Research on Teaching Reform of Civil Engineering Materials Based on Individuation and Interactivity

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Abstract: Teachers should take the initiative to develop specialties of students and drive the progress of the curriculum. The traditional course of civil engineering materials has some obvious problems such as redundant course content, unreasonable scoring assessment mechanism, and low output of post-class practice. As a result, students in the classroom are less motivated and do not get insight into the understanding of this course. To conquer these limitations, this paper aims to optimize the traditional teaching system from three aspects: (1) the teaching method of course teaching, (2) the course evaluation system and (3) the extracurricular practice output. In addition, it also helps to carry out teaching activities for students based on the perspective of individuality and interaction as well as cultivate applied talents. This paper also provides a reference for the innovative teaching model.

1. Introduction
Civil Engineering Materials is a basic professional course for civil engineering education in colleges and universities, and its contents involve various materials commonly used in the field of engineering [1-2]. The courses are mainly offered by civil engineering, road and bridge engineering, river crossing engineering, and architecture. The contents of course would be changed based on different majors. Most universities in China offer this course in the first semester of the second year undergraduate study or in the first semester of sophomore year. It plays a major role in the learning system of civil engineering, and it conforms to the national teaching reform orientation of ‘building energy saving’ [3-5].

For this course, there are some existing challenges including the complicated knowledge points, weak connection between different chapters, and poor planning of the practical links and teaching sessions, due to the special nature of the course itself [6]. Thus students often lack autonomous learning and motivation, just passively accept the traditional “cramming” teaching model. It is difficult to truly develop the students’ practice ability and innovative thinking. Thus, the graduated students are difficult to deal with the practical engineering problems, which is conflict with national education at the present stage [7]. There are many innovative educating methods have been adopted by the researchers in our country to improve the education efficient, referring to the state-of-art education model from foreign countries [8-11]. This mainly includes CDIO concept teaching method [12-13], flipped classroom teaching model [14], interactive teaching method [15-16], case analysis method [17]. The methods presented above attempt to improve students’ learning enthusiasm and innovation, which can enrich the students’ extra-curricular knowledge to some extent.

Thus, the main purpose of this paper is to propose a new education method to deal with the
limitations of existed education mentioned above. More specifically, there are three key categories regarding the education reform: reforming the interaction between teachers and students based on the existed traditional teaching method; introducing the university students’ innovation and entrepreneurship training program into the practical teaching experiment class such as civil engineering materials; adjusting the assessment criteria and mechanism of experimental operation.

2. Problems in Traditional Teaching Programs
Teaching is a key step for student to understand theoretical knowledge, and practice their scientific thinking, improve their application ability and motivate their innovative consciousness. However, the existed teaching model would restrict the thinking mind of student, which is limited inside the classroom. In addition, the students cannot learn more knowledge outside the classroom. Basically, the current teaching model includes five steps: (a) Teachers would arrange the content of course before teaching; (b) Students would get their first look about the civil building materials via some images; (c) Teachers would check whether the students are fully understand the knowledge during the class teaching; (d) Students would join a team to operate some experiments and analyze the experimental results. (e) Teachers would use the final test to examine the learning situation of students.

2.1. The Lectures Are Mainly Demonstration, and Students Are Difficult to Access the Physical Objects
It is well known that the main line of the course of civil engineering materials is based on material science. Taking the civil engineering materials published in China building industry press as an example, the order of its chapters is shown as follow: construction steel, inorganic cementitious materials, cement concrete and mortar, masonry materials, asphalt materials, etc. For the construction materials described in each chapter, teachers often give lectures in the following teaching methods:

- Text + multimedia (PPT)
- Text + multimedia (PPT) + animation (mainly Flash)
- Text + multimedia (PPT) + video (short video within 5 minutes)
- Text + multimedia (PPT) + multiple combination

The main characteristic of these teaching methods is let the teachers to be leading role in the classroom while the students are only the participants. This method pays too much attention to the explanation of theoretical knowledge, but ignores the importance of practical courses for students' learning, which makes it difficult for students to get in touch with the defects of civil materials and engineering experience. The reasons for this situation are as follows: (1) the practical teaching resources are relatively scarce; (2) the course schedule of theoretical and practical courses still needs to be further improved.

2.2. Unreasonable Practice Site and Practice Teaching Planning
The experimental practice of civil engineering materials at current stage is followed the procedures as follow [18-19]. At the beginning, the teacher will generally demonstrate how to operate the experimental equipment and how to record the experimental data. After that, they will let the students to handle the experimental test by themselves. Finally, the teacher will evaluate and score students’ classroom performance according to the experimental report. Table 1 shows the basic experimental courses offered at this stage.

Practical classes are not limited to the above courses, but also include decoration material experiment, masonry material experiment, plastic pipe performance experiment, etc. The traditional experimental class practice class is 3 periods at one time, each period is 45-50 minutes. However, the teacher’s explanation or video demonstration will occupy a lot time of class, the time left for students to practice is only 1-1.5 hours. Students often need to delay the class dismissed or adds lessons after class to complete the experiment. The narrow experimental site and limited experimental funds are also the main reasons that hinder the teaching effect of this experimental course. The above reasons lead to the lack of interest of students in the later stage of the experiment.
Table 1. Basic experiment of civil engineering materials [20-23].

| Experimental project | Partial experiment content |
|----------------------|---------------------------|
| Cement               | Cement specific surface area test, Standard consistency water demand test, etc. |
| Concrete             | Apparent density of sand, Bulk density and screening, Concrete workability test, etc. Concrete block masonry strength measurement |
| Reinforced Steel      | Steel bar tensile test, Cold pull reinforcement, Cold drawing bar aging strengthening experiment |
| Asphalt              | Asphalt penetration; Softening Point; Ductility test |

At the same time, the scores of civil engineering materials practice course only occupy 20%-30% of the total score. The scores of practice course is made of: an experimental report 50% + classroom performance 30% + classroom attendance 20%. The above evaluation system often makes students pay too much attention to the examination part and loses the enthusiasm for practical operation. In addition, the criteria for class performance are not obvious. Some team members can still get high scores even if they do not work hard, which is likely to cause some emotional dissatisfaction for other students who work hard and loss of fairness.

2.3. Less Output after Class with Students Themselves
Innovative teaching methods and skills are the key part for the evolution of engineering course. In the next few years, the new teaching model requires more interactive, intelligent and personalized teaching methods and techniques [24].

The civil engineering materials course should focus on classroom teaching and practice. Since students have less contact with experiments in class, the theory and practice are seriously disjointed. The ‘Output oriented method’ starts from output and ends at output, which pays special attention to the effective evaluation of students’ output results [25]. Traditional teaching mode mainly focuses on input. Not only teachers, but even students themselves will ignore the output after class. The participation of students in after-class practice activities has been statistical analysis based on about 130 civil engineering students. Table 2 indicates that the students who did not participate in after-class practice activities have poor professional instrument operation skills and personal quality cultivation, leading to low classroom evaluation. This also proves that teacher should effectively guide the student how to release ‘learning fatigue’ through practical teaching.

Table 2. Statistical table of the mastery of practical knowledge under the student class [20-23].

| Assessment criteria          | Object of investigation                          | No extracurricular training | Extracurricular training |
|-----------------------------|-------------------------------------------------|----------------------------|--------------------------|
| Experimental skills         | Poor operational ability, more as a team member  | Good operational ability, more as a team leader |
| Report plagiarism rate      | 68%                                             | 21%                        |
| Experimental course grade   | Poor (the score is about 70.8-75.2)              | Good (the score is about 84.6-90.0) |
| Coordination ability        | Poor                                            | Good                       |

3. Teaching Reform Measures for Civil Engineering Materials Course
Based on the teaching problems mention above, how to ‘give a good class’ and how to ‘cultivate a good person’ has become an urgent problem that need to be solved. Thus, the author attempts to propose some relevant curriculum reform measures based on the author’s enrich teaching experience, which is eager to cultivate the students’ personality and increase their interaction.
3.1. Adjustment and Innovation Subject Teaching Method
On the basis of traditional teaching, students should take the initiative to understand the learning method of civil engineering materials. Research teaching practice model can be developed. Firstly, the demonstrative part of the class should be improved. On the one hand, special sample rooms can be set up in the laboratory, which can help teachers to move the teaching facilities into the laboratory and show geotechnical materials such as cement, concrete and lime to students through physical objects. On the other hand, teachers should also make or collect animations and videos of experiments, tests and engineering applications of civil engineering materials. When practical conditions are limited or practical class hours are limited, multimedia teaching method can be adopted to play in class.

In addition, some research teaching activities should be arranged according to the course schedule, in which 4-5 students can be set as a team to attend these activities. The team leader needs to collect the information of all members and submit it to the teacher. The team leader should take responsibility to assign jobs for the members and evaluate the contribution of different members, which will be the basis for the teacher’s final grading.

Teachers can set relevant research emphases according to the teaching content of civil engineering materials course, which can be set according to the arrangement of teaching schedule according to Table 3. According to the discussion content, students are required to complete the data collection, group communication, PPT production, on-site report, etc. They are required to combine the current domestic and foreign research on new technologies and new materials. The teacher takes the role of answering questions and takes 10 minutes at the end of each class for each group to report their work. The research-based learning method can effectively mobilize students’ learning enthusiasm and can be used as the basis for teachers to grade their classroom performance.

Table 3. Civil engineering materials course research teaching activities to carry out class schedule.

| Group | Report content |
|-------|----------------|
|       | Steel | Cement | Concrete | Mortar | Asphalt | Wood |
| 1     | √     |        | √        |        |          |      |
| 2     |        | √      |          | √      |          |      |
| 3     |        |        | √        |        | √        |      |
| 4     |        |        |          | √      |          |      |
| 5     |        |        |          |        | √        |      |
| 6     |        |        |          |        |          | √    |

3.2. Improve the Teaching Evaluation System of Practical Courses
The traditional evaluation system takes the final examination as the main characteristic. Taking the Ningbo Institute of Technology, Zhejiang University as an example, the final examination paper is produced by the teacher, and academic affairs office finally decides which examination paper is used as the final examination, and the remaining one is reserved for make-up examination. The remaining one is limited to the make-up examination. Based on the analysis of students’ review for the final exam, nearly 84.2% of students believe that they can achieve an ideal result in the final exam of civil engineering materials only by rote learning. This is related to the key point of knowledge highlighted by the teacher in the class. At the same time, the high proportion of this key knowledge in the final test would lead to a bad situation where students can get a high score but did not know about practical skills. Moreover, it might generate some student who can achieve high score but low practical ability.

Table 4 shows that the final exam of civil engineering materials. The proportion of experimental operation questions was increased in the exam paper after the reform. There are examples as shown below: listing 3-4 instruments in civil engineering laboratory and explain their functions; Evaluating the laboratory curriculum teaching sentiment and so on; Correcting the mistake that made by the students in the lab. The above methods are conducive to cultivating application-oriented talents of civil engineering specialty, and enhancing students’ enthusiasm for practical course, thus playing a role of
linkage and promotion.

**Table 4.** Civil engineering materials course final exam examination paper score adjustment table.

| The proportion of the score | Choice question | Fill-in questions | Calculation questions | Design questions | Experimental Operational Question |
|-----------------------------|----------------|------------------|----------------------|-----------------|---------------------------------|
| Traditional examination    | (13 questions) 26% | (15 questions) 15% | (2 questions) 39% | (1 questions) 20% | (0 questions) 0% |
| Post-reform examination     | (10 questions) 20% | (10 questions) 10% | (2 questions) 25% | (1 questions) 18% | (2 questions) 27% |

### 3.3 Setting up an Extracurricular Discipline Practice Platform

Student Research Training (SRT) is a project funding plan designed specifically for college students. Students can be independently to complete project research under the guidance of tutors, which can take various forms of research, such as experiments or surveys [26-27]. At present, SRT research platform, which is generally set up by domestic universities based on the scientific research projects of the college and topped by the national innovation and entrepreneurship training program for college students, is a good platform for after-class practice (figure 1). On the one hand, the results can effectively review the classroom knowledge of civil engineering materials and further expand this knowledge. On the other hand, it can significantly improve students’ comprehensive quality and innovation ability for scientific research.

![Figure 1. Schematic diagram of the output of civil engineering materials after class.](image_url)

Table 5 shows that the civil engineering students of the Ningbo Institute of Technology, Zhejiang University applied for university-level innovation training program and national college students’ innovation program in 2018, it can be seen that civil engineering materials are the most welcome projects for the undergraduates. Apart from the differences in the professional guidance of teachers in the sample schools, the subject of civil engineering materials can make it easier for undergraduates to start operation. The main reason is that undergraduate have been exposed to civil engineering material practice course and have a preliminary understanding of how to operate experiments. The teachers should work together to carry out the scientific research training for the students according to their hobby and knowledge foundation.
### Table 5.
Civil engineering students apply for school-level innovation training program and national university student innovation project in 2018.

| Project type            | Number of declarations | Declaration level       |
|-------------------------|-------------------------|-------------------------|
| Civil engineering materials | 6                       | National-level (1), Provincial-level (1), School-level (4) |
| Architectural planning  | 2                       | School-level (2)        |
| Civil software analysis | 1                       | School-level (1)        |
| Structure design        | 1                       | School-level (1)        |

4. Conclusion

In contemporary education and teaching system, the key point in the revolution of education is to cultivate innovative students and motivate their enthusiasm of studying [28]. Through the course teaching reform of civil engineering material curriculum, students can give full play to their dominant position and teachers can be more recognized. In view of the problems existing in the traditional teaching mode of civil engineering materials, figure 2 proposes three improvements to the traditional teaching model from three aspects: course teaching means, course evaluation system and extracurricular practice output. It hopes that this mode can provide reference for the current efficient and innovative teaching mode.

![Flow chart of civil engineering materials teaching mode](image)

**Figure 2.** Flow chart of civil engineering materials teaching mode.

Under the latest practical teaching mode of civil engineering materials, students can apply the knowledge in class to their future career. At the same time, with the advent of the era of information technology, more and more multimedia and remote teaching technologies have been introduced into the classroom [29-30]. How to apply these technologies to the teaching of civil engineering materials will also be a major point for future consideration.
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