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Classroom Teaching of Engineering Courses Assisted by Artificial Intelligence and Digital Twin Systems

-- Taking industrial robot technology course as an example

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Abstract: This paper explores the integration of Artificial Intelligence (AI) and Digital Twin systems in the classroom teaching of engineering courses, with a focus on the Industrial Robot Technology course1. It addresses the challenges of traditional practical teaching methods and proposes a new model that leverages AI and Digital Twin technology to enhance student engagement, improve learning outcomes, and better prepare students for the demands of the industry. The paper discusses the implementation of AI-assisted teaching, the creation of a ubiquitous teaching ecology, and the strengthening of vocational skills through digital twin.

Keywords: Artificial Intelligence, Classroom Teaching, Digital Twin.

1. Introduction

China's numerous policy orientations in the 21st century clearly propose to promote the deep integration of information technology and experimental teaching, strengthen the construction of demonstrative virtual simulation experimental teaching projects, fully utilize new technologies such as virtual reality and augmented reality to actively explore intelligent and personalized new teaching methods. This is both an urgent need to reform traditional teaching methods and to advance the innovation of talent training models, as well as to strengthen the educational activities that integrate teaching, learning, and practical training.

In recent years, industrial robot technology has developed rapidly, and the industry has grown quickly, leading to a high demand for skilled professionals in industrial robot technology. On one hand, as the demand for professional technical talent continues to increase and higher vocational education expands continuously, on the other hand, the expensive equipment related to industrial robot technology means that most higher vocational colleges with limited funding cannot keep up with the increase in student numbers to meet the requirements of vocational skill level standards. These factors directly lead to low enthusiasm for classroom learning among students, less than ideal class effectiveness, lack of proficiency in operations, insufficient integration of professional knowledge, and low adaptability to work.

In general, traditional practical teaching models face the following issues:

(1) Traditional practical teaching relies on various experimental and training equipment, and also consumes a certain amount of materials during the teaching process, all of which require the school to invest a significant amount of teaching funds. Generally, higher education institutions struggle to meet the equipment quantity demands of this practical teaching model, and many students face limited operation time due to workstation restrictions, which prevents them from digesting the taught content in time.

(2) Due to limitations in equipment resources and teaching staff, practical teaching occupies a lighter proportion in the teaching syllabus, usually only arranging 1-2 weeks of practical training hours. Such a time arrangement, when applied to each student, results in even less actual hands-on time, making it difficult to ensure good learning outcomes for students and failing to meet the requirements of innovative practical teaching activities.

(3) In traditional practical teaching, in a one-to-many live teaching environment, due to the number of students and training conditions, the interactive process in theoretical teaching mainly relies on teachers or students asking questions. If students lose focus or miss the opportunity to ask questions to aid understanding, it can lead to learning barriers or lack of personalized guidance, hindering learning progress. The practical process mainly relies on students to discover and report issues, interacting one-on-one with the teacher to solve problems. However, one teacher in a large class of dozens of students still finds it challenging to effectively understand all students' interests and needs, making it difficult to provide targeted learning resources and personalized guidance, which restricts student development and the improvement of course teaching quality.

(4) Under the traditional practical teaching model, the teacher evaluation process lacks timeliness. The practical training tasks of core courses in industrial robot specialties are characterized by high process complexity and long demonstration times. Even if students complete tasks in groups, group grading still occupies a lot of class time. As classroom tasks progress, many students wait for grading, teachers are overwhelmed, and the actual usage rate of equipment is difficult to improve. Outcome-based assessment methods fail to ensure the participation of each student during the teaching process, and teachers are also trapped in problem-solving and project grading, leading to a "one-size-fits-all" phenomenon in grading.

However, with technological advancements, the deep integration of information technology tools in classroom teaching provides opportunities to solve the above issues. Against the backdrop of the fourth industrial revolution, new infrastructure represented by big data, artificial intelligence, and digital twins is driving systemic changes in vocational education. Comprehensive data collection, both online and offline, makes it possible to shift from outcome-based to process-based evaluation. Modern classroom teaching is no longer a one-way knowledge transfer process but a systematic project of effective teaching and mutual growth between teachers and students. Online teaching and learning are becoming prevalent, making the deep integration of information technology tools and classroom teaching an inevitable result of adapting to the development of the times. The state encourages the advancement of intelligent education development. The Ministry of Education's "Higher Education Artificial Intelligence Innovation Action Plan" proposes to "explore new teaching models based on artificial intelligence, reconstruct teaching processes, and use artificial intelligence to monitor teaching processes, analyze learning situations, and diagnose academic levels, establishing a comprehensive multi-dimensional intelligent evaluation based on big data, accurately assessing the performance of teaching and learning, and achieving personalized education."

2. Way to Teaching Assisted by AI and Digital Twin

2.1. Teaching Tailored to Job Positions, Creating 'Typical and Real' Teaching Projects under Digital Twinning

Following a student-centered teaching philosophy, relying on three types of national platforms-industry-education alliances, innovation platforms, and training bases-new loose-leaf task-driven teaching is introduced. Digital twin technology integrates training platforms with real enterprise cases and updates digital course teaching resources, creating a new 'ubiquitous' teaching ecology. Combined with a diverse collaborative evaluation system, it guides students to "learn by doing, create by doing," supporting task-driven, outcome-oriented teaching strategies and fostering students' practical innovation skills.

2.2. Integrating Ideological and Political Elements into the Unity of Learning and Doing, Shaping Precise and Pragmatic Industry Values

Based on teaching stages and task characteristics, the values of "precise control and pragmatic efficiency" are organically integrated into teaching tasks. Before class, "platform data" is used; during class, "teacher-student, student-student, and industry standard evaluations" are applied; after class, "platform advancement and labor effectiveness evaluations" are conducted. This forms a craftsman comparison and scoring board, encouraging students to value ideological and political literacy and internalize industry values.

2.3. Implementing Teaching Process to Strengthen Robot Integration Skills

With the goal of solving real enterprise problems, the teaching is organized as "pre-class initial learning and exploration, in-class enhancement and breakthrough, post-class expansion and incubation." Before class, real cases are used to connect with actual enterprise problems and outline key knowledge and skills. During class, a seven-step, five-practice method is used to master the skills needed to solve actual problems. After class, real projects on the innovation platform are used for practical application to solve actual enterprise problems and incubate technological innovations.

2.4. 'AI + Digital Twin' Technology Integrates Digital Teaching Resources, Creating a Time and Space Unlimited Teaching Platform

Digital twin technology is used to build a digital training platform identical to the real one, connecting to online course platform videos, animations, and other digital teaching resources. Students can engage in independent inquiry, collaborative communication, and online training through loose-leaf textbook tasks and QR code links. In post-pandemic remote teaching, teachers can demonstrate on both real and digital training platforms. Online students use a full-time teaching tracking system composed of "surveillance cameras + mobile camera control cloud platform + remote server" to integrate into offline classrooms, follow training on the digital platform, and interact and assist with offline group members in real-time, with teachers and enterprise tutors providing real-time evaluations.

3. Way to Teaching Assisted by AI and Digital Twin

3.1. Method of Implementation

3.1.1. Preliminary Preparation

Adopting the survey method, utilizing school-enterprise cooperation to conduct in-depth and long-term research, contacting friends in related industries or collecting materials such as digital twin software tutorials and typical system designs through extracurricular journals, books, and literature.

3.1.2. Group Meetings

Using the group collaboration method, holding project research group meetings, where group members discuss and communicate about the research goals and directions of the topic, and establish a mechanism for regular communication and coordination on work progress. A WeChat discussion group can be set up for feedback on issues later on.

3.1.3. Summary and Integration

Using the reference and learning method, integrating past course construction resources to address issues such as course content restructuring, course standard formulation, course scenario creation, and course implementation and evaluation.

3.1.4. Conducting Teaching

Adopting the theory-practice integrated teaching method, teaching classes within the specialty for this course, reasonably allocating teaching progress, and promptly collecting student information and feedback to facilitate the next step of teaching optimization.

3.1.5. Improvement and Perfection

Using the experience summarization method, continuously improving and perfecting teaching models and methods through action research in the later stages of teaching.

4. Specific Implementation Plan (Including Annual Progress) and Feasibility Analysis

4.1. Specific Reform Content

Create a digital and intelligent teaching environment, follow the main thread of integrating learning with doing, and organically incorporate ideological and political elements to shape precise and pragmatic industry values. Advance course teaching according to the teaching process, strengthening the application ability of robots. Use digital twin technology for virtual programming design to break through the visualization difficulties of debugging and verification. Integrate artificial intelligence technology both inside and outside the classroom to achieve “assisted teaching, learning, and evaluation,” constructing a new digital and intelligent teaching model for industrial robot technology.

4.2. Reform Objectives

Based on “AI + Digital Twin,” focus on improving the core vocational abilities of students majoring in industrial robot technology. Research how to reform teaching methods, alleviate equipment usage pressure, integrate and communicate job-related courses and certifications, and implement a full-course value-added evaluation. Through this research, innovate classroom teaching models, integrate “AI + Digital Twin” with courses, achieve efficient resource utilization, enhance professional knowledge levels, and improve students’ overall qualities. Thus, explore a set of new digital and intelligent teaching models for the industrial robot technology specialty.

5. Significance of the Project

In the context mentioned above, combined with the talent training goals of higher vocational education, researching classroom teaching reform in vocational education from the perspective of “AI + Digital Twin” can significantly improve teaching quality in the following aspects.

5.1. Breaking through Spatial and Temporal Limitations, Creating a Ubiquitous Teaching Ecology

By applying digital twin technology to the teaching of industrial robot technology, we can break down barriers between courses, strengthen the connections between different disciplines, and meet the demand for highly skilled professionals required by enterprises within a limited time. This approach ensures the integrity of the professional knowledge chain system, effectively addressing the “two skins” issue where vocational education’s talent cultivation supply side and the industry demand side do not fully align in structure, quality, and level, thereby enhancing the quality of talent training in the field of industrial robot technology.

5.2. AI-assisted Teaching and Evaluation, Improving the Entire Teaching Process

In the digitalized and intelligent teaching model, on one hand, teachers, as leaders of educational activities, can precisely assess students’ learning situations based on the educational data analysis provided by the AI monitoring system, optimizing course teaching design and adjusting classroom activity formats. On the other hand, AI supports comprehensive evaluation for all staff and the entire learning process by collecting pre-class, in-class, and post-class teaching data, combined with a value-added evaluation system. This frees teachers from the complex and inefficient grading process, improving classroom teaching efficiency.

5.3. Consolidating Vocational Skills, Increasing Students’ Job Identification

The introduction of digital twin technology allows students to fully experience the complete process of “learning by doing” and “doing while learning,” enabling them to master the knowledge points being assessed throughout the process. By building virtual models of actual enterprise scenarios and continuously simulating and practicing various tasks, students’ interest in the industry can be greatly increased. This better experience of engineering practice is conducive to the cultivation of students’ professional abilities and the improvement of their professional qualities, laying a solid foundation for smooth employment.

5.4. Delving into Theoretical Difficulties, Boosting Students’ Competition Practice

In some vocational colleges, after the explanation of theoretical knowledge, students begin corresponding practical operations. However, due to insufficient grasp of theoretical knowledge in the early stages or the lack of knowledge consolidation through virtual simulation, students enter the practical phase without knowing how to operate, leading to low interest in practical operations. Even though micro-course videos are provided and students complete the practical content step by step following the instructions, they merely mimic the steps without deeply mastering the practical skills. As a result, many students still cannot understand the knowledge well after the practical operations, leading to poor experimental results and reduced learning efficiency. Therefore, incorporating the digital twin phase can better guide students to familiarize themselves with the practical operation scenarios through virtual models. After the simulation, students can carry out practical verification with their questions, using a self-questioning learning method to better understand the theoretical knowledge learned.

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References

[1] Walter, Y. Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education. Int J Educ Technol High Educ 21, 15 (2024). https://doi.org/10.1186/s41239-024-00448-3W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[2] Pham, T., Nguyen, T. B. ., Ha, S., & Nguyen Ngoc, N. T. (2023). Digital transformation in engineering education: Exploring the potential of AI-assisted learning. Australasian Journal of Educational Technology, 39(5), 1–19. https://doi.org/10.14742/ajet.8825B. Smith, “An approach to graphs of linear forms (Unpublished work style),” unpublished.

[3] Chaudhry, M.A., Kazim, E. Artificial Intelligence in Education (AIEd): a high-level academic and industry note 2021. AI Ethics 2, 157–165 (2022). https://doi.org/10.1007/s43681-021-00074-z.

[4] Diwanji, P., Hinkelmann, K., & Witschel, H. F. (2018, March). Enhance Classroom Preparation for Flipped Classroom using AI and Analytics. In ICEIS (1) (pp. 477-483).