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AI-Enabled Teaching Reform and Practical Exploration of Compressor Courses

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Abstract: Against the background of the comprehensive advancement of emerging engineering construction and the deepening of industrial intelligent transformation, compressor courses, as core courses for majors such as Energy and Power Engineering, Mechanical Engineering, and Chemical Process Machinery, assume the important task of cultivating students' engineering practice capabilities and innovative thinking. However, traditional teaching models face problems such as the use of abstract theories and a disconnection from practice, which make it difficult to meet the talent training requirements of the new era. Taking the in-depth integration of AI technology and education as the core concept, this paper systematically sorts out the teaching status and reform needs of compressor courses, and constructs an overall framework for "AI + Compressor" course teaching reform from three dimensions: teaching content reconstruction, teaching model innovation, and practical system optimization. By introducing various carriers such as virtual simulation experiments, intelligent teaching platforms, personalized learning systems, and AI innovative practice projects, it promotes the concretization of theoretical teaching, the scaling of practical teaching, and the precision of the teaching process. The paper also discusses the guarantee mechanism for the implementation of the reform, providing a feasible path for cultivating compound talents with engineering practice capabilities, innovative thinking, and intelligent technology application capabilities, as well as a reference paradigm for the intelligent transformation of engineering professional courses in China.

Keywords: AI technology; Compressor courses; Teaching reform; Emerging engineering; Practical teaching

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1. Introduction

Compressor courses cover multiple knowledge modules such as thermodynamics, fluid mechanics, and structural design, featuring a strong theoretical nature, close connection with engineering practice, and rapid knowledge updates [1,2]. However, against the backdrop of industrial intelligent transformation, traditional teaching methods have gradually revealed various deficiencies: complex formulas and physical models are difficult to intuitively demonstrate, leading to students' understanding difficulties; experimental equipment is large in size and high in cost, resulting in limited actual operation opportunities for students; the update of teaching content lags behind, with insufficient coverage of intelligent technologies [3–5]. These problems restrict the improvement of course teaching quality and affect graduates' adaptability to the intelligent needs of the industry.

The development of emerging technologies, such as artificial intelligence, has provided important technical support and transformation opportunities for the teaching reform of computer courses. Using technologies such as artificial intelligence, virtual simulation, and big data analysis can effectively break the limitations of traditional teaching in terms of time, space, and resources, construct an intelligent teaching environment, optimize the teaching process, innovate practical models, and promote the transformation of teaching focus from "knowledge transmission" to "ability cultivation" [6,7]. Therefore, exploring the in-depth integration of AI technology and compressor course teaching, reconstructing teaching content, innovating teaching methods, and improving the practical system are of great theoretical value and practical significance for improving teaching quality and cultivating high-quality talents adapting to industry development. Combining the actual teaching of compressor courses, this paper systematically expounds the core paths and guarantee measures of AI-enabled teaching reform, providing a reference for the intelligent construction of engineering professional courses.

2. Current teaching status and reform needs of compressor courses

2.1. Analysis of current teaching status

At present, the teaching of compressor courses faces several prominent problems: first, the teaching content is highly theoretical and abstract, involving complex formulas and models related to compressor working principles, thermodynamic processes, and structural design. Traditional blackboard writing and multimedia demonstrations are difficult to vividly show their dynamic processes, resulting in obstacles for students' understanding; second, experimental conditions are limited, and university laboratories are unable to equip sufficient training devices, leading to students' lack of actual operation opportunities and insufficient mastery of key skills such as equipment disassembly and assembly, debugging, and fault diagnosis [8]; finally, the teaching content fails to keep up with technological development. With the wide application of intelligent sensing, the Internet of Things, AI diagnosis, and other technologies in the compressor field, traditional course content lacks a systematic introduction to intelligent technologies, resulting in a gap with actual industry needs.

2.2. Reform demand orientation

Emerging engineering construction emphasizes the cultivation of students' engineering practice and innovation capabilities, while industrial intelligent transformation puts forward higher requirements for talents' technical application level [9–11]. The reform of compressor courses needs to meet the following demands: first, knowledge content should keep pace with the times, introducing cutting-edge applications of AI in compressor condition monitoring, fault diagnosis, and operation optimization; second, practical teaching needs to be upgraded, breaking the limitations of equipment and venues, and constructing a large-scale, high-simulation training environment; third, the demand for personalized teaching is increasingly prominent, and precise teaching and guidance should be implemented according to students' cognitive characteristics and learning progress.

3. Core paths of AI-enabled teaching reform for compressor courses

3.1. Reconstruct the teaching content system and integrate cutting-edge AI applications

Teaching content is the core of course implementation, and reconstructing the content system is the foundation of AI-enabled reform. Guided by industry needs and centered on ability cultivation, a trinity teaching content system of "basic theory + engineering practice + AI application" should be constructed to achieve their organic integration. While consolidating core theories such as thermodynamic principles and fluid mechanics foundations, AI technology is used to realize the visualization of abstract theories. For example, numerical simulation and AI algorithms are used to visualize dynamic changes such as internal flow fields and temperature fields of compressors; virtual simulation animations are developed to simulate working processes such as valve opening and closing and piston movement, converting abstract structural principles into intuitive dynamic images, reducing students' cognitive difficulty, and stimulating learning interest. At the same time, combined with engineering cases, the specific application processes and methods of AI in compressor condition monitoring, fault diagnosis, and operation optimization are elaborated in detail. Introduce real industry cases to promote the close integration of theory and practice. Select typical engineering cases such as intelligent operation and maintenance, remote monitoring, and energy efficiency optimization, guide students to analyze key technical issues and solutions, apply the learned knowledge to solve practical engineering problems, and cultivate engineering thinking and practical problem-solving abilities.

3.2. Innovate teaching models and realize intelligent teaching interaction

Relying on AI technology to build a diversified and intelligent teaching model, changing the traditional one-way teaching pattern, enhancing the interest, interactivity, and effectiveness of teaching, and realizing the transformation from "knowledge transmission" to "ability cultivation". Implement a teaching model combining "virtual simulation + real-scene demonstration" to make up for the lack of experimental equipment. Use AI virtual simulation technology to develop a compressor virtual training system covering modules such as structural cognition, disassembly and assembly training, operation debugging, and fault diagnosis: it supports multi-angle observation, operation guidance, and repeated practice to help students master structures and operation processes; the operation debugging module allows parameter adjustment to observe the impact on performance; the fault diagnosis module simulates typical faults to guide students to analyze causes and formulate maintenance plans. At the same time, combine physical equipment for real-scene demonstrations to promote the integration of virtual operations and actual equipment, deepening understanding. Build an intelligent teaching platform to realize precise teaching and personalized learning support. The platform integrates resources such as online courses, virtual experiments, case libraries, and question banks, automatically collects students' learning data such as learning duration, video viewing progress, and homework completion, and analyzes learning characteristics and weak links through AI algorithms to push personalized learning resources accurately. Use AI Q&A robots to provide 24/7 online Q&A services, and teachers conduct targeted guidance for students with learning difficulties based on platform feedback, realizing "teaching students in accordance with their aptitude."

3.3. Optimize the practical teaching system and improve engineering application capabilities

Practical teaching is a key link in cultivating students' engineering application capabilities and innovative thinking. A three-level progressive practical teaching system of "virtual simulation training + physical experiment verification + AI innovative practice" should be constructed to realize the systematic advancement from basic skill training to comprehensive ability improvement, and then to innovative ability cultivation, comprehensively enhancing students' practical level and innovative quality.

The virtual simulation practice level is mainly oriented to lower-grade students or those with weak practical foundations. Through immersive and repeatable virtual operations, it helps them master basic practical skills of compressors. The content includes structural cognition, basic operations, and simple fault troubleshooting: in structural cognition training, students familiarize themselves with the names, structures, and assembly relationships of components through the virtual system; basic operation training simulates processes such as compressor start-stop and parameter adjustment to master standardized operations; simple fault troubleshooting training simulates common faults to guide students to analyze causes and formulate treatment plans. This level is not limited by time, space, or equipment quantity, and students can practice repeatedly until they master the skills proficiently [12,13]. The physical experiment verification level relies on physical equipment in university laboratories to carry out verification and comprehensive experiments, combining virtual simulation results with actual operations. The content mainly includes experiments such as performance testing, structural parameter optimization, and simple fault diagnosis: in the performance testing experiment, students operate physical equipment to measure indicators such as displacement, power, and energy efficiency under different working conditions [14,15], compare and analyze with virtual results, verify model accuracy, and master instrument usage methods; the structural parameter optimization experiment observes performance changes by adjusting parameters such as valve structure and piston stroke, and analyzes optimization directions combined with theoretical and simulation results; the simple fault diagnosis experiment uses physical equipment to simulate faults, and students use detection methods and instruments for diagnosis to improve actual operation and problem-solving abilities.

4. Guarantee for reform implementation

AI-enabled teaching reform of compressor courses is a systematic project that requires guarantees from multiple aspects, such as teacher team building, teaching resources, management mechanisms, and school-enterprise cooperation, to ensure the smooth implementation and effectiveness of the reform. In terms of teacher team building, focus on cultivating a “double-qualified” teaching team. Organize teachers to participate in training on AI technology and teaching reform to improve their application capabilities. In terms of teaching resource construction, increase investment to develop high-quality intelligent teaching resources. Invest funds to build a highly simulated and practical virtual training system, simulation animations, and experimental projects; cooperate with enterprises to introduce real project cases, operation data, and technical documents to enhance engineering practicality. In terms of teaching management mechanism optimization, establish a flexible and efficient institutional guarantee. Adjust teaching plans and curriculum settings, reasonably allocate class hours, and increase the proportion of practical and AI-related content; formulate online teaching management specifications, clarify the connection method between online and offline teaching, and ensure the quality of blended teaching; establish a teaching reform incentive mechanism to provide policy and resource support for teachers participating in the reform. In terms of school-enterprise collaborative cooperation, construct a production-education integration talent training model. Establish long-term cooperative relationships with compressor manufacturing enterprises and intelligent technology companies, co-build internship and practice bases, and provide real engineering environments; transform enterprise actual projects into teaching cases and practical topics to guide students to participate in real R&D; invite enterprise experts to give lectures and technical guidance to impart cutting-edge industry technology experience.

5. Conclusion

Driven by both emerging engineering construction and industrial intelligent transformation, AI technology provides important technical support and innovative momentum for the teaching reform of compressor courses, and is an effective way to break through traditional teaching bottlenecks and improve teaching quality and effectiveness. This paper constructs a framework for “AI + Compressor” course teaching reform, systematically expounding the in-depth integration path of AI technology and courses from three dimensions of teaching content, model, and practical system to solve traditional teaching bottlenecks. Through the reform, it is expected to realize the concretization of theory, the scaling of practice, and the precision of teaching, cultivating compound talents meeting industry needs. In the future, it is necessary to continuously deepen the integration of AI and teaching, optimize the model and practical system to adapt to technological development and industrial upgrading.

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