



The Innovative Teaching Model of “Four Integrations and Four Constructs” - The Example of Structural Mechanics

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Abstract

Emergent Engineering Oriented Discipline, the Outcome Based Education (OBE) concept is integrated into all aspects of the teaching of the Structural Mechanics course through the information technology platform, and the innovative teaching mode of “Four Integrations and Four Constructs” is formed by combining with the orientation of talent cultivation of the university, and the course objectives of “three in one” are constructed. In addition, the teaching method of “deliberate practice + three-stage”, “progressive” learning method, and the “whole process” course evaluation system can solve the sore points and promote the achievement of the objectives. The course has achieved good results in terms of participation, challenge, and ability improvement.

Keywords: Four Integrations and Four Constructs; innovative teaching model; deliberate practice; teaching reform

Current Status of Teaching

The course “Structural Mechanics” is an important professional foundation course for civil engineering majors, and it is positioned at the top and bottom of the curriculum. The following sore points exist in the teaching of this course.

- Learning this course requires a foundation in mathematics and mechanics, and students tend to form a scientific mindset, neglecting humanistic exercise and training, resulting in a lack of value leadership.
- Since “New Engineering” was formally proposed in 2016 [1], students are often disconnected from the theory and engineering practice in the learning process, lacking the organic connection between mathematics, mechanics principles, and engineering.

- Large classes lead to a lack of effective teacher-student interaction, resulting in a lack of motivation and interest of students.

To solve the above problems, a teaching reform is attempted for the course “Structural Mechanics” for civil engineering majors.

Teaching Reform Ideas

Geared to the needs of new engineering, through the information technology platform, the OBE concept into the curriculum teaching, combined with the school talents cultivation orientation, formed “Four Integrations and Four Constructs” innovation teaching modes: the integration of ideological education and knowledge education, the integration of mechanics principles with engineering practice, the integration of self-directed learning and cooperative

inquiry and the integration of teaching evaluation and teaching activities. Meanwhile, construct a trinity of curriculum objectives, deliberate practice [2] + three-section [3] teaching method, progressive learning method, curriculum evaluation system in the

whole process, focus on problems, breakthrough traditions, solve pain points, promote the achievement of goals, and achieve good results in the challenges and difficulties of learning participation and ability improvement (Figure 1).

Teaching Innovation Model — "Four Integrations and Four Constructs" - Solving Painful Problems and Promoting Goal Achievement

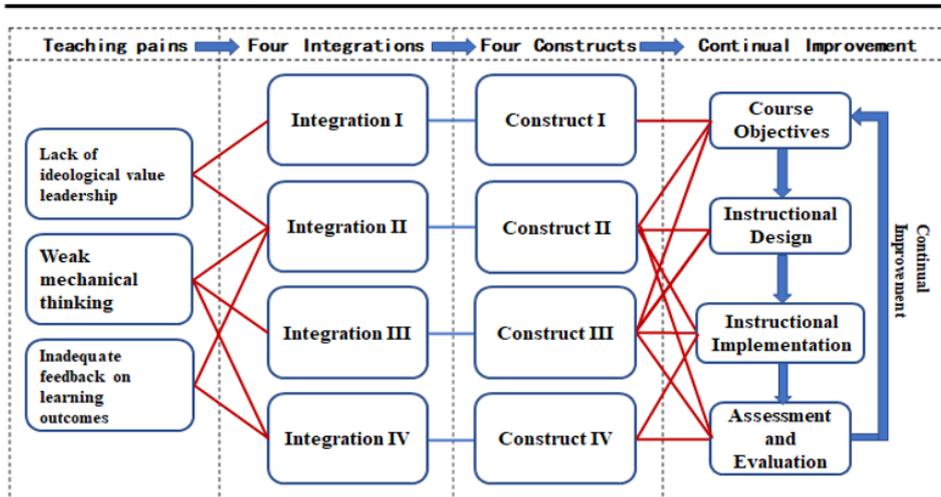


Figure 1: Teaching model of structural mechanics – “Four Integrations and Four Constructs”.

Integration I: The integration of ideological education and knowledge education

Integration II: The integration of mechanics principles with engineering practice

Integration III: The integration of self-directed learning and cooperative inquiry

Integration IV: The integration of teaching evaluation and teaching activities

Construct I: Constructing a “trinity” of curriculum objectives

Construct II: Constructing the “deliberate practice + three-section” teaching method

Construct III: Constructing a progressive learning method

Construct IV: Constructing a “whole process” evaluation system

Implementation of Curriculum and Teaching Reform

Construct “Trinity” course teaching objectives, “progressive” learning style, the integration of ideological education and knowledge education

Based on the OBE concept and the requirements of the construction of engineering education accreditation standards,

we set the objectives of the course based on the concept and the graduation requirement index points 1.2 and 2.2 in the graduation requirement training program of this course, set the objectives of thinking and politics, and enhance the value guidance, and construct the “progressive” learning mode for students.

The “progressive” learning style of self-directed learning → cooperative learning → discussion learning is constructed according to the course objectives. (refer to Figure 2).

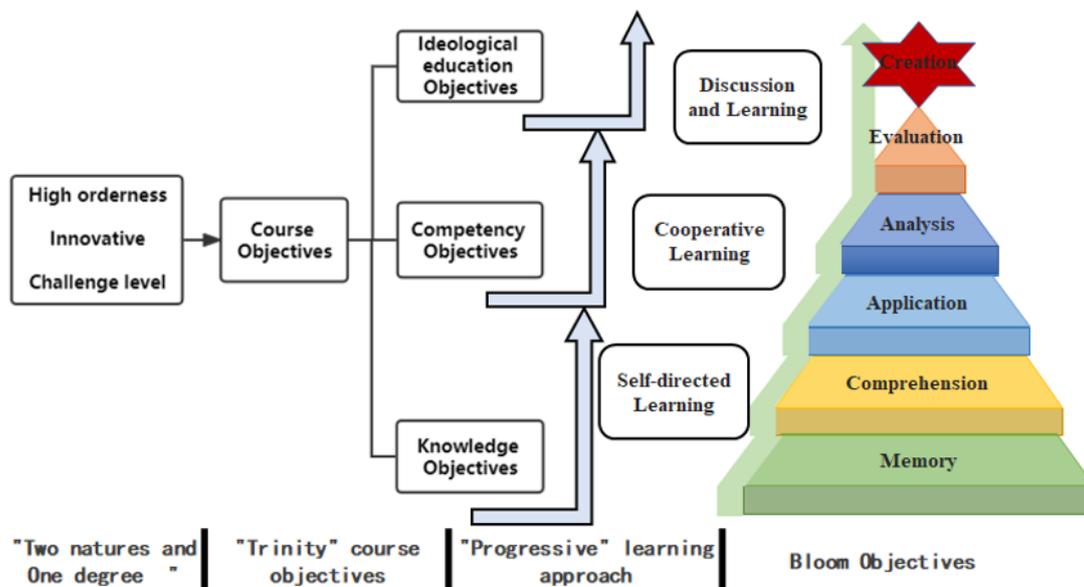


Figure 2: Teaching objectives of Structural Mechanics Courses.

Knowledge objectives: To master and apply the principles and methods of calculating internal forces, displacements, and stability of various types of rod structures; to distinguish the force characteristics and performance of various types of structures; to analyze and design relevant structures in subsequent professional courses.

Competency objectives: To abstract the actual engineering problems into the corresponding mechanical models; to be able to

choose the corresponding structural mechanics methods for the mechanical analysis and calculation of structures; to compare and analyze the results with the commonly used mechanical calculation software.

Ideological education objectives: to enhance the awareness of norms and improve engineering literacy; to cultivate communication ability and teamwork spirit; to stimulate the awareness of engineering innovation.

Restructured teaching content

Module 3	Mechanics Modeling and Practice	Structural model design			
Module 2	Computational Analysis	Torque distribution method.			
		Force Method		Displacement Method	
Module 1	Theoretical foundation	Single-span static beam internal force	Multi-span static beam internal force	Three hinge arch internal force	Line of Influence
		Geometric composition analysis	Static rigid frame internal force	Static structure displacement	Static trusses internal force

Figure 3: Modularity of course content.

According to the teaching innovation model of “Four Integrations and Four Constructs”, the teaching content of the course is reconstructed. As the foundation of engineering science, mechanics should focus on cultivating students’ mechanical thinking. Therefore, the 11 chapters of this course are divided

into three modules. Modules 1 & 2 require students to sort out the knowledge points of each chapter according to the characteristics of mechanics thinking, with the mainline of “engineering background, mathematical foundation, and mechanics principles”, and draw a mind map to realize the reconstruction of course content, connect

the knowledge points of the previous course, realize the transfer of knowledge points, establish the organic connection of engineering, mathematics, and mechanics and cultivate their The third module is about model design. Module 3 is about model design, which is project-driven and organized for students to participate in structural design competitions. All of the above requires the students to make a jump, or even several jumps, to complete the tasks (Figure 3).

Construction of “deliberate practice + three-stage” teaching method, integration of mechanical principles and engineering practice

The reconfiguration of teaching content is realized by using a three-stage teaching method. We provide timely feedback on the learning effect through “Cloud Class” and design a lot of repetitive and progressive deliberate exercises for the three-stage teaching: publish the learning task list in “Cloud Class” one week in advance, watch the course video through MOOC (Comfort Zone), complete the pre-class test, Q&A discussion, homework (Learning Zone), guide students to complete the case study, student three-stage lecture, and structural model design (Challenge Zone), summarize the shortcomings in each of the previous deliberate exercises in self-summary, check the gaps, and write study notes for each chapter. Offline teaching is to cooperate with online teaching, focusing on teachers organizing classroom teaching according to the teaching feedback from the “Cloud Class”, timely checking and filling gaps and providing timely feedback and guidance.

The whole online & offline teaching is from Comfort Zone → Learning Zone → Challenge Zone sets interval, interspersed, and diversified deliberate exercises, from easy to difficult, from basic to advanced progressive deliberate exercises, offline and online teaching cooperates, through teachers’ elaborate design, allowing students to consolidate and flexibly apply the basic knowledge learned online, integrating mechanics principles with engineering practice, aiming to cultivate students’ mechanical thinking and stimulate their interest in learning. Led by the sense of achievement, it makes machine learning easy and challenging.

Construct the whole process curriculum evaluation system and integrate teaching evaluation with teaching activities

Applying the advanced quality concept, we construct the whole process curriculum evaluation system oriented to output standards. Course assessment consists of process and summative evaluations, which are multiple, measurable, and hierarchical. Focusing on process management, teaching evaluation data guide teaching content optimization and improve teaching organization activities. Teaching activities are evaluated, standardized, recordable and traceable.

The online and offline hybrid teaching is implemented in three stages: before class, in class, and after class, and uses a combination of process evaluation and summative evaluation, teacher evaluation, student mutual evaluation, and student self-evaluation. There are eight kinds of assessment links, including three-stage study notes, three-stage lecture, homework, class tests, question

and answer discussions, test activities, structural model designs, and examinations, which correspond to each “deliberate practice”.

A final grades of structural mechanics = usual grade [three periods of study notes (20%) + three-stage lecture (20%) + homework (10%) + 5 points deducted for one missing “Cloud Class” activities (class test, Q&A discussion, test activity) + structural model design (10%)] + exam (40%) is composed.

Conclusion

Due to the lack of teaching interaction in large classes in 2019, this course began to try online and offline hybrid teaching, mainly using “Cloud Class” to carry out online teaching for a total of 20 class hours (20%). The online teaching contents include video learning, classroom tests, homework, Q & A discussion, and model design; Offline teaching is mainly three-stage lecture, and the teaching content is learning notes and final examination.

In 2020, because of the epidemic, structural mechanics (1) was taught online for 48 hours (66.7%). According to the course teaching quality analysis report, we try to focus on students, let them learn in “three segments”, face the emergent engineering-oriented discipline, and focus on cultivating students’ mechanical thinking. According to the 2019 year, the online teaching content added three-stage lectures, and start to try flipped classroom to carry out homework, comment, and three-stage lecture; Offline lectures and Q&A discussions are mainly conducted by teachers. And the three-stage mind mapping is added to the teaching content to construct the curriculum knowledge map.

In 2021, according to the unsatisfactory achievement of the previous courses of Class 2019 students, appropriate adjustments will be made, and the online teaching will be 26 hours (26%), the course objectives will be adjusted to enhance value leadership, the theory of “deliberate practice” will be tried to be introduced to enhance students’ learning interest and motivation, the online and offline teaching contents will be reconstructed, and timely feedback will be provided through the “Cloud Class”. We design a lot of repetitive and progressive deliberate training for the three-stage lecture and integrate hybrid teaching to guide students to move from their Comfort Zone to Challenge Zone.

The attainment of structural mechanics (1) of civil engineering students in three sustained years was 0.72 for Class 2017, 0.76 for class 2018, and 0.76 for Class 2019, and the learning effect of Class 2019 was the same as that of Class 2018 despite their weak foundation and after adding deliberate practice. Better results were achieved in terms of learning participation, challenging difficulties, and ability improvement.

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Conflict of Interest

No conflict of interest.

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