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Research on the Teaching Practice of Mechanical Drawing Courses Based on AI Technology

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Abstract: With the rise of AI technology in recent years, its powerful functions have brought numerous conveniences to work across various fields. Driving AI-supported initiatives to deepen curriculum and teaching reforms, and exploring new teaching models and future learning approaches have become key priorities in higher education reform. Mechanical Drawing, as a core foundational course for mechanical engineering majors, is characterized by strong abstractness and practicality. The traditional teaching model is mainly teacher-centered, making it difficult for students to establish effective connections between spatial concepts and drawing expressions. Currently, students face challenges such as reduced class hours and limited practical training resources, which further affect learning outcomes. Therefore, conducting teaching practice research on mechanical drawing courses based on AI technology will effectively address the above dilemmas, facilitate teaching, enhance learning interest, and improve learning efficiency. This research is expected to be promoted and applied in more engineering education courses, providing guiding significance for further advancing the in-depth transformation and systematic improvement of higher education toward intelligence, adaptability, and personalization.

Keywords: Mechanical drawing; Artificial intelligence; Teaching reform; Learning analytics

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1. Introduction

In recent years, artificial intelligence technology has risen globally, demonstrating significant advantages in personalized learning customization and intelligent evaluation in the field of education [1]. Both the State Council's Development Plan for the New Generation of Artificial Intelligence and the Ministry of Education's Action Plan for Artificial Intelligence Innovation in Higher Education Institutions clearly promote the integration of "artificial intelligence + education" and build an intelligent education system [2]. Against this background, exploring a new AI-supported teaching model for mechanical drawing aligns with national strategies and meets the needs of cultivating practical and innovative capabilities of talents in emerging engineering, possessing both practical significance and application value.

Mechanical Drawing is a core foundational course for mechanical engineering majors, known as the "language of engineers". Its core goal is to cultivate students' spatial imagination and graphic expression abilities, requiring proficient conversion between three-dimensional structures and two-dimensional drawings [3]. However, traditional teaching mainly relies on teacher lectures, transmitting knowledge through textbooks and blackboards, leading most students to struggle with establishing clear spatial geometric concepts and understanding projection relationships and complex shapes, resulting in poor learning initiative and teaching effectiveness. In addition, due to the compression of practical class hours after curriculum optimization in colleges and universities, how to improve teaching quality within limited class hours has become a key issue to be solved in the teaching reform of mechanical drawing.

2. Current situation and problem analysis of mechanical drawing teaching

2.1. Limitations of the traditional teaching model

Traditional mechanical drawing teaching faces significant challenges at multiple levels. Firstly, the core content of the course is highly abstract, and students often struggle to establish effective associations between two-dimensional drawings and three-dimensional spatial structures, lacking intuitive cognition and spatial perception, thus forming high entry barriers and learning obstacles. Secondly, the current teaching model is mostly teacher-centered, tending to one-way knowledge instillation, with insufficient interaction between teachers and students, as well as among students. Classroom collaboration and inquiry links are weak, leading to low student participation and difficulty in fully motivating their enthusiasm for independent learning and in-depth exploration. In addition, teaching resources still rely heavily on static textbook diagrams and limited physical models, lacking modern multi-dimensional resource support such as dynamic demonstrations, three-dimensional animations, virtual simulations, and interactive operations. This limits students' in-depth understanding of complex shapes and projection relationships, making it difficult to expand the breadth and depth of their cognition. Finally, the teaching evaluation mechanism has an obvious lag. The cycle of homework correction and feedback is long, making it difficult for teachers to timely and accurately grasp students' learning status and dynamically adjust teaching strategies; students also struggle to promptly identify and correct errors, resulting in the accumulation of knowledge gaps, thereby restricting the improvement of overall teaching efficiency and effectiveness.

2.2. Necessity and possibility of introducing AI technology

With its powerful image recognition, semantic understanding, and data analysis capabilities, AI technology provides a transformative solution for the field of education, especially in mechanical drawing teaching. Through key technologies such as machine learning, natural language processing, knowledge graphs, and computer vision, AI has built various intelligent tools and platforms for education, with typical applications including Intelligent Tutoring Systems (ITS), adaptive learning platforms, Learning Analytics (LA) systems, and educational robots [4]. These systems can conduct real-time monitoring of the learning process, provide personalized resource recommendations, and achieve dynamic evaluation and feedback of learning situations, significantly improving the accuracy and efficiency of teaching.

In courses like mechanical drawing, which are graph-intensive and have strong spatial logic, AI has outstanding application potential. In visual teaching, AR/VR and generative 3D modeling can be used to construct highly immersive interactive spatial models, enhancing students' spatial perception and shape understanding; in personalized learning, adaptive learning paths can be automatically planned based on real-time data to achieve teaching students in accordance with their aptitude; intelligent evaluation can automatically analyze the drawing process and drawing quality, provide real-time feedback, and assist teachers in precise intervention; it can also integrate resources, build a structured curriculum system with knowledge graphs, connect abstract concepts with engineering practice, and reshape the "teaching" and "learning" ecology.

Internationally, countries such as the United States, the United Kingdom, and Japan started the application of AI in education earlier, accumulating rich practical experience, especially in intelligent tutoring systems and educational data mining [5]. For example, ChatGPT based on the GPT-3 architecture, has played a role in text generation and teaching dialogue scenarios, and has been gradually applied in homework correction, independent learning support and other links [6]. Although China started relatively late, it has developed rapidly under policy guidance, emerging achievements such as intelligent programming teaching and virtual simulation experiment platforms [7].

However, the deep integration of AI and mechanical drawing is still in its initial stage, lacking mature teaching models and promotion cases, and there is a need to explore adaptive paths. Relying on AI to innovate the traditional model can stimulate learning interest, optimize results, inject rich interactive forms, and provide new directions and practical paths for the intelligent transformation of the course [8].

2. Research design and practical paths

2.1. Research objectives and content

This study aims to construct an AI-based teaching support system for mechanical drawing, address problems such as strong abstractness and insufficient interaction in traditional teaching, and promote the intelligent transformation of the teaching model [9]. The specific research content includes four aspects: first, AI resource integration, investigating and selecting AI tools and digital platforms suitable for mechanical drawing teaching to provide technical support; second, system construction, deeply integrating and connecting core AI modules with existing teaching platforms such as "Xuexitong" and knowledge graph systems to create an integrated teaching support environment; third, teaching practice, applying the AI-assisted system in real classrooms for teaching, collecting feedback from teachers and students, and iteratively optimizing; fourth, effect evaluation, comprehensively assessing the system's role in improving teaching quality and learning outcomes through questionnaires, score analysis, teacher-student interviews, etc., to provide replicable paths and experiences for intelligent technology empowering engineering education.

2.2. Research methods

(1) Resource Integration Method: Conduct a comprehensive investigation of AI tools and digital resource platforms suitable for mechanical drawing teaching, select core technical support from dimensions such as image recognition, model generation, and learning situation analysis, and consolidate the resource foundation for system construction.

(2) System Development Method: Focus on core AI modules such as intelligent drawing assistance, dynamic 3D model generation, and recommendation algorithms, deeply integrate them with "Xuexitong" and knowledge graph systems to achieve data intercommunication and functional collaboration, and build an integrated intelligent teaching environment.

(3) Practical Verification Method: Deploy the system in real classrooms for teaching experiments, collect teachers' and students' usage experience and feedback through multiple rounds, and iteratively optimize the system to improve usability and teaching adaptability.

(4) Comprehensive Evaluation Method: Adopt questionnaires, score comparison analysis, in-depth teacher-student interviews, etc., to evaluate the system's effects from dimensions such as academic performance, ability improvement, and usage experience, judge its teaching value, and provide replicable experiences for AI empowering engineering education.

3. Practical application and case analysis

3.1. AI-assisted drawing and error correction system

The system integrates AI-assisted drawing tools, which can automatically detect common errors in students' drawings such as inconsistent projection relationships, improper use of lines, and non-standard dimensioning, and provide targeted modification suggestions. For example, when a student omits hidden lines in drawing three views of an assembly, the system can real-time identify the omission through image recognition, highlight the position with prompts, and link to an explanatory video demonstrating the correct drawing method and spatial basis. This transforms error correction into a learning opportunity, helping to consolidate spatial concepts and improve drawing capabilities [10].

The core process of the system includes five steps: student drawing input, image preprocessing, Convolutional Neural Network (CNN)-based detection model, error analysis report generation, and result output.

Image preprocessing consists of three steps: first, binarization processing, converting color or grayscale images into black-and-white binary images to separate lines from the background; second, Gaussian filtering and median filtering to remove salt-and-pepper noise and Gaussian noise introduced by hand-drawn burrs, ink dots, and equipment environments; finally, line thinning using the Zhang-Suen algorithm to extract single-pixel skeletons of thin solid lines, retaining line trends, connection relationships, and thick solid line features, laying the foundation for subsequent detection [11].

The CNN detection model uses mechanical drawing exercises and student homework as data sets, labeling information such as line types, view types, and annotation elements, and selects the optimal model after multiple training sessions [12]. In the error analysis report generation stage, the system will mark the error parts in the submitted images and link to explanatory videos, helping students modify in a timely manner and understand the principles.

3.2. Personalized learning path recommendation

Based on students' behavioral data from "Xuexitong" and online mechanical drawing learning platforms (such as video viewing duration, quiz scores, homework completion, CAD operation records, etc.), the system uses machine learning algorithms to analyze knowledge mastery and learning preferences, accurately recommend learning resources and personalized exercises, realizing "one student, one strategy" adaptive teaching and improving learning efficiency and motivation [13].

Taking the core module of "CAD three-view drawing and reading" as an example, the system integrates multi-dimensional features such as drawing command frequency and dimensioning error rate to construct learner profiles, quantitatively evaluate capabilities through cognitive diagnostic models, and provide adaptive suggestions.

The core functions of the system include three aspects: first, learning progress tracking, recording operation behaviors and data, and building a dual-dimensional system of "knowledge points - skill points." For example, the three-view module is decomposed into 5 core nodes, such as "projection principle cognition", each node containing 3-4 skill sub-items, and a visual "learning progress graph" is generated through operation logs to mark mastery status. Second, learning difficulty identification and analyzing data to identify weak links. For example, 42.5% of students have unclear projection relationships when drawing intersecting lines, and the system immediately locates this difficulty and pushes targeted resources. Third, personalized path generation, pushing content based on progress and difficulties. For example, for students with difficulty in understanding assemblies, exclusive videos and exercises are recommended.

3.3. Virtual 3D model library and AR display

At present, some students struggle with learning mechanical drawing due to insufficient spatial imagination. However, providing students with 3D models for learning and research can greatly improve their spatial imagination. Therefore, the 3D model library generated using AI technology provides students with a highly flexible and interactive learning approach. Students only need to input their drawn 2D drawings into the system, and the system will select the corresponding 3D models from the 3D model library. Through mobile phones, tablets, or VR devices, they can access and observe the 3D structures of various mechanical parts at any time, supporting interactive operations such as free rotation, virtual disassembly, and scaling measurement. This immersive experience transforms abstract spatial relationships into visible and perceptible dynamic objects, greatly enhancing the intuitive understanding of complex shapes and assembly relationships, and effectively improving students' spatial thinking and drawing reading abilities [14].

4. Implementation effects and reflections

4.1. Existing problems and challenges

Although the AI-assisted teaching system has significant application advantages, its promotion still faces multiple challenges. First, high technical dependence. Some core AI modules may experience response delays or functional abnormalities in complex teaching environments, affecting teaching continuity and learning experience; second, the lack of a systematic teacher training mechanism. Teachers are unfamiliar with the functional logic and operation of AI tools, making it difficult to deeply integrate them into teaching, limiting the exertion of the system's value; third, prominent data privacy and ethical risks. The collection and analysis of students' learning behavior data need to establish strict safety and compliance mechanisms to prevent information leakage and abuse.

4.2. Improvement suggestions

To address the above challenges, it is necessary to construct a sustainable intelligent teaching support system from multiple dimensions [15]. First, strengthen teacher training. Improve teachers' AI tool application and teaching integration capabilities through special workshops, practical training, and teaching and research exchanges; second, optimize technology selection and deployment. Prioritize the adoption of stable and compatible AI platforms to reduce operational uncertainty and ensure teaching fluency; third, strengthen data governance. Establish a full-process data security and compliance system, clarify data usage boundaries and permissions, and build a trusted data environment that conforms to educational ethics.

5. Conclusion

This study integrates artificial intelligence technology into the teaching of mechanical drawing courses, constructing a new intelligent, personalized, and highly interactive teaching model. Practice has proved that the application of AI technology not only significantly improves students' spatial imagination and learning initiative but also provides teachers with precise learning situation analysis, resource scheduling, and teaching decision support. With the evolution of core AI algorithms, the expansion of educational application scenarios, and the innovation of educational concepts, such AI teaching models are expected to be promoted in more engineering education courses, driving the in-depth transformation and systematic improvement of higher education toward intelligence, adaptability, and personalization.

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Disclosure statement

The authors declare no conflict of interest.

References

[1] Zheng A, Dong X, 2017, Mechanical Drawing. China Machine Press, Beijing.

[2] Ahmad S, 2023, ChatGPT and the Future of Learning: A Systematic Review. Education and Information Technologies, 28(7): 1–25.

[3] State Council, 2017, Development Plan for the New Generation of Artificial Intelligence. State Council.

[4] Wang M, Li D, 2022, A Review of the Application Research of Artificial Intelligence in Education. E-education Research,

43(2): 76–82.
[5] Baker R, Inventado P, 2014, Educational Data Mining and Learning Analytics. Springer, New York.
[6] Brown T, Mann B, Ryder N, et al., 2020, Language Models Are Few-Shot Learners. Advances in Neural Information Processing Systems, 33: 1877–1901.
[7] Liu W, Huang G, Zheng A, 2020, Research on Industrial Internet of Things Data Processing Delay Optimization. Computer Communications, 151: 290–298.
[8] Guo Y, Su C, Li P, 2023, A Brief Analysis of Exhibition Design Under "Generative AI Image Technology". Shoe Technology and Design, 3(22): 187–189.
[9] Yan H, He X, Lü G, et al., 2025, Research on the Reform and Practice of "Fundamentals of University Computer" Course in the Digital Intelligence Era. Industry and Information Technology Education, 2025(07): 68–74.
[10 Huang F, Ye Y, Wang J, et al., 2022, Research on the Application of Danmu Interactive Teaching Method in Mechanical Drawing Courses. China Modern Educational Equipment, 2022(11): 135–137.
[11] Jiang J, Pei X, Xu B, et al., 2024, Automatic Teaching Quality Evaluation System Based on Facial Expression Recognition. Modern Computer, 30(24): 193–198.
[12] Hao P, 2025, Research on the Application of AI Technology in Mechanical Drawing Courses. China Machinery, 2025(05): 133–136 + 140.
[13] Chen J, 2020, Research and Standardization of Systematic Implementation of Large-Scale Online Education and Teaching. Primary and Secondary School Textbooks and Teaching, 2020(04): 76–80.
[14] Lin X, 2022, Discussion on the Application of BIM in the Teaching of Construction Engineering Measurement and Valuation. Road to Success, 2022(25): 113–116.
[15 Meng L, 2024, Research on the Application of Teaching Intelligent Technology in the Construction of New Courses in Higher Education. New Curriculum Research, 2024(21): 52–54.