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Original Paper

Reform of Teaching Mode in Higher Education Institutions under the Background of New Engineering

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Abstract

New Engineering refers to majors established in higher education institutions based on the new economy and emerging industries. With the rapid development of technology, the education sector has also undergone unprecedented changes. In order to promote the high-quality development of education, enhance students' practical abilities, and effectively implement the fundamental task of cultivating morality and talents. As educators, we deeply understand that innovation is an important force driving the development of education. Therefore, in order to promote the construction of the "four new" curriculum in schools, we have launched a "three-stage" (pre class preparation, in class communication, and post class practice) practical teaching mode for the course of "Soil Mechanics and Foundation Engineering", aiming to explore how to improve the quality and effectiveness of teachers' teaching and students' engineering practice experience.

Keywords

Three paragraph structure, Engineering practice, Practical teaching

1. Course Background and Objectives (Teaching Problems and Solutions)

With the development of the economy, the demand for talents in new occupations is constantly changing. As a carrier of talent cultivation and scientific and technological development, disciplines must adapt to this development through innovative reforms to meet the social demand for talents. In response to the development needs of emerging engineering education and to gain a strategic commanding height in the future global innovation centers, there is an urgent need to cultivate a large number of innovative talents in emerging engineering fields. At the same time, domestic universities generally face problems such as weak on-campus practical teaching links, a disconnect between the knowledge taught in courses and engineering requirements, insufficient practical experience of teachers,

and poor effectiveness of enterprise internships (Lu, L., Liu, P., Lu, L. etc., 2021, pp. 215-218, p. 231). These issues do not meet the strong demand of the current and future environmental engineering industry for high-quality composite talents with strong innovative awareness and engineering practice capabilities. Therefore, centering on the connotative characteristics of the construction and development of "emerging engineering education", developing engineering education that "returns to engineering practice", strengthening the practical awareness and professional skills training of engineering students, and exploring the development model of capabilities have become an urgent task (Zeng, L. L., Wang, Y. J., Bian, X. etc., 2023, pp. 92-96). Students are expected to master the principles and methods of shallow foundation design and pile foundation design, be familiar with the design principles and methods of soft soil foundation treatment, and understand the engineering geological survey methods and data collation of construction sites. By combining relevant structural design knowledge, students' ability to analyze and solve foundation design and calculation problems will be improved. To better adapt to the development of the times and improve the quality and effectiveness of teaching, we have decided to carry out a teaching innovation project. This teaching innovation aims to introduce advanced information technology means, improve teaching methods, enhance students' learning enthusiasm and initiative, cultivate students' innovative thinking and practical abilities, with the goal of cultivating an innovative talent training model featuring "solid foundation, outstanding specialty, and broad vision". Reforms and innovations have been carried out in aspects such as talent training models, curriculum construction, practical teaching systems, and school-enterprise joint training mechanisms. Now, a "three-stage" (pre-class preview, in-class communication, post-class practice) practical teaching model has been created. The cultivation of students' engineering design, teamwork, and professional quality abilities is organically integrated into practical teaching. Students are led to visit and practice according to course requirements, realizing the transformation of teaching activities from one-way transmission to an exchange among three parties (in-school teachers, off-campus practice, and students). A "new engineering" teaching model and talent training curriculum system based on engineering practice have been formed.

2. Implementation Process and Measures

First Stage: Pre-class Preview Students conduct online pre-class preview through the online resources on the Chaoxing Xuexitong platform, which helps them gain a perceptual understanding and increase their interest in the course. With the BIMVR platform, students can enter a three-dimensional world to understand the general situation and processes of relevant projects (seeing the forest before seeing the trees).

Second Stage: In-class Interaction In-class theoretical teaching is closely combined with on-site cases (linking theory with practice).

Third Stage: Post-class Practice, Teachers go out to gain practical experience and then bring it back to nourish teaching. Organize students to participate in engineering design practices, on-site engineering learning, practical competitions, and internships in enterprises to verify the teaching effectiveness (undertaking real-world engineering projects).

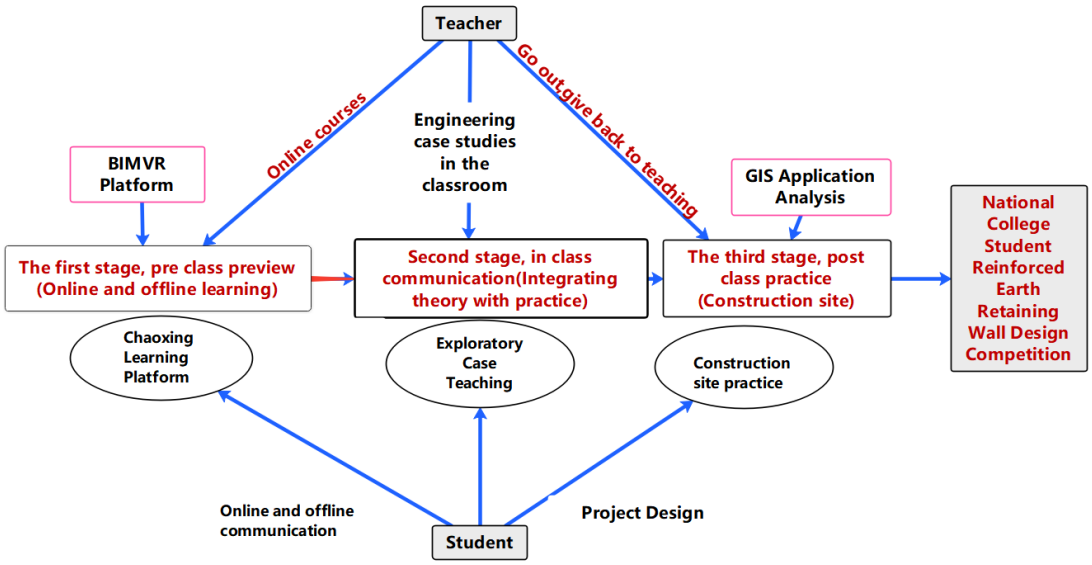

Figure 1. Three Stage Teaching Technology Route

The three-stage teaching technical route is shown in Figure 1. The specific reform methods and practical effects are as follows:

2.1 Construction of the Online Chaoxing Platform + Offline Practice Base (Pre-class Preview)

The course “Soil Mechanics and Foundation Engineering” thoroughly implements the fundamental task of cultivating students with moral integrity, promoting the all-around development of students in terms of morality, intelligence, physique, aesthetics, and labor. Based on fully considering the professional characteristics, the course studies “the hot topics that students are concerned about”. With the help of modern teaching methods such as Chaoxing Xuexitong (Yin, Y. & Yu, X. J., 2020; Liang, Q., Zou, H. B. & Liu, J., 2021, pp. 69-72; Ge, J. Y., Ge, G. J. & Zhang, Y. H., 2024), it uses these hot topics to arouse students’ curiosity, splits and combines the knowledge points of the existing teaching content, organically integrates the hot topics with professional knowledge, and conducts online and offline teaching based on “the hot topics that students are concerned about”, thus enhancing the attractiveness of the course and strengthening the multi-dimensional dissemination of knowledge points both online and offline.

2.1.1 Construction of the Chaoxing Online Platform

To facilitate students to study anytime and anywhere, we have established an online learning platform. The cumulative page views of this platform have reached more than 120,000 times. The platform includes functional modules such as course resources, online tests, and learning exchanges, providing students with an all-round learning support environment. Through the online learning platform, students can arrange their learning progress independently, freely choose learning content, and at the same time communicate and discuss with other students, improving the interactivity and effectiveness of learning.

2.1.2 Establish a Teaching Practice Base Based on Course Requirements

Based on the school enterprise joint training model, a joint training base has been established according to course requirements. In terms of engineering design, a joint training mechanism has been established with Beijing Yingjianke Co., Ltd. and Tekla Digital Construction Center; In terms of construction, a training base has been established with Qingdao Haichuan Construction Group. We have established a comprehensive resource sharing mechanism and cooperation platform that combines industry, academia, and research.

The school has also collaborated with Beijing Exhibition Network to purchase a BIMVR virtual simulation display platform, allowing students to experience virtual simulation engineering cases. Teachers can conduct 3D teaching demonstrations to enhance students' learning interest. Through simulation of soil mechanics foundation, students can have a more comprehensive understanding of this course.

2.2 Application of CBL Teaching Method in Teaching Based on Engineering Certification Background (In Class Communication)

At present, most courses in soil mechanics and foundation engineering use traditional teaching methods, namely teacher lectures and student learning, and the teaching method is mostly PPT teaching. However, due to the complexity of the course content and the independence between course chapters, students are inevitably left with many knowledge doubts after the first round of traditional project-based teaching (Shi, S., Wang, Y., Si, J. et al., 2024, pp. 331-336; Weiguang, Z., Jijun, L., Lei, L. et al., 2024, pp. 238-243; Gao, Y. & Deng, D., 2023). In response to the problem of the disconnect between traditional soil mechanics and basic engineering teaching content and engineering practice, engineering case studies are added to the teaching process of soil mechanics and basic engineering. Real engineering video cases are shared in class, and students are organized to visit and learn from construction projects when conditions permit. At the same time, share research literature on relevant engineering examples in recent years to cultivate students' ability to learn and analyze complex engineering problems from literature.

We actively explore new classroom teaching models, transforming traditional teacher centered classrooms into student-centered interactive classrooms. In the flipped classroom, students master certain basic knowledge through pre class preview and self-directed learning, and then engage in in-depth learning and communication through group discussions, case analysis (Ran, L., 2021, p. 032207), and other methods in class. This teaching model can better stimulate students' interest and initiative in learning, cultivate their teamwork and communication skills.

In the process of course learning, classroom group communication sessions will also be organized, where students will share an engineering case related to soil mechanics and then explain and discuss the case. Enable students to better integrate textbook knowledge with practice, achieving the effect of applying what they have learned.

Fun classroom activities will also be organized every semester, where students can freely form teams and groups to simulate role-playing scenarios and analyze foundation pit collapse accidents. Someone plays the roles of developer, surveyor, construction contractor, and intern, bringing them into their own woven storylines. Finally, analyze the cause of the engineering accident and identify the responsible party. Encourage students to take the lead in the classroom and actively learn knowledge through fun activities.

2.3 Engineering Design, On Site Practice, and Social Practice (After Class Practice)

Engineering education certification follows three basic principles: student-centered, outcome oriented, and continuous quality improvement. For an application-oriented undergraduate institution, more emphasis is placed on students' practical and hands-on abilities. Due to the comprehensive, practical, and experiential nature of the course "Soil Mechanics and Foundation Engineering", achieving ideal teaching results cannot rely solely on classroom lectures. Therefore, the structural design software PKPM is integrated into the teaching process of "Soil Mechanics and Foundation Engineering" to guide students to become familiar with the physical and mechanical indicators of relevant soils, understand the characteristics of different types of foundations, and master various basic design calculation methods during the operation of the software, in order to effectively enhance students' learning effectiveness and comprehensive practical abilities.

2.3.1 Application of PKPM Software in Soil Mechanics and Foundation Engineering

The shear strength of soil in the course of Soil Mechanics and Foundation Engineering is different from the materials involved in other courses of civil engineering. It is not a constant, but a variable that increases linearly with the change of normal stress σ value. In soil mechanics, the shear strength index internal friction angle ψ and cohesion c are generally used to characterize the strength of soil. Beginners often encounter certain difficulties in understanding these physical and mechanical parameters. At this point, the geological model part of the JCCAD module of PKPM software (Wang, Y. Q. & Chen, J., 2013, pp. 2739-2742) is introduced to assist teaching. Through the default geotechnical parameter table provided by the software, students can understand the common types of

geotechnical parameters in engineering practice and the approximate range of their parameter values. Draw soil profile maps and contour lines to help students understand how to apply the scattered parameter indicators learned in textbooks to engineering practice, deepen their understanding of the relevant physical mechanics indicators in the course of Soil Mechanics and Foundation Engineering, and improve their practical abilities.

2.3.2 Constructing an Educational Model of "Internal Mentors Going Out, External Mentors Coming In"

On campus teachers go out and lead students to visit various foundation pit support structures on the construction site, explaining the selection basis of corresponding foundation forms and support structures, as well as the issues that should be paid attention to in the design and calculation process, so that students can discover the differences between teaching and practice from the on-site inspection. Through the teaching mode of linking practical engineering with theoretical knowledge, students' interest in basic engineering disciplines is established, and their understanding of basic engineering course knowledge is deepened.

External mentors walked in and invited frontline experts from enterprises to teach students at the practical base. Through on-site practical teaching, many abstract knowledge points in the classroom can be explained, and students can be taught more cutting-edge engineering practice experience, allowing them to have a preliminary intuitive understanding of the course content. This teaching model can better stimulate students' interest and initiative in learning, allowing for a better integration of theory and practice.

Organize teachers and students to visit the China Construction Project Department during their spare time, and apply some theoretical knowledge to practical engineering projects.

Overall, guiding students to think through practical engineering, stimulating their enthusiasm for learning, and seeking the best state of self-directed learning. Make classroom teaching three-dimensional and three-dimensional. Enabling students to understand the forefront of engineering technology development and industry trends has effectively improved classroom teaching effectiveness and solved the problem of disconnection between classroom teaching content and actual engineering development. Integrate the learning of professional knowledge with the stimulation of personal ideals and social responsibility, and reflect scientific and humanistic literacy in the teaching process.

2.3.3 Established a Teaching Model of "Learning Through Competition" and "Teaching through Competition"

The model of "teacher guidance, student participation" not only enhances students' enthusiasm and confidence in participating, but also greatly improves teachers' teaching ability and professional skills. Students participate in the "National College Student Reinforced Earth Retaining Wall Design Competition" to fully utilize their practical and exploratory abilities. Experiential learning based on competition projects, including experiments, hands-on operations, and teamwork, can enhance

students' sense of identification with engineering, improve undergraduate professional skills, and achieve the educational goal of applying what they have learned.

3. Implementation Effect of Teaching Mode

3.1 Significant Educational Effect

By comparing the academic performance of the experimental group and the control group, we found that the students in the experimental group had significantly better academic performance than those in the control group. In the various exams of the experimental class, the average scores of students were higher than those of the control class, and the excellent and passing rates also showed significant improvement. This indicates that teaching innovation projects have a positive impact on improving students' academic performance, and some students have also achieved excellent results in the postgraduate entrance examination process.

3.2 Students' Comprehensive Quality Has Been Improved

In addition to improving academic performance, innovative teaching projects have also had a positive impact on enhancing students' overall quality. Hangzhou Bay Cross Sea Bridge, Hong Kong Zhuhai Macao Bridge, Qinghai Tibet Railway, etc. These large-scale projects embody the excellent construction wisdom of the Chinese nation, and their construction is closely related to the mechanical properties of the foundation soil and the design of the foundation engineering. In terms of course teaching content, these large-scale domestic projects can be selected as classic cases, which can not only enhance students' interest in professional learning and national dignity, but also cultivate their patriotism. In the experimental class, students' self-learning ability, innovative thinking, and practical ability have been effectively improved. Students are able to actively participate in classroom learning, and are good at identifying, analyzing, and solving problems. At the same time, students' communication and teamwork skills have also been exercised and improved.

3.3 The Teaching Level and Research Ability of Teachers Have Been Improved

The implementation of teaching innovation projects not only improves students' academic performance and comprehensive quality, but also has a positive impact on teachers' teaching level. The humanistic literacy of teachers has a significant impact on the effectiveness of ideological and political education for students. Teachers' teaching concepts have been updated, teaching methods have been improved, and teaching abilities have been enhanced. The teaching level of teachers has been comprehensively improved.

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