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Original Paper

Research on the Reform and Evaluation of the Comprehensive Experimental Teaching Mode of Soil Mechanics under the OBE Concept

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Abstract

A soil mechanics experiment is an important hands-on class for civil engineering students. It helps them understand how soil behaves under different conditions and prepares them for real-world construction work. The old way of teaching has clear problems: even though students know how to use the tools well, but they do not have much experience applying them in real engineering situations. The experimental part does not connect well with real engineering work, and the way we check things is not varied enough. Outcome-Based Education (OBE) and the student-centered idea shows where teaching should change, but most of the important practices inside the country are still not deep enough. We looked at three organized new ideas, which are called the "technology-institution co-evolution" at the theory level, a plan for natural language processing a model for analyzing text sentiment in terms of methods, and one that can be repeated an index system for evaluating the innovation environment in a region when putting it into use At this level, the study brings in critical thinking and uses two main ideas together. builds the system for the experiment again, makes teaching better, and creates an evaluation system that includes five parts. From our teaching experience, we have seen that this mode can help students plan their experiments better, make better decisions about the data, and helps students learn how to solve engineering problems, and gives a model that can be used again changing courses that are similar.

Keywords

OBE concept, student-centered, soil mechanics, comprehensive experiment, teaching reform, critical

thinking, technology-institution co-evolution

1. Introduction

1.1 Research Background and Significance

From many years of teaching, we have seen a problem in soil mechanics lab classes: students can follow the steps to do the experiments, but they struggle to analyze things when there are complicated factors in real engineering work. For example, in the plate loading test for foundation strength, students just copy what to do step by step and don't think much about it we need to look at where the errors come from and what can be detected. If we do not do this, students may lose their ability to think critically and understand engineering basics. This is an important place to start for the changes we want to make.

As a new wave of science and technology comes in since the revolution, civil engineering has left behind the stage where being good at doing things was most important. Now it is moving into a new engineering era. In this era, making good decisions, designing on your own, and working together to create new ideas are the main points. We follow the OBE idea to change how we teach. We also use the framework called "technology-institution co-evolution" and also use some models and systems to check how well things work at the application level, and using ways to think carefully about problems If we keep this approach during the whole teaching process, we can solve the problem of focusing too much on skills and not enough on thinking. Also, this gives us clear ideas that other teachers can use for similar courses.

1.2 Research Status at Home and Abroad

The OBE concept is used a lot in engineering education in other countries, and soil mechanics experiments from other countries pay more attention to work done in real outdoor settings and doing things on your own. But because the way we train people is different goals and how resources are used in China compared to other countries, like these models can't be copied directly. Most of the changes that have happened in our country so far are just making small changes on the surface, and there are still issues like the using the OBE idea in practice, and the gap between what is taught and what is learned engineering, one-sided evaluation, and lack of critical perspective, not doing well to create a complete plan for making changes.

1.3 Research Content and Methods

This study follows the logic of "problem diagnosis—theory fit—model construction—practice verification", integrates three major innovations, and focuses on four core contents: diagnosing the pain points of traditional teaching, explaining the concept fit, building a reform model, and testing the reform effect and improving the evaluation system.

We use many different methods in our research: organizing the looking at existing theories and what is missing in research by checking the literature; explaining the meaning of the findings a new way of doing engineering using a model we built ourselves; understanding it well we found out what teachers and students need by doing surveys and talking to them, and comparing the results of our test with the plate loading test for foundations using bearing capacity as an example; checking how well the reform worked based on it a system for checking how well the application works.

2. Relevant Theoretical Basis and Interpretation of Systematic Innovations

2.1 Core Connotation and Critical Examination of the OBE Concept

The core of the OBE concept is "student-centered, results-oriented, and guaranteed by continuous improvement", and the goal is to build a closed-loop teaching system. If OBE is only used as a tool, it is easy to fall into the misunderstanding of utilitarianism and suppress students' critical and innovative consciousness. The reflective iteration logic of OBE is the basis of integration with critical thinking and the core embodiment of "institutional optimization" in the framework of "technology-institutional co-evolution".

2.2 Characteristics of Comprehensive Experimental Teaching of Soil Mechanics

The comprehensive experiment of soil mechanics is both practical, comprehensive, engineering and uncertain. There is no only standard answer to geotechnical engineering problems. There are many sources of error and complex working conditions. Isn't this a natural carrier to cultivate critical thinking? At the same time, it also provides a basis for the "practical ability" index in the application layer evaluation system.

2.3 Integration of Dual Concepts and Teaching Compatibility

The OBE concept provides a structured framework, the student-centered idea guarantees the student's dominant position, and critical thinking determines the depth of reform. The integration of the three meets the requirements of new engineering disciplines and promotes students to change from "mechanical operators" to "engineering problem solvers", which is the core logic of the "technology-system co-evolution" framework.

2.4 Construction of Systematic Innovations

In view of the deficiencies of existing research, this study builds a "theory-method-application" trinity innovation system, and three major innovations support the reform collaboratively:

- **Theoretical level**: Propose the "technology-institution co-evolution" framework, integrate teaching technology and institutional improvement, solve the problem of disconnection between the two, and provide support for concept integration.
- **Method level**: Develop a special model to accurately capture the emerging engineering orientation, support teaching optimization with data, and make up for the subjective limitations of traditional interpretation.

- **Application level**: Form a replicable regional innovation ecological evaluation index system, focusing on “experiment, thinking and engineering literacy”, suitable for universities at different levels, and providing standards for evaluation and achievement promotion.

3. Current Situation and Core Problems of Comprehensive Experimental Teaching of Soil Mechanics

3.1 Overview of Teaching Status Investigation

The investigation of three universities at different levels shows that soil mechanics experimental teaching generally presents a state of “emphasizing operation over design, weakening subjectivity and low speculation”. Students’ abilities of questioning, data analysis and independent exploration are weak. Both teachers and students are eager to strengthen thinking cultivation and make teaching closer to engineering practice, which also clarifies the reform focus and confirms the necessity of the application-level evaluation system.

3.2 Critical Analysis of Core Problems

Let’s look at the plate loading test for how well a foundation can hold weight as an example, the five main problems in traditional teaching clearly show the how important the new ideas in this research are: first, we focused on small goals, and did not pay attention to other things helping students develop their thinking skills and overall abilities, going against the direction of “technology and institution evolving together”; second, the content not connected to real engineering work, so they can’t help train students properly “engineering literacy”; third, teaching that focuses on control can reduce students’ does not think for itself and does not show the value of “technological innovation”; fourth, looks at things in only one way, and pays no attention to how people think through problems not connected to “making institutions better”; fifth, only making small changes on the surface not creating a teamwork between technology and institutions.

4. Construction of Teaching Mode Guided by OBE and Student-Centered Dual Concepts (Based on Systematic Innovations)

4.1 Principles of Teaching Mode Construction

Relying on three major innovations, the teaching mode follows six principles: focused on results (matching the goals of training students and how they grow together), student-centered (helping them explore on their own), close to real work (linking what happens in the field and helping put the evaluation system into practice), driven by new ideas (adding experiments that involve designing), focused on thinking deeply (teaching students to think critically), and always getting better (using models to improve teaching).

4.2 Clarification of Expected Learning Outcomes

When we use the application-level evaluation system, we can clearly define what we expect to achieve in four areas: knowledge (understanding how experiments work and industry standards); skills (being able to design experiments, handle data, and work with others); values (building a scientific mindset and good engineering ethics); and thinking skills (learning how to spot problems, check evidence carefully, and improve plans).

4.3 Optimization of Experimental Content System

Focusing on what we hope to achieve, we created a three-level system called "basic verification - comprehensive design - innovative exploration": basic experiments help students practice skills and understand the theory; comprehensive experiments include real engineering tasks to show how to use knowledge in practice; innovative experiments give open topics, use virtual simulation to encourage creative thinking, and meet the needs of co-evolution.

4.4 Innovative Teaching Implementation Methods and Paths

Use the approach of "independent exploration + project-based learning + mixing virtual and real elements + tiered instruction", create a complete teaching cycle, link policy goals with teaching models, and offer a practical way to carry out the evaluation system.

5. Construction of Teaching Evaluation System under the Guidance of Dual Concepts (Combined with Application-level Innovation)

5.1 Principles of Evaluation System Construction

Combined with the application layer evaluation system, the evaluation follows six principles. It not only pays attention to the experimental results, but also pays more attention to the thinking process and students' personal progress, ensures that the evaluation is comprehensive and objective, and meets the requirements of "system optimization" in the framework of "technology-system co-evolution".

5.2 Design of Evaluation Indexes and Methods

Build a five-in-one index system of "knowledge, ability, literacy, personal progress and critical thinking", and integrate the core content of application layer evaluation: knowledge (30%), ability (40%), literacy (10%), personal progress (10%), critical thinking (10%). It adopts the evaluation method of "process (60%) + result (40%)", absorbs multiple evaluation subjects, and uses the model to ensure the fairness of evaluation.

5.3 Evaluation Feedback and Continuous Improvement Mechanism

Guided by the framework of "technology-system co-evolution", a closed loop of "evaluation-feedback-improvement-re-practice" is established. Combined with the model and application layer evaluation system, the teaching plan is adjusted in time to realize the collaborative optimization of technology and system.

6. Teaching Reform Practice and Effect Analysis (Verification of Innovation Effectiveness)

6.1 Practical Scheme Design

The 2024 civil engineering students of our school were selected and divided into the experimental group and the control group (30 people each) to complete the one-semester control teaching. The experimental group adopted the dual-concept teaching mode integrated with critical thinking, relying on three major innovations to teach; the control group followed the traditional model, recording the learning situation and achievements throughout the course, and providing data support for the effect analysis.

6.2 Practical Effect Analysis and Critical Reflection

The practical data show that the average score of the experimental group is 83.4 points, the average score of the control group is 75.2 points, and the score is increased by 11 %. The effect of improving students' core competence is clear, which proves that the reform model and innovation points are effective.

Taking the plate loading test for foundation bearing capacity as an example, before the reform, students operated mechanically and experimental reports were identical; after the reform, relying on the "technology-institution co-evolution" framework, students independently design schemes, identify errors and judge results, truly transforming from "mechanical operators" to "problem solvers"!

This study also has limitations: critical thinking evaluation is difficult to be fully quantified; some students lack awareness of independent exploration; tight class time compresses the depth of discussion; some teachers' teaching ability needs to be improved, which points out the direction for the optimization of subsequent innovations.

7. Conclusion and Prospect

7.1 Research Conclusion

There are three main conclusions: first, the most important part of changing soil mechanics experiments is to help students think better, get closer to real engineering work, and let students take more control in learning, and the "technology-institution co-evolution" idea gives good support for these changes; second, putting together both kinds of ideas and thinking critically, along with three big new methods, helps move teaching from just training skills to building real abilities; third, the full process teaching method and the five-part evaluation system have worked well in practice, and they meet what is needed for new engineering education.

7.2 Research Prospect

In the future, we will optimize the innovation points and extend the research direction: promote the experimental content to be more suitable for the project, more personalized, and adapt to the application layer evaluation system; improve the virtual simulation platform, optimize the co-evolution framework technology module; strengthen teacher training and ensure the implementation of innovation points; improve the adaptability and operability of innovation points. In the future, we will deepen school-enterprise cooperation and promote the research results.

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