered during the project from the perspective of his role.

From above, traditional professional knowledge and expanded relevant knowledge can be fully exercised by students. In particular, all the project information is integrated into a shared information platform. Thus, each student could get what he needs in time and make decisions. In addition, all knowledges are acquired through self-directed learning and teachers only provide advice. Through the course reconstruction, that is, the transformation and extension of the traditional course, the aforementioned three abilities are cultivated, i.e. engineering practice ability, innovation ability and cross-border ability.

3. Case Study
3.1. Detailed Implementation
104 students were divided into 12 project groups. According to the workload and the five roles specified, a typical group includes 1 owner, 1 designer, 3 producers, 2 supervisors and 2 constructors. Teachers will provide special guidance for students of each role type. Due to the different focus of each role, five teachers were selected to provide course guidance separately.

Firstly, the owner released project requirement document in the course group. Take group-1 for example, the bending capacity of midspan normal section designated by the owner was 6.3 kN·m. The span was 1800 mm, but the height of the section shall not be greater than 220 mm. Choose one concrete strength from C20, C25 and C30. The stirrup was HPB300 and the main reinforcement was HRB400. Design the beam according to single reinforced concrete beam and ensure bending failure before shear failure. And then the designer gave drawings and details in 2 days. The producer got the formwork and steel cage ready for pouring concrete. And they should design the concrete mix proportion too. The supervisor should record all the work of the producer and gave their feedback in
time, aiming at avoiding mistakes to the maximum extent possible. After 28 days standard cure for beam and cubes, the constructor installed the beam and all the instruments. The final loading test was carried out by all the roles and they would give a formal test report. In addition, each role should report on their own work and interactions with other roles during implementation. The process is shown in figure 2a-2f.

3.2. Interactions between Roles

The traditional bending experiment teaching is mostly limited in the analysis of the mechanical properties of concrete beams. While the new course organization mode jumped out of this limitation. The interactions between roles increased greatly, and the initiative of students were stimulated. Most of the contents involved in the implementation of PC project were revealed in the reconstructed course. Mobile communication and BIM were used as the information center in this case. Due to the adoption of a unified information sharing platform, the communications between roles were fast and problems were fed back in time as shown in figure 3.
When necessary information from the owner reached the designer, an information model for beam in Revit was created. Interestingly, not only the owner, but also the producer and the constructor put forward corresponding suggestions considering the practical operations, for example arranging the spacing of main reinforcement, reducing the types of reinforcement, adding stirrup at the support and so on. After all of the requirements were met, the producer designed the concrete standard mix proportion and formulated the construction mix proportion according to the moisture content of sand and stone measured by the supervisor. And the following formwork works, reinforcement works and concrete works were gradually implemented. In this step, the producer made some mistakes and was corrected by the supervisor in time. For example, the deviations of formwork size were too large, no anti expansion measures are taken during pouring. In addition, insufficient anchorage length at the end of steel bar due to wrong calculation of steel bar cutting was found in most groups, and then was rectified. Before bending of beam, many mistakes of the constructor were found out by all the other roles. When the concrete beam was installed on the reaction frame, the supports were not levelled with cement mortar. The cement mortar mixed by some groups did not meet the requirements of current specifications.

![Figure 3. Schematic representation of interactions between roles.](image)

### 3.3. Evaluation

Total score includes score of roles and score of experiment report. In order to evaluate the effect of the new course mode, five teachers rated the work completion of different roles from the perspective of onlookers, including the initial completion score and the final completion score. The basic scores of each group were weighted average by 5 scores, ensuring that the final role scores were fair to members of the same group. As in previous years, another part of total score is the score of experimental report. Figure 4 displayed the average score of 12 groups according to roles. Obviously, the final score of each character is much higher than the initial score, implying the effect of interactions. What is more important, the average score for the experiment report in the past 5 years is 76.4. While the average score after adopting the new model is 82.4 as shown in figure 5, indicating that students’ mastery of professional knowledge has improved.

From the above analysis, interactions between roles helped improve the construction quality as much as possible. Different from the traditional way of cooperation for the purpose of completing experiments, each role would consult relevant specifications or documents first when encountering problems in the new mode and then carry out intense discussions. This kind of immersive participation in PC project stimulated students’ initiative to the greatest extent. Both professional and extended knowledge were practiced better in the new mode, and thus the three abilities were cultivated.
4. Conclusions

The three abilities, i.e., engineering practice ability, innovation ability and cross-border ability are very important to talents under the background of building industrialization and new engineering. Through course reconstruction of bending experiment of reinforced concrete (RC) beam based on PC project, the course reform method and its effect are examined in this paper. Conclusions are as follows:

(1) Traditional professional knowledge and expanded professional knowledge are well learned through course reconstruction. Practice of this course demonstrate that higher education should be student-centered, especially the interactions between students.

(2) Teachers should change their roles from the narrators of knowledge to the guide of students. Purpose of course reform and extension should be to stimulate students' independent learning ability. Design of reconstructed course should conform to the most typical engineering project.

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