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College Teaching Innovation from the Perspective of Sustainable Development: The Construction and Twelve-Year Practice of the 2P3E4R System

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Abstract: It is imperative to construct high-level, innovative and challenging courses in the teaching of colleges and universities. It is also of great significance to explore innovative teaching methods for improving students' learning effect. In this paper, the course "Civil Engineering Construction" of a civil engineering major is taken as a reform example. In this teaching-innovation mode, guided by students' moral education and students' achievements, and the course platform is built in order to achieve the education concept of sustainable development and cultivate applied talents who can solve complex problems in civil engineering. In teaching practice, "Dual Platforms", which combines course teaching platform and virtual simulation platform, is built mainly to expand the learning approaches. The "Three Educations" mode, which combines on-site education, classroom education, and mental health education, is established to improve the comprehensive quality of students. Comprehensive academic evaluation is carried out through "Four Reports", including an open assignment report, special technical study report, BIM (building information modeling) technical work report, and final comprehensive written test report. Through studying this course, students not only master the knowledge of civil engineering construction, but also acquire knowledge-innovation ability, such as thesis publication, patent writing, discipline competition, and cultivating the craftsman spirit and social responsibility to abide by professional ethics in future work. This teaching innovation mode has been implemented for 12 years and achieved excellent results in cultivating students' intelligent ability for sustainable development. It has been promoted in 14 courses, and has certain reference significance for engineering-course teaching.

Keywords: teaching innovation; virtual simulation; sustainable development; mental-health education

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1. Introduction

As an agreement for the mutual recognition of engineering-education undergraduate degrees, The Washington Accord aims to promote the mutual recognition of engineering degrees and international mobility of engineering technicians through multilateral recognition of engineering education qualifications. Engineering-education quality standards are the core of engineering-education accreditation and the basis for the mutual recognition of academic qualifications. According to The Washington Accord, colleges and universities should track and evaluate students' performance in the entire learning process, regularly carry out course-system setting and quality evaluation, and establish an evaluation mechanism for the achievement of graduation requirements. Course setting should be designed to effectively support the achievement of graduation requirements, and the course-system design must involve the participation of enterprise or industry experts. It is necessary to set up a complete teaching system, and cooperate with enterprises to carry out practice and training, and cultivate students' practical ability and innovation ability, as well as

students' engineering awareness, collaborative spirit, and ability to comprehensively apply the knowledge they have learned to solve practical problems. Therefore, course teaching needs to innovate the aspects of teaching-platform construction, mental-health and professional-spirit education, and process assessment, to evaluate students in a holistic way.

In recent years, China has actively and effectively promoted teaching innovation in colleges and universities. In June 2018, Minister Chen Baosheng of the Ministry of Education proposed for the first time, at the National Conference on Undergraduate Education in Colleges and Universities in the New Era, that we should effectively "increase the burden" on college students, improve their academic challenge, reasonably increase the difficulty and expand the depth of courses. In 2018, 40 articles of higher education in the new era opened a new chapter in promoting a revolution in classroom teaching. Then, in 2019, the quality of undergraduate education reform was 22 articles, and the "Double Ten-Thousand Plan" for the construction of national and provincial first-class courses was put forward. Education informatization has become an indispensable means, and virtual simulation technology has opened up a new path for teaching reform with the advantages of intuitiveness, operability and repeatability. Virtual-simulation teaching can enable students to carry out safe and economically repeatable simulation practice operations in an open, independent and interactive virtual environment, helping students to deeply understand the complex construction technology and professional norms of civil engineering, and effectively improving teaching efficiency and teaching effect. With the rapid development of the marketization of construction industry and building information technology, the business scale and demand on civil engineering construction management are also rapidly expanding, and the demand for improving work efficiency, reducing error rates, and improving construction management quality and information management and utilization, are also increasing [1]. Under such a new situation, the teaching content and teaching mode of courses should closely follow the development of industry, adapt to the requirements of revolutionary changes in methods of knowledge acquisition and teaching under the condition of informatization, and deepen the deep integration of information technology and education and teaching, so as to meet the high goals and high requirements of the new era and new engineering.

In December 2017, the General Office of the State Council issued "Several Opinions on Deepening the Integration of Industry and Education", comprehensively implementing the overall goal of "school–enterprise cooperative education". In 2018, the Ministry of Education launched the industry–university cooperative education project, which aims to promote the reform of talent training in colleges and universities with the latest needs of industrial and technological development. At present, the emergence of new concepts in BIM (building information modeling), prefabrication and other industries has brought challenges to students' learning and application of knowledge on courses, as well as challenges to teachers' teaching. How to use the OBE (outcome-based education) teaching concept to realize the cultivation of new engineering talents, how to integrate the emotional-value goals of the course into industry–university cooperation, and how to achieve university teaching innovation from the perspective of sustainable development, are worthy of our in-depth consideration.

2. Literature Research

Many scholars have conducted in-depth research on this subject. Lee [2] proposed one kind of augmented-reality learning method and conducted an experiment to test its effect. The results show that the use of augmented reality not only effectively improves students' self-efficacy, but also reduces their cognitive load. The implementation of augmented-reality technology in certification courses is conducive to learning outcomes.

Deng's research [3] acknowledged that students' self-evaluation is an important alternative outcome measure in massive open online courses, and emphasized that the careful design of teaching conditions can give learners some psychological challenges and stimuli, which is more conducive to their comprehensive understanding of the content.

Konrad [4] reported that diverse interactions among students, instructors, stakeholders, and mentors are more conducive to cultivating students' key competencies in sustainable development. Using this approach, course instructors can consciously use interaction with students, instructors, stakeholders, and mentors in project-based sustainability courses to cultivate students' ability to cooperate successfully in teams and with stakeholders.

Sanchez-Almeida and Sandoval Palis [5] adopt the method of factor analysis and principal component extraction, and consider four factors: teaching development and planning, teacher–student relationship, evaluation and global evaluation, and propose a university-teaching evaluation process for higher education systems.

Formative assessment and cooperative work are teaching methods based on peer support to promote students' learning. They can not only solve problems, but also identify errors through feedback. Revilla Cuesta [6] analyzed the practical experience of 49 students majoring in mechanical engineering at Burgos University in a technical discipline. The results show that these teaching methods are particularly conducive to promoting autonomous learning, cultivating teamwork skills, and cultivating engineers with correct knowledge and skills for today's world.

"Civil Engineering Construction", as the first stage of the professional-practice ability, has become the first choice of teaching-mode innovation for the civil engineering major. In order to realize the effective innovation and application of the course teaching mode, we carried out a lot of active exploration. This paper will take the course "Civil Engineering Construction" of the civil engineering major as an example to discuss and analyze the student-centered teaching innovation method and practice of the "Dual Platforms, Three Educations, Four Reports", namely, **2P3E4R system**, providing an important reference for engineering courses teaching.

3. Basic Information of the Civil Engineering Construction Course

3.1. Main Content

Shaoxing University aims to build a high-level application-oriented university with distinctive characteristics based in Zhejiang, and cultivate high-quality applied talents with a high sense of responsibility, solid professional knowledge and skills, and the ability to creatively solve complex practical problems in their major. The training goal of the civil engineering major is to cultivate senior applied talents who can creatively solve complex engineering and technical problems in the fields of civil-engineering survey, design, and construction with information technology.

According to the university's orientation and professional training objectives, the "Civil Engineering Construction" course is the core course of civil engineering major, with 56 credit hours and 3.5 credits. It is recommended for students to take it in their fifth semester at the university. The course mainly explores the main types of construction technology and methods in civil-engineering construction, the development and application of new technologies, new materials, and new processes in construction, as well as the scientific and reasonable organization principles and methods of construction projects. It contains 12 chapters in two parts: civil engineering construction technology and construction organization. Construction technology, specifically, includes: earthwork, foundation engineering, masonry engineering, concrete engineering, decoration engineering, waterproofing engineering, installation engineering, building industrialization, bridge engineering, and road engineering. Construction organization, specifically, includes: construction organization principle, construction network plan. In recent years, we have reconstructed and divided the course content to be task driven, and the basic content and teaching requirements are shown in Figure 1.

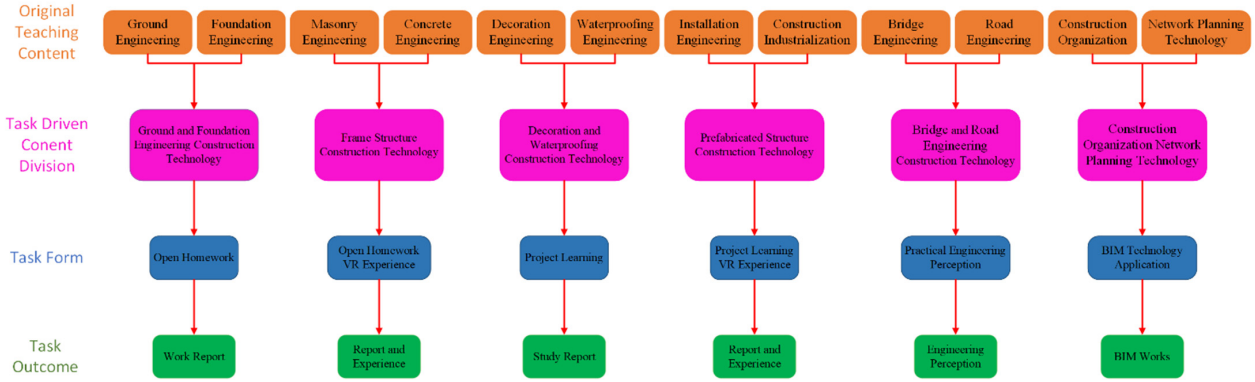

Figure 1. Restructuring diagram of course content to be task driven.

3.2. Main Objectives

The role of the instructor is to promote learning, not to provide knowledge by presenting solutions. Taking the construction technology of Tishk International University as an example, Shareef [7] proposed a teaching/learning framework based on problem-based learning (PBL), a constructivist teaching method and design, so that students can learn technology courses in a way that promotes sustainable and autonomous learning. The results show that, through a variety of teaching methods including autonomous learning, the problem of unclear definitions is solved, and the fun of learning various subjects is improved. This approach provides students with technical knowledge and enables them to benefit from a sustainable learning experience and professional life after graduation.

Combined with the university's orientation and professional-talent training requirements, with the focus on cultivating students' professional ability for sustainable development, the objectives of this course mainly include the following three points.

(1) Knowledge objective. Students are able to use the basic principles of civil-engineering construction to select construction methods suitable for project characteristics and innovate construction techniques; in addition, they can use new network-planning techniques and optimization theories to creatively design the construction organization of engineering projects.
(2) Ability objective. Students shall have the ability to use the theoretical knowledge of construction to solve technical problems encountered in the project construction site, have the ability to use information management tools for construction organization and have the ability to continuously innovate in engineering construction.
(3) Emotional value objective. Students shall have a healthy psychological quality and a sense of social responsibility, have excellent moral quality in work and life, and can carry forward the ultimate craftsman spirit in construction technology and management [8].

3.3. Course Development and Effectiveness

In the course of development, this course has been continuously improved, with a variety of achievements during each stage and large-scale improvement in the course level, creating a high-quality engineering-education learning community that integrates professional education and mental-health education. This course won the school-level key construction course in 2010, the municipal-level excellent course in 2016, the provincial-level first-class course and the collaborative education project of the Ministry of Education in 2019, and the second prize in the Teacher Teaching Innovation Competition of Zhejiang Province in 2021. The course teaching team has won the award of Excellent Grassroots Teaching Organization. The main development process of this course is shown in Figure 2, indicating that the curriculum construction system has experienced continuous improvement for 12 years from 2010 to 2021.

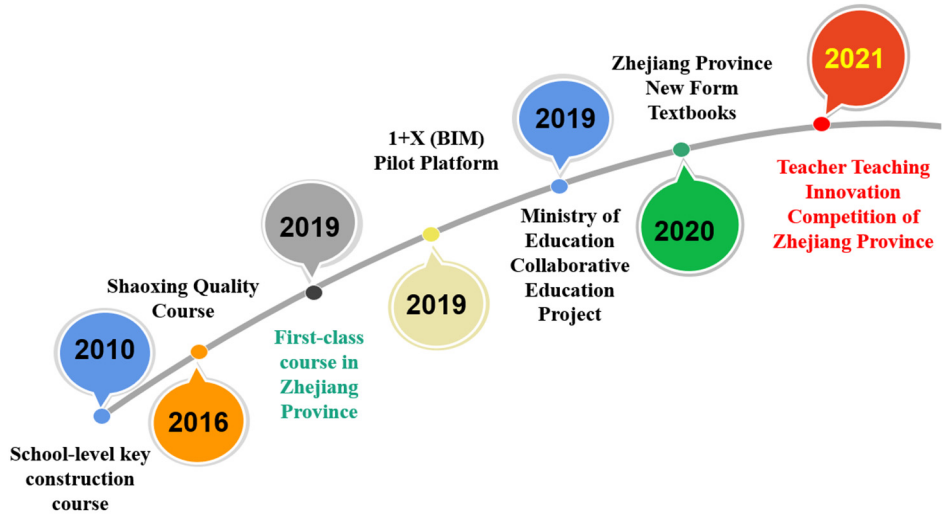

Figure 2. Course innovation and development process.

4. Analysis of Teaching Pain Points and Countermeasures

4.1. Teaching Pain Points

(1) Teaching mode. The construction technology of civil engineering is relatively abstract and the industry is developing rapidly. There is a lag in the integration of cutting-edge technologies into classroom teaching. The traditional teaching mode is insufficient in terms of personalization and innovation, and cannot well support the new engineering goal of cultivating students' ability to solve complex engineering problems.

(2) Students' active-learning ability. Students are mostly passive learners and lack the ability to effectively use all-media three-dimensional teaching resources for active learning, and their self-improvement ability needs to be strengthened.

(3) Students' engineering-thinking ability. Due to a lack of synergy between out-of-class practice and in-class teaching, students' actual perception of the construction process is insufficient and their practical ability is weak. Therefore, students' engineering-thinking ability needs to be further strengthened.

4.2. Countermeasure Analysis

Huang [9] developed the "virtual reality welding course" with students as the main participants, and implemented experimental teaching during a case study with 34 first-year students, with electric welding practice as the research object. The results showed that most students expressed positive affirmation for the learning effect of the virtual-reality-assisted welding course, and their final examination scores at welding practice were significantly higher than those of a mid-term examination. Therefore, virtual reality is an effective method to solve the problem. The main countermeasure of this study is listed as:

(1) A virtual simulation platform and construction-site learning can help to solve the problem of students' weak practical ability.

(2) We help students to form a good knowledge system and professional ethics and a craftsman spirit through activities such as industry elites entering the classroom, team learning, and open assignments.

(3) Through project studies, submitting BIM technical team tasks and other activities, students will have the ability to innovate in civil-engineering construction technology and management.

5. Innovative Thinking and Teaching Practice

5.1. Innovative Thinking

With moral education as the foundation, as well as being student-centered and achievement-oriented, the course platform was built according to the FD-QM (Fudan

University-Quality Matters) standard to realize the integration of practice base, classroom teaching and mental health, so as to cultivate applied talents with sustainable professional ability to solve complex problems in civil engineering. It adopts "Dual Platforms" to expand learning methods, "Three Educations" to improve comprehensive quality, "Four Reports" to carry out comprehensive academic evaluation, and practices a teaching mode that is "high-level, innovation, challenging". The innovative thinking of the course is shown in Figure 3.

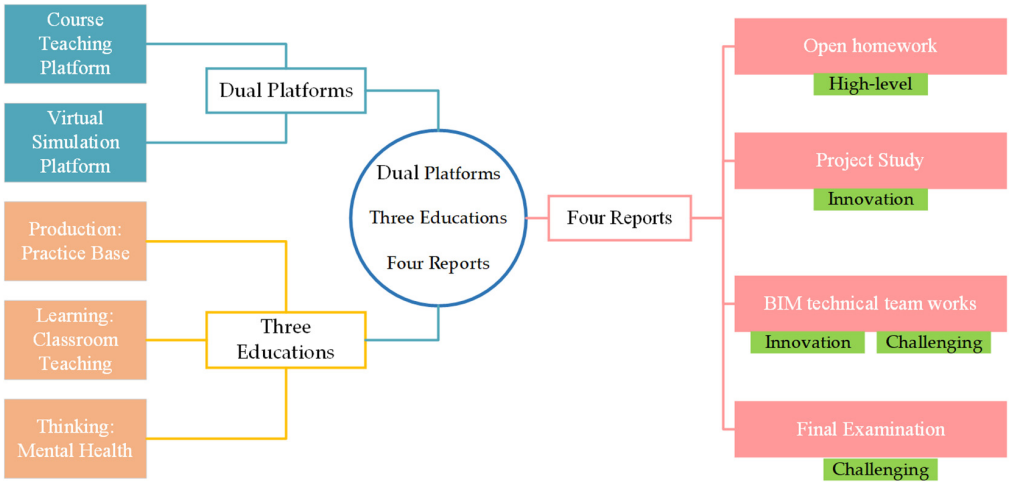

Figure 3. Course innovative thinking.

5.2. Teaching Practice

5.2.1. Dual Platforms

The first teaching platform is the Chaoxing Fanya platform. It is not only a platform for data uploading, but also maximizes the information technology of the teaching website by flexibly using its various functions such as discussion, quick answer, test and PBL in class.

The second teaching platform is the virtual simulation laboratory. Virtual-simulation technology has the advantages of intuitiveness, operability and repeatability, which enables students to conduct safe, economical and repeatable simulation practice in an open, independent and interactive virtual environment. It exemplifies a new way of teaching reform. In 2018, the virtual-simulation center of the university completed preliminary construction, which included the teaching conditions for virtual simulation. The hardware and software facilities for virtual simulation are shown in Figure 4.

(**a**) (**b**)

Figure 4. Hardware and software devices for virtual simulation. (**a**) Construction technology VR; (**b**) safe and civilized construction VR.

5.2.2. Three Educations

The mixed teaching mode of "Three Educations" guided by the OBE concept is adopted, and the "Three Educations" mode combined with on-site production education, classroom-learning education and mental-health education in actual teaching can effectively improve the comprehensive quality of students.

(1) Production-site education. In order to improve students' awareness and understanding of construction production sites, students will go deep into construction sites and have zero-distance contact with engineering, which will effectively stimulate students' interest in learning and cultivate their ability to explore. Table 1 shows the main practical-education foundations of the course and the specific content of the corresponding on-site learning.

Table 1. On-site learning activities of practical production and construction.

No.	Practice Base	On-Site Learning Content
1	Zhejiang Zhongqingda Architectural Industrialization Co., Ltd.	Factory manufacturing process for prefabricated components of prefabricated buildings
2	Zhongsha Construction Group	Hoisting and installation of prefabricated components in prefabricated construction site
3	Huahui Engineering Design Group Co., Ltd.	Deep foundation engineering construction technology
4	Changye Construction Group	Construction technology of concrete engineering in housing construction
5	Tongchuang Engineering Design Co., Ltd.	Road subgrade construction, bridge prefabricated-component lifting
6	Zhejiang Mingye Project Management Co., Ltd.	BIM technology for network planning
7	Huanyu Group	BIM technology for visualization of construction scheme
8	Jinggong Steel Bulding Group	Steel-structure-component factory production technology, steel-structure joint technology
9	Glodon Company Limited	BIM5D construction-management technology

In addition to zero-distance contact with the construction site, the activity of "Industry Elites Entering the Classroom" is also organized; experienced engineers from enterprises are invited to the university to give lectures on cutting-edge engineering technologies such as BIM and prefabrication, so that students can closely integrate learning content with the actual situation of the industry. At the same time, these lectures expand students' vision and thinking, and effectively improve the sustainable development nature of students' employment. Since 2017, we have maintained close cooperation with Zhejiang Zhongqingda Architectural Industrialization Co., Ltd., Huahui Engineering Design Group Co., Ltd., Tongchuang Engineering Design Co., Ltd., Changye Construction Group, Glodon Company Limited and other enterprises, and carried out 32 classroom activities for elites in the industry, and achieved excellent results.

(2) Classroom learning education. On the basis of the traditional classroom teaching mode, a series of innovative learning methods were added. The traditional classroom mode is mainly based on simple PPT explanations, blackboard problem solving and teaching aids' display. To the innovative classrooms have been added rich learning methods such as group puzzle practice, whole-class interactive lectures, and virtual simulations, allowing students to improve classroom-learning enthusiasm, help students to vividly imagine to realize the teaching content, stimulate students' interest in learning, cultivate students' team spirit, and improve students' innovative ability, practical ability and problem-solving ability [10]. In the whole-class interactive lecture, mainly both student–student interaction and teacher–student interaction are adopted. Student–student interaction is dominated by group discussions, group reports and mutual evaluations between groups. It mainly cultivates students' interactive learning and self-solving abilities of difficulties and puzzles, and trains students' active discussion and communication skills. Teacher–student interaction is mainly based

on classroom discussions, classroom guidance and online communication. Through classroom communication, teachers can quickly understand students' learning difficulties, and effectively solve students' problems through detailed guidance. Online communication mainly solves students' learning problems after class. Students put forward questions online, other students can discuss them, and teachers give guidance, which adds a variety of learning paths for students in their spare time, increases the communication between teachers and students, and cultivates strong teacher–student friendship.

Zhang [11] introduced a method like ours to improve students' learning of energy systems through classroom homework, which was applied to a technical elective course called "power generation system" in a course of mechanical engineering. The feedback from students proved that the self-development and use of this tool can significantly improve students' learning experience in the implementation of the curriculum, make the curriculum more dynamic, and give students significant confidence in curriculum learning and sustainable application in the future.

In addition to the above classroom-learning content, the teaching innovation of this course also emphasizes the "three integrations" of learning content pre-class, in-class and after-class. Pre-class, students are encouraged to conduct independent learning, and teachers issue learning tasks and guided-learning tests, so that students can have a preliminary understanding of teaching knowledge and lay a certain foundation for classroom learning. In-class, in-depth exercises are carried out, that is, using the above classroom-teaching methods: virtual simulation, group puzzle practice and whole-class interactive lectures, so as to achieve the vividness and richness of the classroom.

After-class, the engineering expansion is carried out: students' knowledge exploration ability is exercised by assigning open homework and project-based learning, as shown in Figure 5. Moreover, the productive collision between book knowledge and practical theory is realized through the activities of industry elites entering the classroom. Through the "three integrations" of pre-class, in-class and after-class, the effective transformation of students' pre-class independent learning to the after-class externalization of skills is completed.

The innovative mode of this course puts special emphasis on the mental-health education of students. Mental-health education is based on the developmental characteristics of students, the laws of psychological cognitive development, and through the theoretical knowledge and methods of psychology, to cultivate students' good psychological quality to achieve the unity of knowledge, emotion, intention and behavior, so as to have a relatively perfect personality and social integrity, and have good adaptability, positive mental state and good behavior habits [12]. With the development of the times, it has become the consensus of colleges and universities to strengthen the emphasis on students' mental-health education [13,14]. Education in colleges and universities is the last stop for students from the campus to society. Therefore, in the process of education, we should not only teach students professional knowledge, but also pay attention to the sustainable development of students. There are many factors that affect students' mental health in the network environment, so they are more likely to be affected by a variety of values in the process of receiving modern education [15–18]. Teachers play an important role in the mental-health education of college students. Therefore, teachers should fully recognize the importance of the sustainable development of students and ensure that students receive comprehensive guidance and development [19]. In the process of implementing mental health education, teachers should also take students' comprehensive qualities and sustainable development as the basis for evaluation, so as to let students participate more actively in educational activities. Learning enthusiasm is a psychological state, which is powerful motivation to stimulate and maintain learning [20–22]. At the same time, teachers should guide students to develop the ability of self-regulation when educating students, so that students can consciously maintain their psychological health, and correct students who have psychological problems in a timely manner [23].

Open assignments for "Civil Engineering Construction" in the first semester of the 2020-2021 academic year

Class: **Name:** **Student ID:** **Complete time:** **Score (Teacher) :**

Topic: Download or take a related construction picture of a "steel bar project" from the Internet.

(1) Indicate the download URL;

(2) Explore the specific knowledge in the picture;

(3) Explain the key construction technology of this picture, and point out its advantages or disadvantages.

Requirements: Pictures and URLs (1) are printed on A4 paper; Parts (2) and (3) can be handwritten.

Insert photos here.	
URL for photo acquisition:	
Specific knowledge points:	
Picture explanation: **1. Basic explanation** **2. Advantages or disadvantages** **3. Improve proposals**	
Self-rating (full score 100)	
Mutual score (full score 100)	

Figure 5. Students' learning tasks: after-class open homework.

(3) Mental-health education. Based on the above requirements of mental-health education, this course actively pays attention to the mental-health education of students, added a large number of mental-health education elements in classroom teaching, and interspersed multiple mental-health evaluation assessments in the course teaching throughout the semester. At the same time, teachers are required to strengthen and improve their own mental-health knowledge and professional ability, encourage students to solve problems creatively, cultivate students' enthusiasm for active learning, and form a positive psychological state. In the whole process of course teaching, teachers should adhere to the organic integration of mental-health education and course knowledge, so that students are always synchronized with practice. Mental-health education can not only help students develop healthy psychology, but also enable students to have noble morals and correct values [24].

5.2.3. Four Reports

The course teaching focuses on the cultivation and application of students' sustainable innovation ability. To this end, a multi-dimensional evaluation system was constructed, and the comprehensive evaluation is mainly carried out through four reports: an open assignment report, special technical study report, BIM technical work report, and final comprehensive written test report, and the quantification scoring of nodes in the whole process is fully implemented so as to fully practice the teaching mode of "Both-nature and One-extent".

(1) Open assignment report. It accounts for 15%, a total of four times. In view of practical engineering problems, on the basis of mastering basic knowledge, students are required to consult relevant literature and exemplify an in-depth understanding of complex engineering problems and cutting-edge technologies in the industry. There is no standard answer for this assignment, and comprehensive evaluation, student self-evaluation and teacher evaluation are adopted.

(2) Special technical study report. It accounts for 15%, a total of six times. Combining the teaching links of the project department classroom and industry elites entering

the classroom, students are required to expand their knowledge, and innovatively complete the project based on the shortcomings of traditional construction technology and project management. Finally, a class report and defense is conducted, and the results of the project study is comprehensively assessed in the form of students' mutual evaluation and teacher's comments.

(3) BIM technical work report. It accounts for 20%, a total of twice. With the development of BIM in the architecture, engineering and construction (AEC) industry, its influence has gradually increased, and countries around the world have begun to pay attention to BIM education and introduce it into university courses [25,26]. Combined with the course teaching content and production-site learning, BIM design software is used to design and produce BIM works such as a construction-site layout, so as to expand students' knowledge and understanding of civil-engineering construction. After the BIM works are completed, a theme report is produced, and the comprehensive results are assessed by the combination of students' mutual evaluation and teacher's comments.

Li [27] put forward and practiced a seven-stage conceptual framework of problem-oriented and project-based learning in traffic-engineering education, which shows that this method can effectively cultivate students' professional ability and preparation ability. Inspired by the method of Li [27], we improved and expanded the amount of after-school homework.

(4) Final comprehensive written test report. It accounts for 50%. The final exam includes multiple choice questions, fill-in-the-blank questions, short answer questions, calculation questions and case-study questions. This section introduces cross-knowledge of advanced mathematics, mechanics, physics, national industry norms, etc., pays attention to the high-level and challenging degree of test questions, adopts a variety of test questions, and fully checks the students' ability to master knowledge and their sustainable application ability.

Through the four reports evaluation system, the achievement of course objectives has continued to grow in these 12 years, as shown in Figure 6. It can be seen that the four reports evaluation system has achieved remarkable results and has a positive effect on course construction.

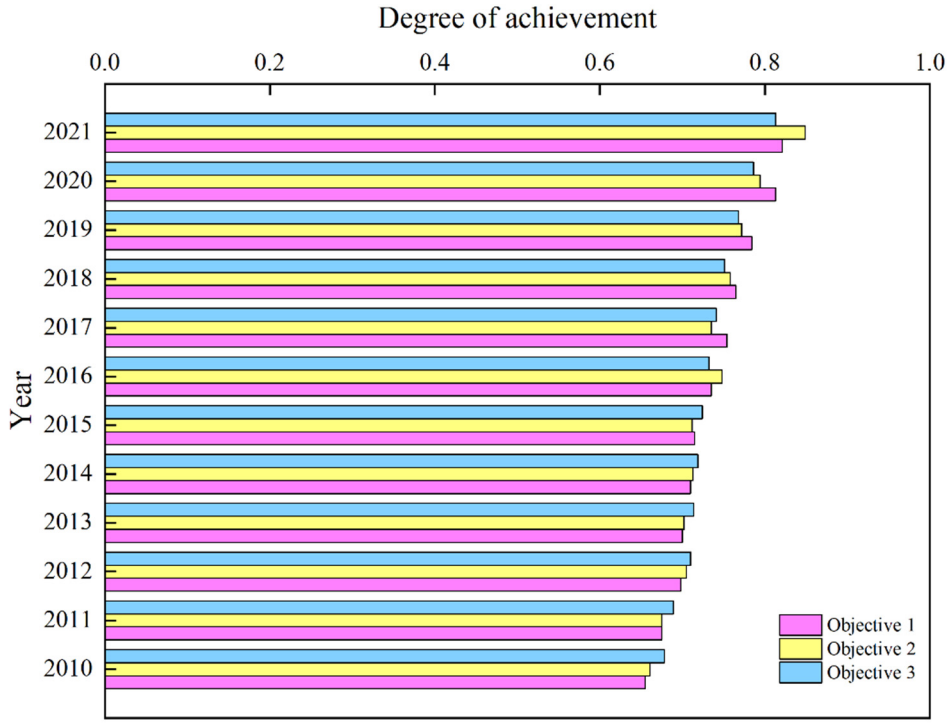

Figure 6. The achievement of course objectives of "Civil Engineering Construction".

The innovation exploration results obtained by the above innovative evaluation methods can be used in later course design, academic thesis and graduation design in the future, and can also be applied to discipline competitions. At the same time, through these methods, an innovative exploration of personalized learning and innovation exploration process can effectively cultivate students' fair-patent thinking and engineering-method thinking, which is of great help to cultivating students' ability to solve complex engineering problems and achieve high-level goals.

6. Innovative Features

The teaching innovation system of "Dual Platforms, Three Educations and Four Reports" has developed the "Dual Platforms" teaching resources of an offline practice platform and online assisted-learning platform. In the teaching process, production and application, classroom teaching and mental-health education are organically integrated to realize the "Three Educations" quality mechanism for the sustainable development of students. Based on being high-level, innovation and challenging, the "Four Reports" evaluation system for the whole process of assessment, including the open assignment report, special technical study report, BIM technical work report, and final comprehensive written test report, was constructed.

School–enterprise co-construction of courses gives full play to the effect of collaborative practice education. With the construction of top-grade enterprises, a course practice base is established combining prefabricated and green-building construction technology, and actively promotes the "project department classroom", so as to cultivate students' engineering-practice thinking. Aiming at cutting-edge industries such as BIM technology and advanced engineering materials, we actively promote the "industry elite entering classroom" to develop students' ability to solve advanced engineering problems.

Thematic open study can cultivate students' engineering innovative thinking. Adhering to the OBE concept, two operation modes are proposed; the open assignment report and special technical study report can provide personalized learning methods. Through group discussion, group report, the student–student interaction of mutual evaluation between groups, as well as the teacher–student interaction of classroom discussion and classroom guidance, the students' innovative thinking in engineering is cultivated.

Through the whole process of mental-health education, we should pay attention to the development of students' mental health. A large number of mental-health education elements were added to classroom teaching, and multiple mental-health assessments are conducted. At the same time, teachers are required to strengthen and improve their own mental-health knowledge and professional ability, encourage students to solve problems creatively, and cultivate students' enthusiasm for active learning, so as to form a positive psychological state.

7. Course Evaluation and Reform Effect

7.1. Evaluation on the Implementation Process of 2P3E4R System

Expert appraisal. Professor M, member of the Civil Engineering Teaching and Steering Committee of the Ministry of Education, and Changjiang Scholar of the Ministry of Education; Professor S, member of the Civil Engineering Teaching and Steering Committee of the Ministry of Education, and Director of the Academic Affairs Office of H University, have given high praise to this course. They both agree that the innovative teaching design of "Dual Platforms, Three Educations and Four Reports" carried out in accordance with the OBE concept well reflects the high-level, innovative and challenging nature of the course, and effectively achieves the goal of course training, which is an excellent offline undergraduate course.

University appraisal. The comprehensive teaching rating of this course in the last semester was Z1, which is the highest level of university appraisal. The university believes that this course is taught in a task-driven way, with good classroom-teaching interaction, focusing on process evaluation and diagnostic improvement, the natural integration of mental-health content, and the effective achievement of course objectives.

Student appraisal. The course is very popular among students. The academic evaluation and teaching score of this course in the most recent semester was 91.61, ranking 9/300. The teaching performance assessment of team teachers for five consecutive years was the highest grade, A. Students think that the pre-learning tasks of this course are vivid and interesting, which can effectively encourage learning. Students can pay attention to the cultivation of mental health while mastering knowledge. The interactive learning in the classroom fully combines theory and practice, laying a solid foundation for future work.

7.2. Evaluation of the of Course Objectives Achievement of Civil Engineering Construction

In order to further analyze and discuss the implementation effect of the 2P3E4R system curriculum scheme, according to the achievement of three curriculum objectives, the students' self-evaluation and employers' evaluation of students were carried out. The survey is divided into four parts, of which the sample number of students was 72 and the sample number of employers was 30. The scoring design of the survey is shown in Table 2.

Table 2. Evaluation achievement grade of curriculum objectives and assignment of degree.

Achievement Grade	Excellent	Good	Pass	Failure
Achievement degree p_i	0.95	0.8	0.7	0.5

Group A: Students' self-evaluation at the end of the course.
Group B: Students' self-evaluation at graduation.
Group C: Evaluation of students by employers after working for one year.
Group D: Employers' evaluation of students after five years of work.

The degree of achievement of course objectives is calculated by the following formula:

$$s = \frac{\sum_{i=1}^{4} p_i n_i}{\sum_{i=1}^{4} n_i} \quad (1)$$

where n_i is the number of people who choose the i-th evaluation level. According to the above calculation, the survey results are shown in Table 3.

Table 3. Survey results of curriculum goal achievement evaluation.

Objectives	Group A	Group B	Group C	Group D
Objective 1	0.80	0.85	0.76	0.85
Objective 2	0.82	0.87	0.80	0.83
Objective3	0.85	0.90	0.70	0.80

Through the above results, we can discuss as follows:

(1) The evaluation results of both students' self-evaluation and employers' evaluation of students are better than the formative evaluation results given by teachers according to the four reports, as shown in Figure 6.
(2) The self-evaluation of students at the end of the course is [0.80, 0.85], indicating that they think they perform well. The study of other professional courses before graduation increases students' self-confidence at graduation, and the self-scoring note increases to [0.85, 0.90].
(3) The lowest evaluation of the employer on the achievement of students' curriculum objectives one year after graduation is [0.70, 0.80], but the corresponding evaluation value increases to [0.80, 0.85] five years later, indicating that students have good sustainable development ability and have been fully recognized by their employers.
(4) Students focus on mastering knowledge during school (corresponding to course objective 1), but employers focus on continuous innovation ability and healthy psychology

(corresponding to course objective 3). These two concerns have the lowest scores in their respective evaluations, but they are still growing. In the future teaching work, teachers should strengthen the cultivation of these two concerns through the 2P3E4R system.

7.3. Achievements and Application of Course 2P3E4R System

Reform effect. After 12 years of teaching accumulation and innovative measures for teaching reform, satisfactory results have been achieved in team building, collaborative education, and teaching effectiveness. In the past 12 years, our students have won 72 awards in BIM-application-skills competitions, intelligent construction and management innovation competitions and other discipline competitions based on this course content. Students, independently, have published 53 papers on construction technology and construction organization, applied for 20 invention patents on prefabricated construction technology, and have won 72 scientific research projects for college students in BIM construction management and other aspects supported by Zhejiang Province or Shaoxing University. Based on the above results, 62 outstanding graduates highly recognized by Shaoxing University and employers have emerged among the students. The specific annual statistical data are listed in Table 4. The team teachers have successively obtained the support of 15 provincial-level teaching-reform projects, including the provincial first-class courses, the provincial virtual-simulation-experiment project, and the provincial college new-form textbook-construction project. At the same time, five teachers have won the provincial five-star young teachers and received individual and other honorary titles.

Table 4. Development of student achievement output in the past 12 years.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Discipline competition award	2	2	2	2	3	4	4	6	10	12	11	14	72
Scientific paper	0	0	1	2	4	5	5	7	6	7	8	8	53
Invention patent	0	0	0	0	1	2	2	3	5	8	10	12	20
Scientific project	1	2	4	4	5	6	6	9	8	8	9	10	72
Outstanding graduates	2	2	2	3	4	4	5	6	6	8	10	10	62

Promotion effect. The teaching innovation mode has been applied to 14 other courses, such as “Construction Engineering Budget”, “Construction Engineering Inspection”, “Engineering Project Management”, and “Operation Research and Engineering Optimization”, as shown in Figure 7. The main information, such as the time when these courses started to use the system, the number of lasting years, the name of their major, course honors, and so on, are listed in Table 5, including three first-class courses of Zhejiang Province and 11 first-class course of Shaoxing University. The teaching evaluation results have improved year by year. The team teachers have participated in teaching conferences and exchanges many times. This teaching innovation mode has been praised by teachers from colleges and universities such as Jiangsu University of Science and Technology, Ningbo Institute of Technology, etc., and has carried out large-scale promotion and application, and achieved excellent results. Practice shows that this teaching innovation mode has certain reference significance for the teaching of engineering courses.

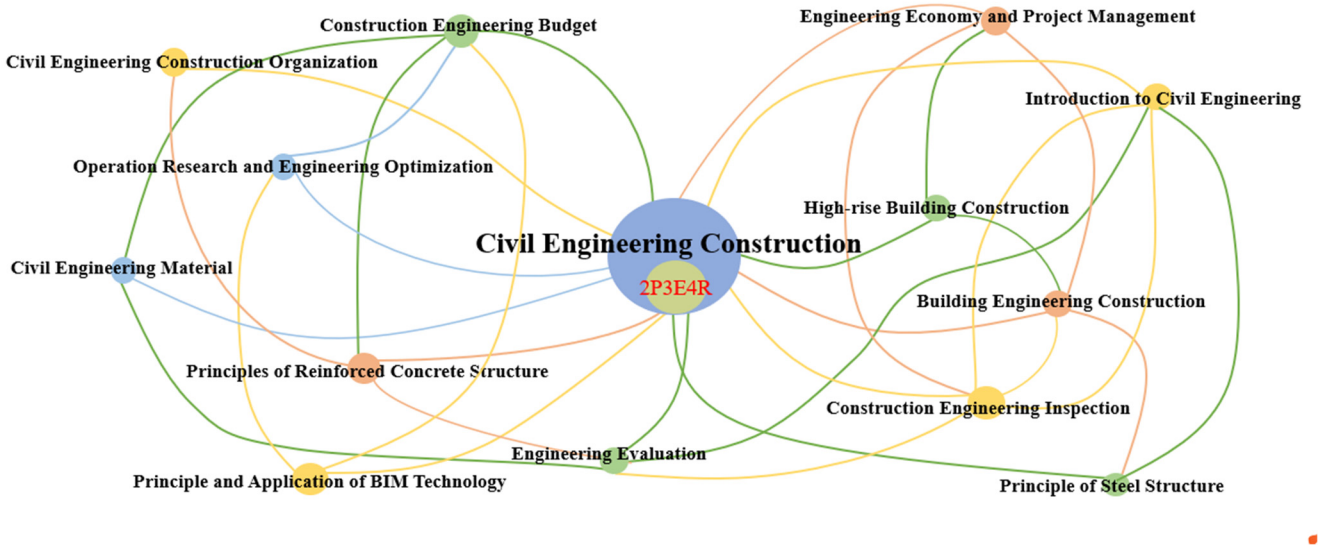

Figure 7. Main courses applying 2P3E4R system.

Table 5. Survey results of curriculum-goal-achievement evaluation.

No.	Course Name	Start Time	Lasting Years	Major Name	Course Honors
1	Civil Engineering Construction	2010	12	Civil Engineering	First-class course, Zhejiang Province
2	High-rise Building Construction	2010	12	Civil Engineering	Key course, Shaoxing University
3	Building Engineering Construction	2010	12	Architecture	Key course, Shaoxing University
4	Civil Engineering Construction Organization	2011	11	Architecture	First-class course, Shaoxing University
5	Engineering Evaluation	2011	11	Architecture	Key course, Shaoxing University
6	Introduction to Civil Engineering	2014	8	Civil Engineering	First-class course, Shaoxing University
7	Civil Engineering Material	2014	8	Civil Engineering	Core course, Shaoxing University
8	Engineering Economy and Project Management	2015	7	Engineering Management	First-class course, Zhejiang Province
9	Construction Engineering Budget	2015	7	Engineering Management	First-class course, Zhejiang Province
10	Construction Engineering Inspection	2015	7	Civil Engineering	Core course, Shaoxing University
11	Operation Research and Engineering Optimization	2016	6	Engineering Management	Key course, Shaoxing University
12	Principles of Reinforced Concrete Structure	2017	5	Civil Engineering	First-class course, Shaoxing University
13	Principle of Steel Structure	2017	5	Civil Engineering	First-class course, Shaoxing University
14	Principle and Application of BIM Technology	2018	4	Engineering Management	First-class course, Shaoxing University

8. Conclusions

This paper presented the construction and practice of the 2P3E4R System for college teaching innovation from the perspective of sustainable development, taking the Civil Engineering Construction course as example.

(1) 2P3E4R System, namely, Dual Platforms, Three Educations and Four Reports, has been gradually established and improved from 2010 to 2021, which enables Civil Engineering Construction course to obtain honor as a key construction course of Shaoxing University and a first-class course of Zhejiang Province.

(2) Focusing on knowledge objectives, ability objectives and emotional-value objectives, this system is of great help to cultivating students' ability to solve complex engineering

problems and achieve high-level goals, enhancing the achievement of course objectives of Civil Engineering Construction from just over 0.6 in 2010 to over 0.8 at 2021.

(3) A survey of thirty employers showed that the achievement of students' curriculum objectives one year after graduation is [0.70, 0.80], but this value increases to [0.80, 0.85] five years later, indicating that students cultivated by the 2P3E4R System have good sustainable-development ability and have been fully recognized by employers.

(4) This teaching innovation mode has helped our college students achieve fruitful and sustainable outputs, including wining 72 awards in discipline competitions, publish 53 scientific papers, apply for 20 invention patents, host 77 scientific projects, and receive 62 outstanding-graduate honors.

(5) This teaching innovation mode has been applied to 14 courses; a good promotion effect has been achieved, including 3 first-class courses of Zhejiang Province and 11 first-class courses of Shaoxing University.

This teaching innovation mode enriches students' learning and thinking methods, and always adheres to the teaching principle of student-centered learning, allowing speculation and exploration to run through the whole teaching process, providing reference for engineering course teaching, and achieving the goal of cultivating new engineering talents based on sustainable development.

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Abbreviations

BIM	Building Information Modeling
OBE	Outcome-Based Education
2P3E4R	Dual Platforms, Three Educations, Four Reports
FD-QM	Fudan University-Quality Matters
AEC	Architecture, Engineering and Construction

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