Exploration and Practice of Blended Teaching Mode Based on Information Technology in Civil Engineering Materials Experimental Teaching

Jie Zhang[1*], Feng Wang[1] and Tao Wu[1]

[1]*Key Laboratory of Building Structure of Anhui Higher Education Institutes, Anhui Xinhua University, Hefei 230088, China*
zhangjie@axhu.edu.cn, wangfeng0706@163.com, taoxia201@163.com

Abstract
This paper takes the civil engineering materials experimental course as the research object, uses the information platform and virtual simulation software to carry out the blended teaching, evaluates the learning effect and rule, explores the effect of mixed teaching in the experiment course, and discusses the possibility of promoting the blended teaching mode. Firstly, the three-dimensional teaching objectives of the civil engineering materials experiment course and the course contents supporting these objectives are designed. Then, the comprehensive experiment of "dynamic constitutive relationship of steel fiber reinforced concrete under impact load", which reflects the transformation of scientific research achievements in the forefront of discipline development, is introduced into the experimental teaching of civil engineering materials. This method enriches the teaching means, makes the concept more intuitive and visual, stimulates students' interest in learning, and cultivates students' ability to analyze engineering problems by integrating theory with practice.

Keywords: *Civil engineering materials experiment teaching, blended teaching, teaching mode, virtual simulation experiment platform*

1 INTRODUCTION

With the rapid development of information technology and the combination of Internet technology and higher education, great changes have taken place in teaching ideas and teaching methods in the new era. One of the changes is blended teaching, that is, combine the advantages of traditional teaching methods and online learning, fully realize the mixing of learning resources, learning environment and learning methods, and finally improve students' learning efficiency and effect [3] [5] [8].

Civil engineering material is a practical science. The rapid development of materials technology puts forward new requirements for the teaching of experimental courses in Contemporary Colleges and universities, which makes the teaching reform of experimental courses a prominent problem. Taking the small restricted online course (SPOC) teaching class of "civil engineering materials" experimental course as an example, according to the characteristics of students, a teaching method is established, which takes students' independent learning as the main body, teachers' guidance as the auxiliary, combines online learning with conventional experimental teaching, and combines the traditional civil engineering materials experimental course with online network learning. Through three years of online and offline interactive website blended teaching practice, we analysed the learning effect, summarized the learning rules, and collected students' feedback information. We found that this teaching model is a very suitable teaching method for college students, with good student foundation and the characteristics of the information age.

Research shows that blended teaching can improve students' learning experience and learning effectiveness, and make students learn more effectively [1] [7]. In 2013, it began to promote the construction of resource sharing courses. The experimental courses represented by the "basic biology experiment" of Jilin University carried out online resource construction on the "i Course" platform and faced domestic sharing. From then on, it opened the prelude to the online and offline blended sharing teaching of experimental courses in

B. Fox et al. (Eds.): IC-ICAIE 2022, AHCS 9, pp. 889-894, 2023.
https://doi.org/10.2991/978-94-6463-040-4_134

domestic universities. The experimental course of civil engineering materials in our university takes this opportunity to constantly explore the introduction and integration of modern educational technology. Make use of the advantages of online teaching to make up for the shortcomings of experimental teaching.

2 BLENDED TEACHING MODE DESIGN OF CIVIL ENGINEERING MATERIALS EXPERIMENTAL COURSE

As shown in Figure 1, the three-dimensional teaching objectives of civil engineering materials experimental course are composed of knowledge and skill objectives, process and method objectives and emotion, attitude and values objectives. According to the course objectives, the civil engineering materials experimental course is provided with teaching projects such as basic skill experiment, comprehensive experiment, virtual simulation experiment and design experiment (Figure 2). The course cultivates students' basic experimental operation ability through basic skill experiments, and cultivates students' experimental theoretical knowledge and high-order experimental skills through comprehensive experiments and virtual simulation experiments that are transformed from teachers' scientific research achievements and reflect the forefront of disciplines.

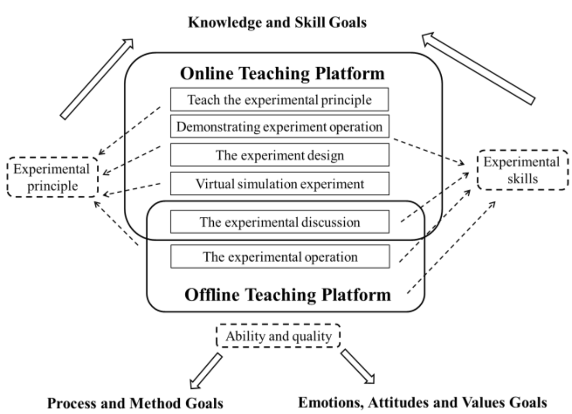


Figure 1: Teaching goals of experimental course corresponding to blended teaching platform.

The online learning platform built by making theory explanation video, experiment demonstration video, virtual simulation experiment and other digital resources can enable students to learn the experimental principle and understand the experimental operation process in advance before classroom practice [2] [4]. The virtual simulation technology can also be used to develop high-risk experiments, irreversible experiments and large-scale training projects that cannot be built in the laboratory, so that students can learn experimental knowledge and cultivate preliminary operation skills in the virtual environment [6]. The online teaching platform of the course consists of theory and demonstration teaching platform and virtual simulation experiment teaching platform. The civil engineering materials experiment course based on the information platform can realize the functions of experiment principle teaching, experiment operation demonstration, design experiment teaching and online experiment discussion. The virtual simulation experiment platform developed by Beijing Yige Tongzhi Simulation Technology Co., Ltd. has the functions of experimental scheme design and virtual experiment operation.

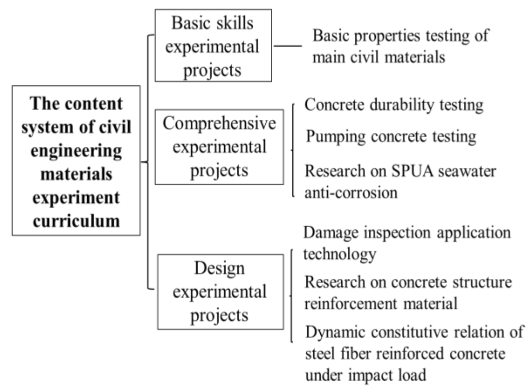


Figure 2: The contents of civil engineering materials experimental course.

3 IMPLEMENTATION CASES OF BLENDED EXPERIMENTAL TEACHING

This course has designed an experimental teaching process to make online and offline teaching deeply integrated. Through the information platform and virtual simulation software, the teaching of experimental principles, the demonstration of experimental operations, and the design of experimental operation schemes, the knowledge-based teaching objectives among the knowledge and skill objectives are realized. Basic skill experiments, comprehensive experiments and other practical projects are mainly carried out by relying on offline classes, focusing on the completion of skill teaching objectives. Through course design and discussion, organization and management of teaching process, emotional blending between teachers and students, moral infection, we can achieve the experiential teaching objectives of process and method, emotion, attitude, values, etc.

The civil engineering materials experiment course is mainly divided into three modules: (1) basic experimental technology: including the basic properties testing of main civil materials; (2) comprehensive test module, mainly including concrete durability testing, pumping concrete testing, research on SPUA seawater anti-corrosion. (3) The design test module is mainly transformed from the teachers' scientific research achievements, including damage inspection application technology, research on concrete structure reinforcement material, and dynamic constitutive relation of steel fiber reinforced concrete under impact load. According to the experimental contents of different modules, the emphasis of blended teaching design is different. Taking the "dynamic constitutive relation of steel fiber reinforced concrete under impact load" in the third module as an example, the blended teaching design includes three parts: self-study in pre-class, classroom practice and sublimation after class.

3.1 Experimental Theory Teaching Through Blended Classroom

First of all, the test tasks were assigned to each group, including the key points of concrete mix design, the volume content of steel fiber, the operation of split Hopkinson pressure bar (SHPB) device, and the design of experimental scheme. Each group of students is question oriented, learning materials such as website videos and courseware, and looking for answers to questions. In this process, students report and discuss the concrete mix proportion calculation scheme and determine the steel fiber volume content through the information platform.

3.2 Cultivating Experimental Operation Ability by Combining Deficiency with Reality

At class time, each group of students will report the experimental scheme and introduce the division of labour arrangement within the group. This is the first blended teaching practice. In particular, the students who are the first to explain are generally unable to get to the point and find the key points. However, the characteristic of the experimental course is that there should be no ambiguity, because it is followed by hands-on experimental operation. It is necessary to practically guide students to find specific executable work plans through thinking, so as to promote the experiment in an orderly manner in the following work. The students' thinking runs at a high speed in questioning, thinking and designing schemes. Finally, each group member is required to have a 10 minute discussion. The teacher can start the actual operation only after asking a member at random to clearly state the final implementation scheme of the group.

Students learned the specific operating principles and steps of SHPB through the virtual platform. The experimental parameters were determined through discussion. Finally, it is determined that the SHPB experiment is launched with the Φ75mm-diameter SHPB experimental system, as illustrated in Figure 3. The experiment of typical stress wave pulse signal is shown in Figure 4. The stress-strain curves of 6 groups of concrete with different steel fiber volume contents are obtained as shown in Figure 5. Due to the large number of experimental courses and the large number of skill points included in the courses, it is difficult to comprehensively evaluate the individual's mastery of many skill points. By reviewing the experimental operation videos recorded by students themselves, students' mastery of experimental skills can be comprehensively evaluated.

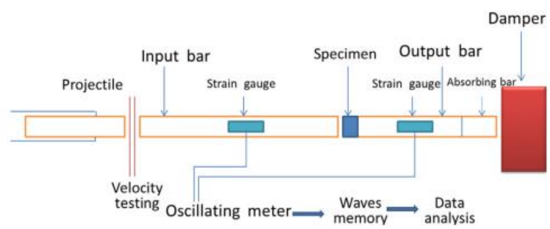


Figure 3: SHPB apparatus.

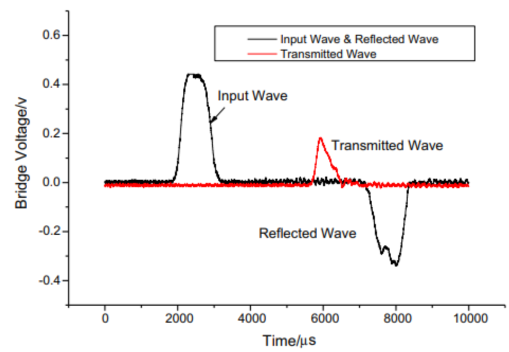
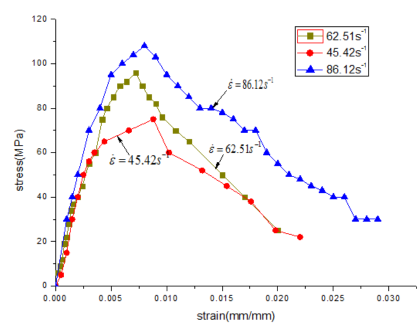
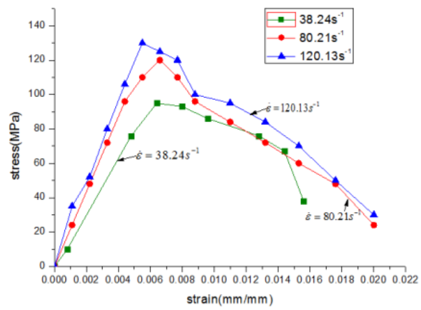


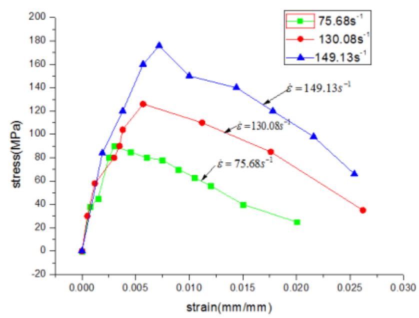
Figure 4: SHPB experimental measurement bridge voltage pulse waveform.



(a) SFRC ($V_f = 0\%$).



(b) SFRC ($V_f = 0.75\%$).



(c) SFRC ($V_f = 1.5\%$).

Figure 5: Stress–strain curves under different steel fiber contents and strain rates.

3.3 Improvement of Comprehensive capability

This experiment is not simply to determine the stress–strain curves under different steel fiber contents and strain rates. In the data analysis stage, students are guided to propose and fit the constitutive relationship of steel fiber reinforced concrete. On the basis of the stress–strain curve of materials, the theory of phenomenology, the consistency and regularity of stress–strain curves, and the random statistical distribution hypothesis for the SFRC strength, the strain rate effect is introduced, and a constitutive model is proposed in the following equation (1).

$$\begin{cases} \sigma = \mathrm{E}\varepsilon, & \varepsilon \le 0.7\varepsilon_b \\ \sigma = \mathrm{E}\varepsilon(1-D), & \varepsilon > 0.7\varepsilon_b \end{cases} \quad (1)$$

ε_b represents the strain at the peak stress. D refers to damage amount, which is expressed by equation (2).

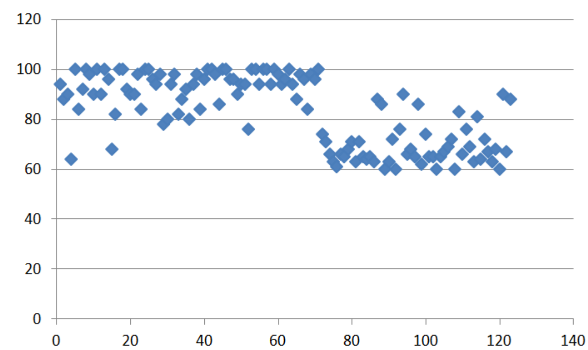
$$D = 1 - \exp\left[-\frac{(\varepsilon - 0.7\varepsilon_b)^{k_1}}{10^{-4}}\right] \quad (2)$$

In order to obtain the value of the material constant k_1, we use the constitutive equations (1) and (2) to test the stress-strain of three groups of different steel fiber contents. This will become the topic of discussion and analysis, the content of sublimating thinking and deepening learning after class. Students with a unique analytical perspective will effectively improve the quality of experimental reports.

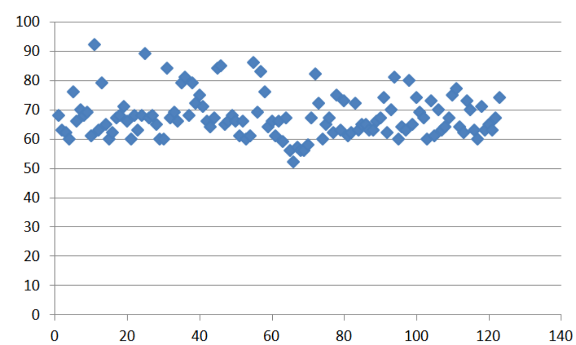
4 TEACHING EFFECT EVALUATION

In the process of teaching, formative evaluation and summative evaluation are used to evaluate the teaching effect of the course. The formative evaluation of students' experimental process is carried out from three dimensions: pre-class preparation (30%), classroom performance (30%), and experimental results (40%).

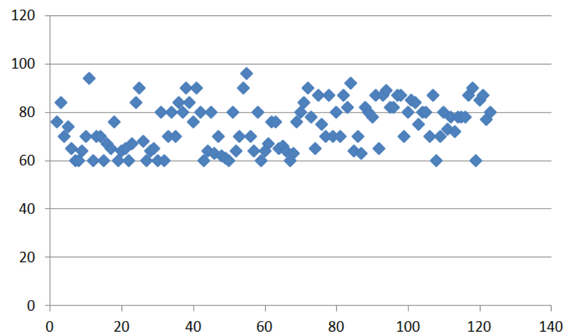
A total of 127 students in three consecutive civil engineering materials experiments were taught in a blended way. The data were collected and analysed from three factors: pre-class performance, experimental operation and experimental results, showing the learning rules under the blended teaching and making a scatter diagram (Figure 6).



(a) Pre-class preparation.



(b) Classroom performance.



(c) Experimental results.

Figure 6: Scatter diagram of evaluation indicators (the abscissa represents the number of students arranged by student number, and the ordinate represents the score).

Pre-class scores include experimental preview and experimental scheme design. This part reflects students' willingness to learn independently and their self-learning ability. The average score of this project reaches 82 points, indicating that most students can independently complete pre class preview tasks, which reflects that most students have certain learning initiative. The scatter chart also shows convergence and is concentrated in higher score segments (Figure 6(a)). Classroom performance includes experimental habits and on-site operation. The average score of this indicator basically reaches 70. The scatter diagram shows that the degree of dispersion is slightly higher, indicating that the performance of this part of students is different (Figure 6(b)). The scores of this part directly reflect the level of students' individual abilities. The experimental results mainly include the experimental report and operation video. This indicator mainly measures the students' group cooperation ability and comprehensive ability to solve practical problems. The average score of this indicator is basically 80 points. The scatter diagram shows that the degree of dispersion of this part of students is slightly higher, indicating that there is a difference in the degree of representation of this part of students (Figure 6(c)). Most students can truly master the experimental operation steps, understand and write the experimental report.

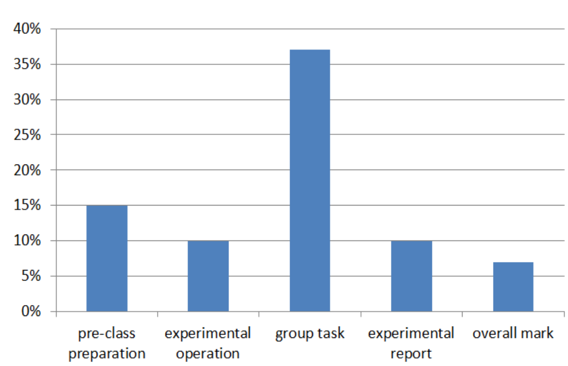


Figure 7: Analysis of performance increase difference.

Comprehensively analyse the three factors studied, and take pre-class preparation, experimental operation, group task (experimental scheme design, operation video production, Video Comments) and experimental report as the indicators of in-depth learning. Select the ratio of the index data of the top 30% and the bottom 30% students to the average to analyze the growth difference. In various data statistics, if the growth difference exceeds 5%, the growth performance is significant (Figure 7). Among the four factors studied, pre class preparation and group tasks showed the most significant growth, with group tasks showing the most significant growth, exceeding 35%, indicating that students with in-depth learning have stronger group cooperation ability and comprehensive ability to solve practical problems, and are excellent in various indicators. The difference in the increase of final scores indicates that these students who study deeply eventually get better scores.

5 CONCLUSIONS

The basic, comprehensive and design experimental projects of the civil engineering materials experiment curriculum enable students to form comprehensive ability to solve problems while mastering basic knowledge and skills. Through discussion, students can digest and absorb knowledge, transform knowledge into ability, and support the high-level nature of the course. The course will transform the scientific research achievements that can reflect the frontier of discipline development into teaching experiment projects. It provides students with personalized learning opportunities by setting up exploratory and design experimental projects. The blended teaching mode is adopted to improve the interactivity in the teaching process, improve the teaching effect of the course, and support the innovation of the course. In the teaching process, teachers are required to prepare rich online learning resources before class to help students better understand the course content; The students are required to explain the learned knowledge through video after learning, and score and evaluate the explanations of other students, which increases the challenge of course teaching and learning.

ACKNOWLEDGEMENTS

The research described in this paper was sponsored by Quality engineering project of Anhui Province (2020jyxm0791, 2020xsxxkc225, 2021jyxm0610, 2021jyxm0612, 2021jyxm0607). At the same time, thanks for the support of Key Laboratory of Building the research results can only be used as a reference, and the teaching design scheme needs to be combined with specific practical application to continue to improve.

REFERENCES

[1] Eryilmaz M. (2015). The effectiveness of blended learning environments. Contemp. Issues. Educ. Res. CIER. 08(04), 251-256.

[2] Hall S, Villareal D. (2015). The hybrid advantage: graduate student perspectives of hybrid education courses. IUJTLHE. 27(01), 69-80.

[3] Han J. (2020). Online courses promote teaching innovation in Higher Education. Educational Research. 41(08), 22-26.

[4] Li M. (2018). Exploration and practice of blended learning teaching based on superstar online class. Henan Education (Higher Education Press). (05), 74-76.

[5] Lin Y. W., Tseng C. L., Chiang P. J. (2017). The effect of blended learning in mathematics course. EURASIA J Math Sci. Technol. Educ. 13(03), 741-770.

[6] Tang H. F., Liu Y., Yan G. D. (2020). Carrying out online and offline mixed teaching to boost opening large-scale instruments to undergraduates. Experimental Technology and Management. 37(11), 174-177.

[7] Wai C. C., Seng E. L. (2015). Measuring the effectiveness of blended learning environment: a case study in Malaysia. Education Inf. Technol. 20(03), 429-443.

[8] Wu Y. (2018). Build and make good use of the national excellent online open course, and strive to write the "striving pen" of higher education. China University Teaching. (01), 7-9.