



Hybrid Teaching Practice of Structural Mechanics Based on Deliberate Practice Theory

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Abstract

The reduced class time for Structural Mechanics and the lack of interaction in large classes have led to the lack of students' interest and motivation in learning. Facing the new engineering discipline, combined with the objective of this course to cultivate students' mechanical thinking and thus enhance the ability of model simplification and computational analysis of complex engineering, the modular design of the course content, timely feedback on learning effect through cloud class lessons, design a large number of repetitive and progressive deliberate exercises for the three-stage teaching, integrate hybrid teaching, and try to guide students' courage to step from the comfort zone into the challenge zone.

Keywords: Structural mechanics; Deliberate practice; Hybrid teaching

Current Status of Teaching

The course "Structural Mechanics" is an important professional foundation course for civil engineering majors. The following problems exist in teaching.

- Since 2016 the "New Engineering" was formally proposed [1], there is often a disconnect between theory and engineering practice in students' learning process, and there is a lack of organic connection between mathematics, mechanics principles, and engineering.
- Class hours in basic mechanics courses have been compressed. The streamlining of class time with the same teaching content leads to teachers being tired of catching up.
- Large classes lead to a lack of effective teacher-student interaction, resulting in a lack of motivation and interest in learning.

In order to solve the above problems, and in response to the current situation that the overall mechanical thinking of civil engineering students in our school is weak, we tried to carry out a hybrid teaching reform based on deliberate practice [2] theory in the course of Structural Mechanics.

Teaching Reform Ideas

The teaching reform of mechanics courses for the new engineering should cultivate students' mechanics thinking through mechanics course learning. Mechanics thinking contains three landing points and the three landing points refer to engineering (or natural phenomena), mechanics, and mathematics (hereinafter referred to as the three segments). For the cultivation of mechanical thinking, it is appropriate to use the three-step teaching method [3]. Combined with the objective of this course to cultivate students' mechanical thinking so as to enhance the ability of model

simplification and computational analysis of complex engineering, the modular design of the course content, the timely feedback of learning effect through cloud classroom, the design of a large number of repetitive and progressive deliberate exercises for the three-stage teaching, and the integration of hybrid teaching, try to guide students' courage to step from the comfort zone into the challenge zone.

Implementation of Curriculum and Teaching Reform

The modularity of course content

Combined with the school's positioning of training high-quality applied talents and the requirements of the construction of engineering education accreditation standards, based on the

OBE concept, benchmarking this course supports the graduation requirements in the talent training program indicator points 1.2, 2.2, the course objectives identified: knowledge objectives (objectives 1) and ability objectives (objectives 2). According to the course objectives, the content of this course is divided into a total of three 11 chapters, a total of 72 credit hours (see Figure 1). In the three-stage teaching, students are required to reconstruct the course content according to the three-stage structure: combing the knowledge points of each chapter with the mainline of "engineering background, mathematical foundation, and mechanics principle", drawing a three-stage mind map of each chapter and writing study notes. Students and faculty members will work together to construct a knowledge map for the course.

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 1: Modularity of course content.

Design of "deliberate practice + three-stage" teaching method

Deliberate practice emphasizes purposeful practice that breaks out of the comfort zone, which is the only way to make rapid

progress. The most important feature of the deliberate practice lies in purposeful mass repetition, the use of spaced, interspersed, and diverse exercises, and the giving of timely feedback. The three-stage teaching design of this course based on the theory of deliberate practice is as follows (see Figure2).

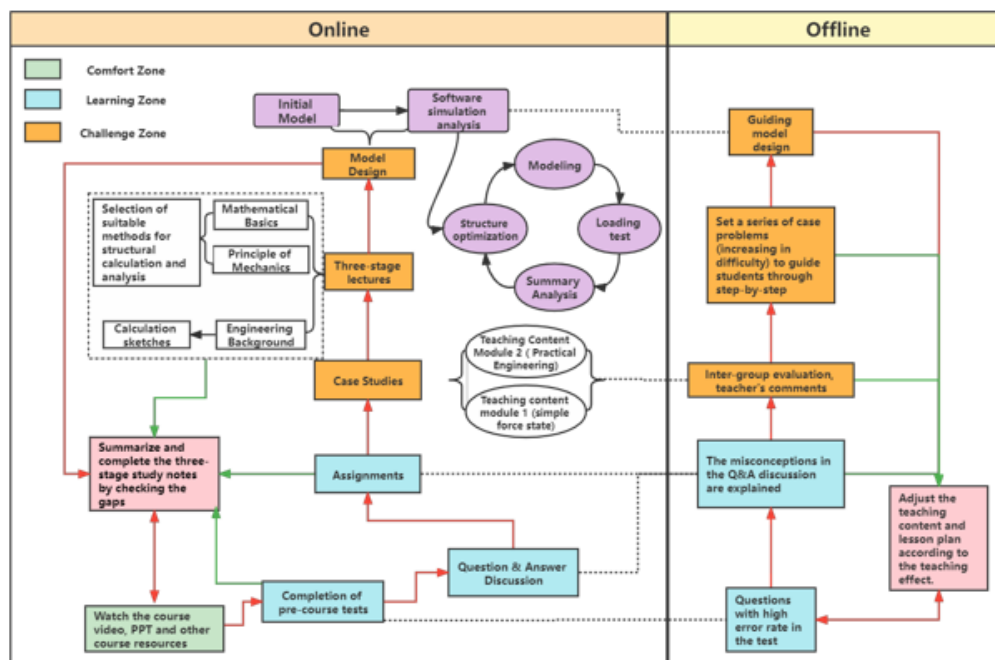


Figure2: Blended instructional design based on deliberate practice theory.

Online teaching

- Combined with the theory of deliberate practice, the three-stage teaching of the course “Structural Mechanics” relies on MOOC and beeping websites, and students use their cell phones or computers to watch the course videos online in fragmented time and arrange their learning progress flexibly according to their own conditions. This stage is the comfort zone.
- Then we move on to the study area: students are required to complete a pre-test. The teacher selects the appropriate level of difficulty in the exercise bank and assigns the pre-class test, which is based on multiple-choice and judgment questions.
- Teachers set up Q&A discussion topics in the cloud class for the misconceptions of the pre-class test, as well as the key points and difficulties in teaching, and teachers and students participate together and arrange them at intervals according to the students’ real-time mastery.
- The teacher assigns homework in Cloud Class and depending on the students’ mastery online and offline, the questions increase in difficulty, requiring students to “tiptoe” to reach them.
- The “test, question and answer, homework” type of deliberate practice is mainly to test students’ mastery of the knowledge objectives, based on this, set higher-order deliberate

practice for the ability objectives, this paper set as a challenging area, through the flipped classroom to implement.

- The case study is mainly to train students to calculate the sketch + structural rationality analysis ability, in the course content module part of the selected case is a simple state of force (such as the year 2021 in Ezhou City, Hubei Province, Wu Huang high speed and Da Guang high-speed interchange approach bridge section bridge overturn). It is required to complete the case analysis and write a report in advance by cooperating with the structural mechanic’s study group. The case chosen in the module II part of the course content is a complex practical project, which needs to be combined with the subsequent collection of specialized courses to choose a suitable engineering case. This deliberate exercise is interspersed and set 2-4 times depending on the students’ learning situation and status.
- The purpose of the three-stage lecture is to cultivate students’ mechanical thinking so as to enhance students’ ability to calculate sketch + calculating analysis. In one part of the course content module, we choose the internal force diagram of a static rigid frame which most students are weak in mastering, and in the second part of the course content module, we choose the lecture content: solving super-static structure by force method and displacement method. It is required to finish the lecture with group discussion, organize the teaching content

in order according to engineering background, mathematical foundation, and mechanics principle, and submit the results as lecture PPT, video, and summary.

- Structural model design aims to cultivate students' engineering innovation ability, corresponding to the course content module 3, by organizing students to participate in our school academic science and technology festival - structural design competition project implementation in small groups, requiring group cooperation and discussion to complete: initial model → software simulation analysis → structural optimization → model making → loading test → summary. The results to be submitted are structural model, design proposal, and video.

- Write three-stage study notes for each chapter, in addition to drawing a three-stage mind map for each chapter, self-summarize the deficiencies in each deliberate exercise, check the gaps, and integrate them into the study notes of each chapter to form a closed loop of online teaching.

Off-line teaching: Offline teaching with online teaching, the focus is on teachers organizing classroom teaching based on the teaching feedback from the cloud classroom, timely checking and remediation, and students are always in the learning zone + challenge zone.

- The teacher sets a series of class quizzes of increasing difficulty and guides students to complete them step by step according to the pre-class tests, Q&A discussions, and misconceptions in the homework based on feedback from the cloud class sessions. For example, drawing a deformation displacement diagram to determine nodal displacement is a weak point for students. The teacher will first choose a corner + a lateral displacement example, students complete the class quiz, the teacher speaks and analyzes the ideas, announces the reference answers and grading criteria, students use a red pen to correct and revise and then upload the cloud class as required; next, the horizontal rod is changed to a rigid rod; on this basis, the vertical rod is changed to a two-force rod, and three deliberate exercises of increasing difficulty are set to guide students' thinking progression and develop their mechanical thinking. The next step is to change the horizontal rod to a rigid rod; and the vertical rod to a diametrical rod.

- Case studies and three-part lectures are evaluated among groups, and group comments + teacher comments are given in a timely manner.

- The teachers follow up and provide guidance in a time when students encounter problems in the design of structural models. According to the teaching effect of each link of offline teaching, the teaching content and teaching progress are

adjusted to form a closed loop of offline teaching.

The entire online + offline teaching from the comfort zone → learning zone → challenge zone set interval, interspersed, diversified deliberate exercises, from easy to difficult, from basic to advanced progressive deliberate exercises, offline and online teaching with each other, through the teacher's careful design, so that students online learned the basic knowledge to consolidate and flexible application, stimulate students' interest in learning, led by the sense of achievement to make mechanics learning It is easy and challenging.

Cloud classes provide timely feedback on learning results

Deliberate practice requires a lot of timely feedback. This course provides timely feedback through Cloud Classroom, a learning platform. The instructor publishes a list of tasks and corresponding activities for each class a week in advance in Cloud Classroom, and each deliberate exercise has a corresponding assessment rule, and students can log in to Cloud Classroom to check their grades and comments, which constitute the usual grade for the course. The online and online deliberate exercises provide students with the opportunity to repeat and correct their mistakes in a timely manner, creating a sense that "making mistakes is an opportunity to learn". When mistakes are made, teachers should encourage students to face up to them and not be afraid to make mistakes, and correcting mistakes is progress.

Conclusion

The attainment of structural mechanics (1) for civil engineering students was: 2017 grade for 0.72, 2018 grade for, 0.76 and 2019 grade for 0.76. 2019. The level students, despite their weak foundation and after adding deliberate practice, have the same learning effect as 2018 the level. In the author's opinion: by guiding students to complete deliberate practice from comfort zone → learning zone → challenge zone, from easy to difficult, from basic to advanced progressive, the harvest after the effort is more accomplished, enhance students' learning enthusiasm, develop their mechanical thinking and vision, stimulate their learning potential, and promote the achievement of the course teaching objectives. In this process, the role of the teacher is particularly important.

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Conflict of Interest

No conflict of interest.

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