The Construction and Practice of Smart Teaching Mode of Engineering Mechanics under the Empowerment of AI

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Abstract. With the deep integration of artificial intelligence and education, intelligent courses have become the core direction of higher education reform. Engineering mechanics, as a core foundational course for engineering disciplines, has traditional teaching problems such as low student participation and difficulty in knowledge transfer. Based on multiple theories including constructivism, combined with AI technology, this paper constructs an "three-dimensional four-stage" intelligent teaching model for engineering mechanics courses, covering three dimensions of teaching objectives, content, and evaluation, as well as four teaching stages including pre-class preview, and integrating various AI application modules. The results show that this model can significantly enhance students' comprehensive qualities, solve the problems of traditional teaching, promote the improvement of teachers' teaching abilities, and provide theoretical references and practical models for the teaching reform of engineering foundation courses.

Keywords: Artificial intelligence, intelligent courses, engineering mechanics, three-dimensional four-stage method

1 Introduction

Artificial Intelligence, which is the technology by means of which computers are utilized to simulate, expand and aid human intelligence so that they can understand, reason, learn, plan and perceive among other things thus attaining intelligent behaviors much like those of humans, [1] can have its concept traced back to the 1950s and in 1956 the Dartmouth Conference was the first to put forward the term "Artificial Intelligence" signifying the formal emergence of AI as a research area and as computer technology developed rapidly especially in 2017 when Google introduced the Transformer model and relevant institutions were set up AI witnessed an explosive growth and its applications had spread across numerous fields such as machine learning and natural language processing driving human society into the artificial intelligence era. [2]

In the realm of education, an increasing number of universities and educators have started to probe into the utilization of artificial intelligence (AI) technology within teaching practices, which has led to the creation of top - quality educational resources like "model courses" and "excellent courses", and when it came to teaching administra-

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tion, AI considerably enhanced the precision and efficacy of management, also regarding curriculum reform, AI furnished robust support for novel teaching approaches such as project - based learning and inverted classrooms, moreover, in terms of teaching assessment, AI made the evaluation contents and standards diverse and systematic.[3]

Engineering mechanics, as the central fundamental course for engineering disciplines, mainly consists of two principal components: statics and mechanics of materials, and its course content encompasses the fundamental concepts in statics, the simplification of force systems, the equilibrium of object groups, the internal force computation of straightforward planar trusses, the tension and compression of bars, the torsion of circular shafts, the bending of beams, etc.,[4] while the traditional teaching approach of engineering mechanics had certain issues like monotonous teaching means, inadequate student involvement, and insufficient development of students' capacity to simulate and resolve intricate engineering problems, but the incorporation of AI technologies, such as virtual simulation technology, could construct a genuine - life engineering mechanics experimental setting, enabling students to conduct experiments within a virtual realm and witness mechanical phenomena directly, and knowledge graphs, by presenting the engineering mechanics knowledge system in a structured manner, assisted students in constructing a methodical knowledge framework, and mind maps were favorable for clarifying the knowledge structure and enhancing learning efficiency, so under these circumstances, establishing an AI - enabled intelligent engineering mechanics classroom teaching model had become a crucial route to address the traditional teaching challenges and enhance teaching quality。[5]

2 Construction of an Online-Offline Hybrid Teaching Model Based on Smart Courses

The intelligent classroom teaching model for engineering mechanics empowered by artificial intelligence, which was constructed in this paper, had a "three - dimensional four - stage" structure; "Three dimensions" referred to the three key aspects of teaching goals, teaching contents, and teaching evaluations; "Four stages" referred to the four teaching phases of pre - class preview, in - class interaction, post - class consolidation, and stage improvement as shown in Figure 1; each dimension and stage were interrelated and mutually supportive, forming a complete teaching loop.

2.1 Three-Dimensional Core Dimension

(1) Teaching Aims Aspect: In line with the engineering education certification criteria and the course plan, figure out the knowledge - related aims, competence - related aims and quality - related aims where the knowledge - related aims cover grasping the fundamental notions, principles and formulas in engineering mechanics, the competence - related aims involve the capacity to analyze mechanical issues, perform calculations, carry out experiments and apply engineering knowledge, and the quality - related aims mean fostering a meticulous scientific mindset, innovative ideas and a spirit of teamwork.

(2) Teaching Content Aspect: Split the engineering mechanics course content into the fundamental theory part, the engineering application aspect, and the innovative extension section, where the fundamental theory part encompasses crucial elements like statics, kinematics, dynamics, etc., the engineering application part contains engineering instances associated with the major such as analyzing the mechanics of mechanical structures and resolving civil engineering mechanics issues, and the innovative extension part involves leading - edge mechanics technologies and cross - disciplinary combination applications, and employ AI technology to transform the teaching content into distinct forms of teaching resources including videos, animations, virtual experiments, and engineering cases.

(3) Teaching Evaluation Dimension: Build a multi - aspect evaluation framework that combines "process evaluation + final evaluation", where process evaluation covers pre-class preparation, classroom engagement, the quality of homework, and laboratory work performance while final evaluation consists of final exams, practical project evaluations etc., and employ AI technology to automatically collect, analyze, and offer feedback on evaluation data so as to guarantee the objectivity and precision of the evaluation.

2.2 Four-Stage Teaching Process

(1) Pre - class preview phase: Teachers utilize an AI-driven lesson preparation system to select and provide personalized preview materials based on teaching objectives and students' comprehension abilities. Students study these preview materials online through the Superstar Learning Platform and take preview tests. The AI learning analysis system automatically grades the tests and identifies students' weak points in knowledge, and then feeds the analysis results back to the teachers and students. Teachers adjust the focus of the class and teaching methods according to the students' preview progress.

(2) In - class interaction stage: The classroom teaching was mainly interactive and immersive and was divided into three sections. First, there was the knowledge explanation part where teachers concentrated on the issues that students had come across during their preview and made use of AI visualization tools like mechanical simulation animations and three - dimensional models for crucial explanations to assist students in getting over their knowledge - related difficulties. Second, the interactive exploration section in which students carried out group discussions and virtual experiment operations via the AI interactive platform and cooperated in solving mechanical problems while teachers monitored students' participation in real - time through the AI classroom management system and offered targeted guidance. Third, the immediate assessment phase where teachers pushed on - the - spot test questions by means of the AI intelligent assessment tool and students completed the answers online after which the system generated the assessment results straight away and teachers corrected the gaps and deficiencies according to the assessment results.

(3) After - class consolidation phase: Educators utilize an AI-driven personalized recommendation mechanism to deliver review materials and graded assignments based

on students' learning situations and knowledge gaps in the classroom. Students complete their assignments and review tasks through an online platform and an AI-assisted grading system. The system automatically grades multiple-choice questions and provides initial scores and comments for essay questions.

(4) Phase Enhancement Phase: Through an integrated assessment system based on artificial intelligence, conduct a comprehensive assessment of students regarding the current unit. Based on the assessment results, provide students with personalized supplementary learning materials and targeted reinforcement exercises, and organize them to participate in engineering practice projects so that they can apply the knowledge they have learned to solve practical engineering problems, thereby enhancing their engineering practice skills and innovative thinking. The four-phase teaching process is shown in Figure 1:

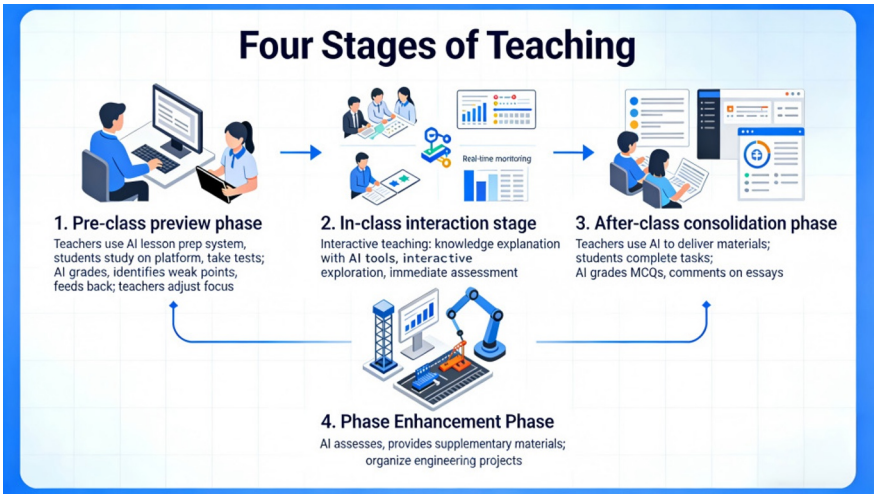

Fig. 1. "Four Stages" of Smart Teaching

3 Smart Course Platform Construction

3.1 Introduction to Superstar Learning Tong

Superstar Learning Platform is developed by Beijing Superstar Company. It is a mobile educational platform with interactive functions. Teachers can use it to create courses, publish and share teaching materials, even use mobile screen projection to form interactive classrooms. It also supports various teaching activities such as sign-in, topic discussions, voting, scoring, questionnaires, homework upload and scoring, thereby enhancing the interaction between teachers and students. Students can use it for self-study, and teachers can conduct offline communication and interaction based on students' feedback information, thereby improving teaching effectiveness. [6]

3.2 Knowledge Graph Construction

The formulas and other information in the engineering mechanics course can be presented graphically, thus forming a comprehensive knowledge framework. This enables students to quickly locate the required knowledge elements through the knowledge map, understand the interrelationships between them, and improve their learning effectiveness [7]. In actual teaching, teachers collect relevant materials such as textbooks, slides, and academic papers, and then use mind mapping tools to construct the engineering mechanics knowledge map. This map divides the engineering mechanics course into three knowledge sub-modules, namely statics, mechanics of materials, and engineering application examples, as shown in Figure 2. The current knowledge map constructed in this study contains 59 knowledge elements and 91 associations. Each sub-module contains several specific knowledge nodes, which gradually branch out according to the logical structure of knowledge and are interconnected through lines or... As shown in Figure 3, this is the static version of the completed knowledge map. It is based on data about students' learning progress, grades, and incorrect answers. The knowledge mapping algorithm is used to provide personalized learning paths for students. For students with weak foundations, it will first recommend them to learn resources related to basic knowledge to strengthen their basic understanding. For students with sufficient learning ability, additional learning content will be provided to guide them to further explore related knowledge and "intelligent teaching assessment".

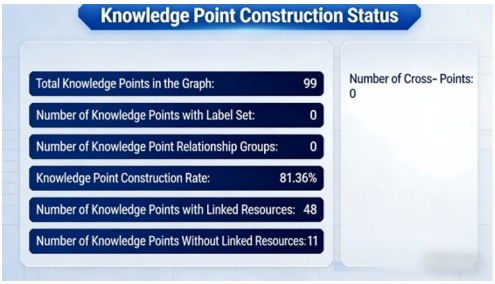

Fig. 2. Circular Pattern of Course Map

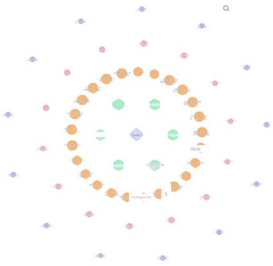

Fig. 3. Statics Knowledge Graph

3.3 Intelligent Teaching Evaluation

The intelligent teaching evaluation of engineering mechanics relying on artificial intelligence is incorporated throughout the whole teaching process, using a "process - centered + final evaluation" evaluation approach, specifically calculating the assessment as follows: total score equals 40% of the average score plus 60% of the final score, where the average score was assessed via a "three - time spans (see Fig 4), four - levels, multi - aspect" evaluation method to collect the score data information of students prior to, during, and after class, and the multi - aspect evaluation process of "self-evaluation→ mutual evaluation → teacher evaluation" formed the final evaluation score, emphasizing the evaluation of students' overall capabilities. This evaluation approach is more effective in arousing students' enthusiasm for study and assisting them in forming

the excellent practice of active contemplation, and moreover, teachers constantly enhanced teaching plans in light of students' responses and their self - assessments, eventually attaining the aim of elevating teaching quality.

4 Teaching Practice of the Intelligent Course Platform

The intelligent engineering mechanics course was carried out over four semesters on the "Superstar Learning Platform" and knowledge graphs, big data, large-scale models, and artificial intelligence (AI) were utilized to construct an intelligent course platform (see Fig 5), and altogether 1,580 students enrolled in the course, achieving a cumulative page view of 1,164,433 and a cumulative interaction count of 42 times.

The existing course platform has set up a repository for instructional resources containing elements like curriculum outlines, lesson plans, multimedia presentations, examination blueprints, laboratory guidelines as well as collections of questions, test papers, animation clips etc., there were 455 questions in total and the platform had released assignments 119 times, examinations 22 times and chapter-based quizzes 6 times, once students finished answering the questions, the platform could offer feedback regarding their grasp of knowledge points.

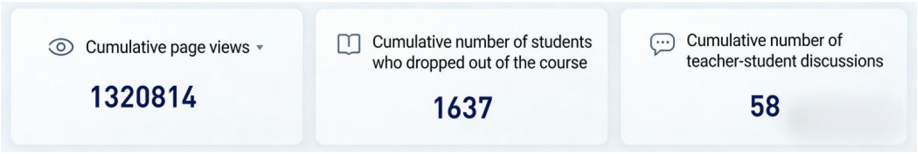

Fig. 4. Superstar Learning Platform - Smart Course Platform

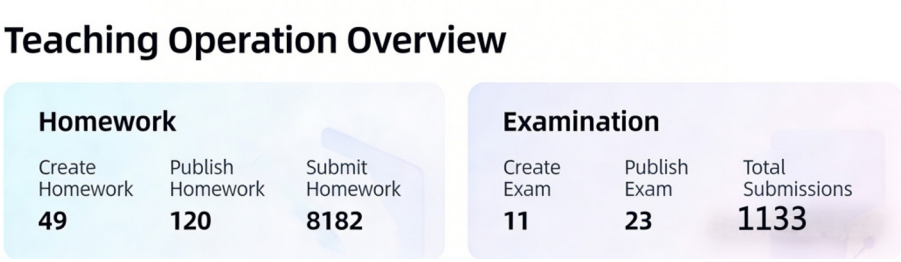

Fig. 5. Overview of Course Teaching

5 Evaluation of the Effect of AI Enabling Engineering Mechanics Course Teaching

The engineering mechanics teaching under the AI-enabled mode has played a positive role in helping students master and apply mechanical knowledge proficiently. By using knowledge mapping and mind mapping tools, students can better organize the

knowledge framework and summarize the core points, thereby deepening their understanding of the knowledge and enhancing the memory effect. As a result, the learning quality has been significantly improved. Based on the assessment data of the achievement of course objectives in the past three years, the learning effectiveness of students has improved significantly: the excellent rate of students' final exam scores in the latest round has increased by 11.56% compared to the previous two rounds, and the average score has increased by 7.06 points and 5.26 points respectively compared to the previous two rounds. The achievement of each dimension of the course objectives has also realized substantial improvement compared to the previous two rounds.

6 Conclusion

In conclusion, based on the "Super Star" learning platform, this paper conducts a study on the intelligent teaching methods for the engineering mechanics course. It integrates the entire teaching process (pre-class, in-class and post-class) as well as online and offline teaching situations, combines with the reform of assessment methods, closely links the learning process with the assessment results, and effectively stimulates students' interest and enthusiasm in learning. At the same time, in the era of educational informatization, by leveraging the power of artificial intelligence and applying digital tools such as virtual simulation and knowledge mapping, it promotes the application of mixed teaching methods and the digital transformation of teaching assessment, successfully addressing the problems of theoretical and practical disconnection, high learning difficulty, and single teaching methods in traditional teaching, significantly enhancing students' autonomous learning ability and practical ability. It also possesses innovative thinking ability, helps improve teachers' teaching skills, plays an important role in promoting the cultivation of applied talents in universities, and effectively improves the quality and effectiveness of the course.

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