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Exploration and Practice on the Construction of Virtual Teaching-Research Offices for Traditional Engineering Majors in the Intelligent Era: A Case Study of the Course "Foundation Treatment"

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Abstract: Aiming at the problems existing in the teaching mode of the course *Foundation Treatment* against the background of the intelligent era, the teaching team for *Foundation Treatment* at Zhongyuan University of Technology has built a virtual teaching-research office with multiple types of members by adopting modern information technologies. Based on the requirements of emerging-engineering construction and the concepts of engineering accreditation, the team reshapes the teaching objectives and knowledge units of this course through collective teaching research, and establishes an integration mechanism for curriculum-based ideological-and-political education and professional content. Intelligent technologies are utilized to develop digital teaching resources matching different types of knowledge units, and a teaching-resource bank mainly composed of engineering cases, virtual-simulation experiments and academic papers is constructed. By combining physical teaching-research offices and virtual teaching-research offices, a new teaching mode for the course *Foundation Treatment* adapted to emerging-engineering construction requirements is jointly built. The research outcomes can provide references for the teaching reform of the *Foundation Treatment* course in similar universities.

Keywords: Intelligent era; Virtual teaching-research office; Foundation treatment; Teaching resources; Teaching mode

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1. Introduction

Foundation Treatment is an important specialized course for the Civil Engineering major. In recent years, with the in-depth development of the emerging-engineering concept, cultivating interdisciplinary compound innovative talents has become the development trend for talent cultivation in civil engineering [1]. Documents such as the *Key Points of the Work of the Higher Education Department of the Ministry of Education (2022)*

(Jiao Gao Si Han [2022] No. 1) explicitly require universities to "further advance emerging-engineering construction" and "deepen the pilot work of virtual teaching-research offices". Therefore, exploring a new teaching mode for the course *Foundation Treatment* under the emerging-engineering concept and improving its teaching quality constitute an important task for promoting the teaching reform of the Civil Engineering major, which bears great research significance.

For this reason, the School of Civil Engineering at Zhongyuan University of Technology has built a virtual teaching-research office for the course *Foundation Treatment* with multidisciplinary backgrounds by making use of intelligent technologies [2-4]. Based on engineering-accreditation concepts and emerging-engineering construction requirements, it has reshaped the teaching objectives and contents of this course, established an integration mechanism for curriculum-based ideological-and-political education and teaching contents, and developed engineering-case teaching resources with multidisciplinary backgrounds [5]. Furthermore, a teaching mode for the *Foundation Treatment* course adapted to emerging-engineering construction requirements and engineering-accreditation concepts has been constructed.

2. Existing problems in the traditional teaching mode of the course *Foundation Treatment*

At present, the traditional teaching mode of the course *Foundation Treatment* for the Civil Engineering major in universities mainly has the following problems:

(1) The traditional teaching mode fails to integrate curriculum-based ideological-and-political elements effectively

As a specialized course for the Civil Engineering major, *Foundation Treatment* features strong professionalism, which creates obstacles to the integration of curriculum-based ideological-and-political elements. In addition, some teachers still hold the notion that curriculum-based ideological-and-political education belongs to ideological-and-political theory courses. They only attach importance to the teaching of professional knowledge and skills and lack subjective awareness of curriculum-based ideological-and-political construction. At present, ideological-and-political elements and professional teaching contents in the course *Foundation Treatment* are disjointed, and effective integration between curriculum-based ideological-and-political education and professional teaching contents has not been realized.

(2) The traditional teaching mode hardly cultivates students' craftsmanship spirit and awareness of outstanding engineers

The course *Foundation Treatment* involves a large number of construction techniques for foundation treatment, which requires instructors to possess rich practical engineering experience. Nevertheless, front-line teachers are mostly young doctors with little practical-engineering experience. Consequently, the teaching of construction-technique-related content in *Foundation Treatment* tends to be textbook-oriented. Students have little understanding and in-depth thinking about advanced foundation-treatment technologies at home and abroad, so it is impossible to cultivate their awareness of outstanding engineers and a craftsmanship spirit.

(3) The traditional teaching mode struggles to foster students' interdisciplinary capabilities and higher-order thinking

The teaching contents of *Foundation Treatment* cover principles and construction technologies for foundation treatment, involving extensive knowledge. To guarantee teaching progress, many teachers adopt the "cramming-style" teaching method. Some students with weak foundations lack interest in theoretical content

and can hardly keep up with the teaching progress in class, which leads to a loss of learning interest and creates a vicious circle of "cannot learn → unwilling to learn". It is difficult to cultivate students' higher-order thinking of inquiry and innovation.

3. Construction contents of the virtual teaching-research office for *Foundation Treatment*

3.1. Reshaping teaching objectives and contents: Reorganizing course objectives and knowledge units of *Foundation Treatment* based on emerging-engineering concepts and engineering-accreditation requirements

Relying on physical teaching-research offices, the teaching team for *Foundation Treatment* has established a virtual teaching-research office for this course by applying intelligent technologies [6-7]. Members of the virtual teaching-research office consist of experts from civil-engineering-related industries and research institutes, computer-industry experts, lecturers for *Foundation Treatment* from different universities, teachers committed to the teaching reform of this course, and outstanding students [8-9]. Based on emerging-engineering concepts and engineering-accreditation requirements, members of the virtual teaching-research office reorganize the teaching syllabus, teaching contents and knowledge units for *Foundation Treatment* [10-11]. After multiple teaching seminars, the virtual teaching-research office reshapes the objectives of the course *Foundation Treatment* as follows:

(1) Course Objective 1: Master design and calculation methods for commonly-used foundation-treatment approaches; be capable of identifying complex foundation-treatment engineering problems and putting forward reasonable solutions. Understand gaps between domestic and foreign advanced technologies through the development history of foundation treatment, and cultivate students' sense of patriotism and responsibility.

(2) Course Objective 2: Master reinforcement mechanisms, construction techniques and quality-inspection requirements of common foundation-treatment technologies; be able to study and analyze key links of foundation-treatment engineering problems so as to draw valid conclusions.

(3) On the basis of the reshaped course objectives, the virtual teaching-research office reorganizes the teaching contents and knowledge units of *Foundation Treatment*, and divides the teaching contents into 12 teaching knowledge units, as shown in **Table 1**.

Table 1. Reshaped Knowledge Units of the Course *Foundation Treatment*

Basic-Level Knowledge Units	Intermediate-Level Knowledge Units	Advanced-Level Knowledge Units
Knowledge Unit 1: Current Status and Trends of Foundation-Treatment Technologies	Knowledge Unit 5: Lime-Soil Compaction Pile Method	Knowledge Unit 9: High-Pressure Jet Grouting Method
Knowledge Unit 2: Soil-Replacement Cushion Method	Knowledge Unit 6: Cement-Fly-Ash-Gravel Pile	Knowledge Unit 10: Geosynthetics
Knowledge Unit 3: Dynamic Compaction Method	Knowledge Unit 7: Preloading by Drainage Consolidation	Knowledge Unit 11: Reinforced-Earth Retaining Wall
Knowledge Unit 4: Stone Column	Knowledge Unit 8: Grouting Method	Knowledge Unit 12: Composite-Foundation Theory and Design

3.2. Ideological-and-political concepts: Establishing an integration mechanism for curriculum-based ideological-and-political education and professional teaching contents of *Foundation Treatment*

In view of the characteristics of *Foundation Treatment* featuring both theoretical complexity and construction comprehensiveness, the virtual teaching-research office explores mechanisms for integrating curriculum-based ideological-and-political elements into theoretical-knowledge explanation and construction-technology teaching, so as to realize whole-process ideological-and-political education in this course. For theoretical-knowledge parts, physical teaching-research offices elaborate the development history of foundation-treatment technologies, analyze gaps between China and Western advanced technologies, and introduce deeds of scientists in the field of foundation treatment to cultivate students' patriotism and their mission to tackle bottleneck technologies. For construction-technology parts, the virtual teaching-research office explores and builds a material bank of engineering cases containing ideological-and-political elements, and cultivates students' craftsmanship spirit and awareness of outstanding engineers through such cases. By analyzing lessons learned from engineering accidents caused by improper foundation treatment, students' awareness of engineering ethics for civil engineers is fostered. In addition, curriculum-based ideological-and-political elements are integrated into regular assignments, process-oriented assessments and final examinations, bringing curriculum-based ideological-and-political education into the assessment process.

3.3. Resource construction: Developing engineering-case-oriented course resources with interdisciplinary backgrounds

Members of the virtual teaching-research office carry out collective teaching seminars according to characteristics of basic-level, intermediate-level and advanced-level knowledge units, and formulate development schemes for teaching resources matching different types of knowledge units [12-13]. For intermediate-level knowledge units, members of the virtual teaching-research office investigate industrial enterprises, and condense common engineering problems in the Central-China region into digital engineering-case teaching resources by virtue of intelligent technologies. For advanced-level knowledge units, members of the virtual teaching-research office transform cutting-edge scientific-research achievements in civil engineering and interdisciplinary fields into virtual-simulation-experiment teaching resources [14]. To further cultivate students' higher-order thinking, the virtual teaching-research office introduces the reading of scientific papers into teaching activities, establishes a regular reading mechanism for frontier academic papers, guides students to learn cutting-edge foundation-treatment technologies, and arouses their interest in such technologies. After years of construction, a teaching-resource bank mainly consisting of engineering cases, virtual-simulation experiments and academic papers has been formed.

4. Establishment of a new teaching mode for *Foundation Treatment* adapted to emerging-engineering construction requirements and engineering-accreditation concepts

Virtual-teaching-research-office and physical-teaching-research-office members jointly discuss the proportion of different knowledge units and various teaching resources in teaching activities, reconstruct curriculum teaching paths, and build a new teaching mode for *Foundation Treatment* adapted to emerging-engineering construction requirements (**Figure 1**). As shown in Figure 1, physical teaching-research offices mainly

deliver lectures for basic-level knowledge units. Theoretical teaching consolidates students' theoretical foundations. Ideological-and-political elements, including gaps between modern domestic and foreign foundation-treatment technologies and glorious ancient Chinese foundation-treatment technologies, are introduced to cultivate students' patriotism. Virtual teaching-research offices are mainly responsible for teaching intermediate-level and advanced-level knowledge units. After students learn intermediate-level knowledge units, the virtual teaching-research office guides them to study supporting engineering cases to improve their practical-engineering capabilities. Meanwhile, ideological-and-political elements such as engineering-accident lessons foster students' craftsmanship spirit and professional ethics. After students learn advanced-level knowledge units, members of the virtual teaching-research office guide them to conduct supporting virtual-simulation experiments to cultivate their interdisciplinary capabilities and scientific-research thinking. Afterward, reading academic papers further develops their scientific-research thinking. The study of cutting-edge scientific-research achievements and academic papers cultivates students' scientific spirit.

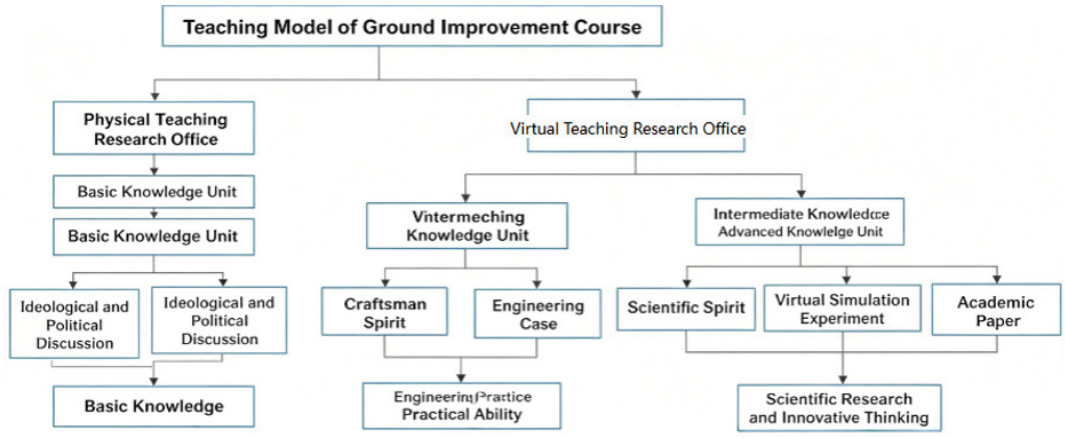

Figure 1. New Teaching Mode for Foundation Treatment Combining Physical and Virtual Teaching-Research Offices.

5. Conclusions and suggestions

The current teaching mode for *Foundation Treatment* fails to effectively incorporate curriculum-based ideological-and-political concepts. Teaching activities are dominated by traditional physical teaching-research offices with single disciplinary backgrounds, which can hardly cultivate students' practical-engineering capabilities, interdisciplinary capabilities and higher-order thinking, and cannot satisfy the construction requirements for civil-engineering-specialty courses in the intelligent-era context. Based on emerging-engineering construction requirements and engineering-accreditation concepts, this paper builds a virtual teaching-research office for *Foundation Treatment* with interdisciplinary features, constructs a curriculum-teaching-resource bank, and further establishes a new teaching mode adapted to emerging-engineering construction requirements. The conclusions are as follows:

(1) A virtual teaching-research office for the course *Foundation Treatment* has been established. Integrating diverse members, including enterprise experts, experts from scientific-research institutes, university teachers, and outstanding students, it provides strong platform support for curriculum-teaching reform. Based on emerging-engineering construction requirements and engineering-accreditation concepts, the virtual teaching-research office carries out collective teaching research, reshapes teaching objectives and contents

for *Foundation Treatment*, and classifies teaching contents into three types of knowledge units: basic-level, intermediate-level and advanced-level.

(2) A multi-type curriculum-teaching-resource bank has been constructed. Making use of intelligent technologies, the virtual teaching-research office transforms cutting-edge disciplinary achievements into high-quality teaching resources, and forms a teaching-resource bank mainly containing digital engineering cases, virtual-simulation experiments and academic papers. Some virtual-simulation experiments have been popularized and applied in universities inside and outside the province and have received favorable comments from peer universities.

(3) A new teaching mode for *Foundation Treatment* combining physical and virtual teaching-research offices has been built. Based on emerging-engineering construction requirements, the new teaching mode clarifies corresponding relationships among various knowledge units, teaching resources, practical-engineering capabilities and scientific-research-innovation thinking, and reshapes teaching paths for each type of knowledge unit. Curriculum-based ideological-and-political elements are fully integrated into all types of knowledge units, imperceptibly fostering students' patriotism, craftsmanship spirit and scientific-research literacy.

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