Exploration of Blended Teaching of Python Artificial Intelligence Programming Foundation in Medical and Engineering Integrated Universities

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Abstract: ***In response to the training needs of compound talents in the integration of medicine and engineering and digital and intelligent transformation, aiming at the problem of the disconnection between theory and medical practice in the traditional teaching of information technology courses in medical and engineering integrated universities, this paper takes the Python artificial intelligence programming foundation course as an example and proposes a project-driven online and offline collaborative blended teaching model. Based on policy orientations such as the Implementation Plan for the Digital and Intelligent Transformation of the Pharmaceutical Industry (2025-2030), a teaching system of "medical case-driven + hierarchical practice" is constructed. Through the collaborative linkage of the Superstar Learning Platform and offline project training, a learning situation database is established and intelligent analysis is used to feed back teaching, forming a complete teaching closed-loop. Teaching practice shows that this model can significantly improve students' programming application ability and the thinking of the integration of medicine and engineering, and effectively solve the pain points of traditional teaching. The research results provide a set of promotable blended teaching paradigms for the information technology curriculum reform in medical and engineering integrated universities, which are driven by real medical scenarios and supported by data intelligent analysis.***

Keywords: Integration of Medicine and Engineering; Python Teaching; Blended Teaching; Learning Situation Data; Artificial Intelligence Programming; Project-driven.

1. INTRODUCTION

In the context of the "Healthy China 2030" strategy, the integration of medicine and engineering has become the core driving force for the high-quality development of the pharmaceutical industry. The "Guiding Opinions on Accelerating the Innovation and Development of Medical Education" issued by the General Office of the State Council clearly states that "vigorously promote the deep cross-integration of medicine and multiple disciplines" and requires the cultivation of "medicine + X" compound talents. The "Implementation Plan for the Digital and Intelligent Transformation of the Pharmaceutical Industry (2025-2030)" jointly issued by seven departments including the Ministry of Industry and Information Technology further emphasizes that it is necessary to rely on interdisciplinary platforms to accelerate the cultivation of high-level compound talents in the field of digital and intelligent transformation of the pharmaceutical industry.

As a core tool for artificial intelligence and data processing, Python is widely used in fields such as medical image analysis and disease prediction model construction. For example, the clinical data of patients can be cleaned through the Pandas library, tumor image segmentation can be completed with the Py-Torch framework, bioinformatics analysis can be carried out using Biopython, and medical image preprocessing can be achieved through SimpleITK. However, the current basic Python artificial intelligence programming courses in medical colleges mostly follow the traditional teaching mode of "theory explanation + experimental questions", with problems such as the disconnection between teaching content and medical scenarios and the lack of pertinence in practice links, making it difficult to meet the skill requirements of talents for the digital and intelligent transformation of the pharmaceutical industry. Therefore, exploring a blended teaching mode suitable for the characteristics of medical majors is of great practical significance for improving the quality of course teaching and cultivating compound medical talents under the background of cultivating new productive forces.

The reform of programming courses was carried out relatively early in the foreign medical education field. Duke University completed the Python teaching transformation of 11 biomedical engineering courses in 2024, and achieved cross-semester knowledge connection of the curriculum system by jointly developing medical-oriented programming cases by teachers and students. Domestic research mainly focuses on the application of single teaching methods. For example, Yuan et al. [1] introduced TA-Mem, a tool-augmented autonomous memory retrieval system for LLMs in long-term conversational question answering (Yuan et al., 2026), while Yang et al. [2] developed a recursive multi-agent trading system for iterative optimized portfolio strategy under geopolitical uncertainty (Yang et al., 2026). In the area of model efficiency, Gong et al. [3] provided a comprehensive review of neural network lightweighting techniques (Gong et al., 2023). Peng et al. [4] proposed NavigScene, a framework that bridges local perception and global navigation for beyond-visual-range autonomous driving (Peng et al., 2025). For human motion analysis, Zheng et al. [5] presented DiffMesh, a motion-aware diffusion framework for human mesh recovery from videos (Zheng et al., 2025). In multimodal personalization and healthcare, Shan et al. [6] rethought wine tasting for Chinese consumers using a service design approach enhanced by multimodal personalization (Shan et al., 2025), while Xia et al. [7] developed KOA-Monitor, a digital intervention and functional assessment system for knee osteoarthritis patients (Xia et al., 2025). Xu et al. [8] conducted a systematic review on game-based learning for environmental resilience, highlighting the transition from engagement to resilience (Xu et al., 2026). In natural language processing, Deng et al. [9] proposed LLM-MVR, an LLM-guided multi-view reasoning distillation framework for sarcasm detection (Deng et al., 2026). For computer vision tasks, Wang et al. [10] introduced QA-ReID, a quality-aware query-adaptive convolution method leveraging fused global and structural cues for clothes-changing person re-identification (Wang et al., 2026), and Li et al. [11] developed MFT, a memory-aware fine-tuning strategy for SAM2 enabling efficient long-sequence video object segmentation (Li et al., 2026). Wu et al. [12] presented Tiny-Critic RAG, empowering agentic fallback with parameter-efficient small language models (Wu et al., 2026), while Yan et al. [13] designed PRISM, a pipeline for root-cause investigation via specialized multi-agents (Yan et al., 2026). Zhou [14] analyzed hierarchical needs in US automotive customer feedback and the sentiment–function nexus (Zhou, 2026). Wensi [15] explored AI-enabled data visualization marketing for automated production lines to build customer trust and improve lead-to-order conversion (Wensi, 2026). Shen et al. [16] applied the whale optimization algorithm to financial payment fraud detection (Shen et al., 2025). In photonics, Tang et al. [17] designed and optimized a shallow-angle grating coupler for vertical emission from indium phosphide devices (Tang et al., 2020). Sun [18] proposed adaptive interfaces for personalized user experience using a machine learning approach (Sun, 2025). Mao [19] introduced a clustering-based approach to image compression using the K-means algorithm (Mao, 2026). Ding [20] developed and validated a multispectral vision system for in-situ detection of pesticide residues on agricultural produce (Ding, 2025). Luo [21] discussed the integration of computer application technology with information management (Luo, 2026). Ya [22] studied EDA technology in digital circuit design (Ya, 2025). Ma [23] proposed a unified framework for congestion diagnosis and dynamic mitigation in complex networks (Ma, 2025). Jin [24] optimized order allocation algorithms for industrial internet platforms (Jin, 2025). Miao [25] explored big data technologies for enhanced network security analysis (Miao, 2026). Wang [26] developed a multi-scale feature-enhanced YOLOv8 for object detection in photovoltaic farm panoramic imagery (Wang, 2025). Liu [27] researched the application of GPU parallel computing in image processing (Liu, 2025). Lu et al. [28] developed a flame detection system based on the Faster R-CNN model (Lu et al., 2025). Liu [29] systematically evaluated deep learning architectural efficacy for plant image classification (Liu, 2025). Finally, Gao [30] researched intelligent supply chain collaboration for industrial electrical enterprises (Gao, 2025) and also proposed an intelligent operations and public relations collaborative management model for corporate image enhancement in smart manufacturing environments (Gao, 2026).

This paper comprehensively uses the literature research method to sort out the medical-industry integration policies and blended teaching theories, combines the case analysis method to design a teaching practice plan with the Python artificial intelligence programming foundation course as a sample, and collects students' learning feedback through the questionnaire survey method to verify the teaching effect. The innovation points are mainly reflected in: 1) Concept innovation. This project constructs an integrated teaching framework of "policy orientation - content integration - practice implementation"; 2) Content innovation. Build a medical-exclusive case and project library that runs through the course, covering characteristic cases such as breast cancer intelligent analysis and AI embryo screening; 3) Evaluation innovation. Establish a multi-dimensional and process-oriented comprehensive evaluation system, including online learning, offline practice, and project results.

2. COURSE POSITIONING AND RELATED ISSUES IN TRADITIONAL TEACHING

2.1 The Course Value in the Integration of Medicine and Engineering

The basic Python artificial intelligence programming is the core bridge connecting the medical profession and artificial intelligence technology, and its teaching quality directly affects the cultivation effect of compound talents. By cultivating students' abilities such as data processing and algorithm implementation, the course helps students master key technologies such as medical big data analysis and intelligent diagnosis assistance, meeting the requirement of "strengthening the cultivation of digital and intelligent skills" in the "Implementation Plan for the Digital and Intelligent Transformation of the Pharmaceutical Industry", and laying a foundation for students to engage in work such as precision medicine and pharmaceutical R & D in the future.

2.2 Core Issues of Traditional Teaching

The investigation found that there are three major pain points in the traditional teaching mode: First, the content is divorced from medical practice, mainly focusing on general programming cases, lacking professional scenarios such as AI embryo screening and clinical data modeling, resulting in students' difficulty in establishing a correlative cognition of "programming and professional applications"; Second, the teaching methods are rigid. The vast majority of students believe that "medical students have no need to learn information technology and cannot find the connection between medicine and computer technology". The underlying reason is that the course content fails to effectively respond to their professional identity and future career development needs, thus resulting in insufficient learning initiative; Third, the evaluation method is single, mainly relying on the final written examination, focusing on assessing the memory of theoretical knowledge and unable to comprehensively evaluate practical application abilities, which runs counter to the "competency-based" cultivation concept of the new medical science.

3. BLENDED TEACHING MODEL CONSTRUCTION

3.1 Teaching Objectives and Content Design

Based on the requirements of the policy on the integration of medicine and engineering and the needs of cultivating medical professionals, the three-dimensional teaching objectives of "knowledge - ability - literacy" are established: the knowledge objective covers core contents such as basic Python syntax and basic theories of machine learning; the ability objective focuses on practical skills such as medical data processing and simple intelligent model construction; the literacy objective emphasizes the cultivation of the thinking of the integration of medicine and engineering and data ethics awareness. The teaching content is divided into three modules according to the logic of "foundation - application - actual combat": the foundation module (syntax and library operations), which focuses on explaining basic knowledge such as variables, functions, Pandas library, OpenCV, SimpleITK, Biopython library, etc., laying a foundation for subsequent learning; the medical application module (medical cases combined with Pandas and Biopython), which combines cases such as "patient data cleaning" and "medical image preprocessing" to achieve a deep integration of "programming knowledge and medical scenarios"; the project actual combat module (such as the development of a breast cancer intelligent diagnosis model), which takes real projects such as "the development of a breast cancer intelligent diagnosis model" and "the design of an AI-assisted embryo screening system" as carriers to exercise students' comprehensive application abilities.

3.2 Online and Offline Collaborative Implementation

Taking the basic Python artificial intelligence programming course as an example, this paper constructs an online and offline collaborative hybrid teaching model with "offline as the main and online as the supplement". The specific framework is shown in Figure 1. The hybrid teaching model is mainly composed of the organic combination of online and offline teaching methods, with offline teaching as the main and online teaching as a more flexible and effective supplement.

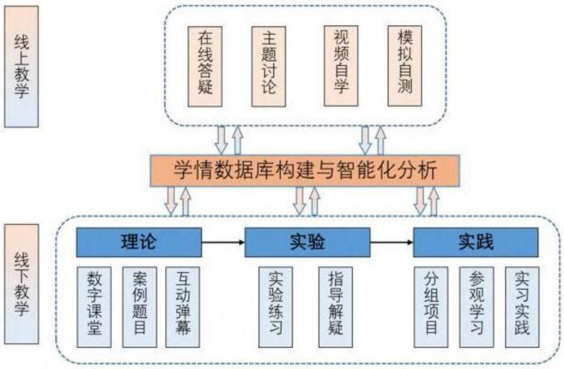

Figure 1: Block diagram of the online and offline collaborative hybrid teaching model

The online teaching relies on the Superstar Learning Platform to build a course platform and push three types of resources: First, hierarchical teaching resources, including fragmented theoretical micro-courses of 10 - 15 minutes (such as "The Application of Python Loop Structure in Medical Data Traversal"), medical case codes with annotation analysis (such as "Medical Image Denoising Code Based on OpenCV"), and discussion topics on the integration of medicine and engineering (such as "The Ethical Boundaries of AI in Tumor Diagnosis"); Second, a multi-dimensional interaction system is constructed, including online Q&A (teachers respond within 24 hours), topic discussions (students initiate programming questions related to the major on their own), and self-learning modules (video self-study + simulation self-test) to track the learning progress in real time.

The offline teaching adopts a multi-level hierarchical practical teaching system driven by medical cases, namely "theory + experiment + practice". In the theoretical teaching session, the teacher analyzes medical cases through the digital classroom, explains important knowledge points such as Python syntax and machine learning basics, and adjusts the teaching rhythm using interactive questions and bullet screens. In the experimental teaching session, the teacher assists students in completing experimental exercises, guides and answers questions, and emphasizes independent practical exploration. In the practical teaching session, driven by actual combat projects (such as intelligent breast cancer diagnosis based on deep learning), the "case analysis - group practice - result defense" model is adopted, enabling students to participate in medical practice projects using artificial intelligence technology, thus effectively enhancing the thinking of the integration of medicine and engineering. In addition, on the one hand, students are encouraged to actively participate in subject competitions such as the China Computer Design Competition, the "Artificial Intelligence +" special competition of the Challenge Cup, and the National Undergraduate Statistical Modeling Competition based on medical scenarios using what they have learned; on the other hand, the cooperation between the university and affiliated hospitals and pharmaceutical enterprises is strengthened, an offline practical research project system is established, and the "medical tutor + computer tutor" dual tutor system is implemented to improve students' programming application practice ability and the integration of medicine and engineering literacy. The "medical tutor + computer tutor" dual tutor system is an important manifestation of the implementation of the "integration of medicine and engineering" at the teacher level.

In the implementation process, this study introduced the theoretical framework of Learning Analytics (LA), constructed a learning situation database covering the "whole learning process", and achieved "promoting teaching with data". Specifically, it includes three aspects: 1) Data collection dimension. It covers three types of core information: online behavior data (completion rate of micro-course viewing, error rate of online tests, participation in topic discussions), offline practice data (timeliness of project code submission, dual-tutor scoring and defense performance), and basic learning situation data (students' professional backgrounds, such as pharmacy, medical imaging, etc.). 2) Data processing and analysis. Rely on the Pandas library in Python to complete data cleaning, and use algorithms such as decision trees to build intelligent analysis models, focusing on mining the "correlation between learning behavior and results" (such as the correlation between the repeatedly viewed chapters of micro-courses and the error rate of offline projects) and the "correlation between professional background and learning adaptability" (such as the acceptance of medical imaging students for imaging processing cases). 3) Application of analysis results. Feed the analysis results directly back to teaching, such as pushing customized supplementary learning resources (such as "Step-by-Step Tutorial on OpenCV Medical Image Processing") to students with weak online learning, and adjusting the case ratio for different majors to achieve a precise teaching closed-loop. As shown in Figure 2, the learning situation database connects "online pre-class guidance", "offline in-class practice", and "online post-class expansion", forming a complete teaching closed-loop.

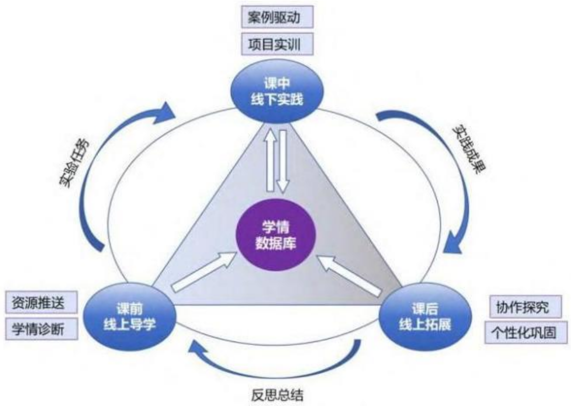

Figure 2: Flow and feedback path diagram of learning situation data

3.3 Multidimensional Evaluation System

Build a multidimensional evaluation system with a balanced proportion, taking into account both the process and the results: Online learning performance accounts for 20%, including course access frequency, assignment completion, etc.; Offline experiments account for 30%, including the enthusiasm for classroom interaction, the standardization of experimental operations, and problem-solving abilities; Project results account for 30%, including the functional integrity, medical adaptability, code standardization, etc. of practical projects; The final comprehensive test accounts for 20%, focusing on assessing the comprehensive application ability, mainly with "medical scenario programming questions". At the same time, incorporate the compliance with data ethics (as a deduction item) and the participation in subject competitions and scientific research projects (as an addition item) to comprehensively evaluate the abilities and qualities of students.

3.4 Practice Results

According to the teaching mode of this study, 62 students from 2 classes of the Clinical College of Guangdong Medical University in the 2023 grade were selected as the research objects for an 8-week teaching practice. 31 students in the experimental group adopted the blended teaching mode constructed in this paper, and 31 students in the control group adopted the traditional teaching mode. The preliminary teaching practice results show that the students in the experimental group have higher learning enthusiasm; the questionnaire survey shows that most students in the experimental group believe that the course "effectively improves the thinking of medicine-engineering integration" and "are willing to apply Python skills to professional research". The teaching mode of this study has achieved preliminary results.

4. REFLECTION ON TEACHING PRACTICE AND CONTINUOUS IMPROVEMENT

In the process of practical teaching, two key problems that need to be solved urgently have emerged: First, there are significant efficiency differences among students in the online autonomous learning link. Due to the lack of effective learning guidance and supervision mechanisms, some students fall into a state of blind browsing when facing a vast amount of online resources and fail to give full play to the advantages of online learning. This problem is closely related to the students' "Self-regulated Learning (SRL)" ability. Students with weaker self-regulation ability are difficult to effectively plan their learning process. Second, the difficulty gradient of medical case design is not reasonable enough. Currently, most cases focus on the basic application level and lack progressive design from easy to difficult, making it difficult to meet the learning needs of students at different levels. This problem fits the core viewpoints of the "Cognitive Load Theory (CLT)" and the "Zone of Proximal Development (ZPD)". If the case difficulty is too high, it is easy to cause cognitive overload, and if it is too low, it cannot effectively stimulate the learning motivation.

In response to the above problems, the research group has developed a systematic optimization plan. First, in terms of improving the efficiency of online learning, it is planned to introduce an intelligent learning path planning function. By analyzing students' learning behavior data, personalized learning plans and resource recommendations will be customized to help students clarify their learning goals. At the same time, a three-level case library of "basic - advanced - innovative" will be constructed: basic cases focus on the combination of programming basic knowledge and medical scenarios; advanced cases incorporate complex medical data analysis tasks; innovative cases focus on cutting-edge medical artificial intelligence application scenarios, encouraging students to carry out innovative practices.

5. CONCLUSIONS AND OUTLOOK

Based on the policy requirements of the integration of medicine and engineering, this paper constructs and practices a blended teaching model for the basic Python artificial intelligence programming in medical colleges and universities, with the core features of "medical case-driven, data intelligence feedback, and multi-dimensional process evaluation". Preliminary teaching practice shows that this model effectively solves the teaching dilemmas of the integration of medicine and engineering, such as the disconnection between theory and medical practice and the single evaluation method in traditional teaching, significantly improves students' programming application ability and the thinking of the integration of medicine and engineering, and achieves remarkable results in improving the quality of compound talent cultivation. This meets the cultivation requirements of "multi-disciplinary cross-integration" in the "Guiding Opinions on Accelerating the Innovation and Development of Medical Education", and provides a blended teaching paradigm for the information technology curriculum reform in medical colleges and universities, driven by real medical scenarios and supported by data intelligent analysis.

In the future, research will be deepened in three aspects: First, further expand the scope of school-enterprise cooperation, jointly develop teaching projects in real medical scenarios with more affiliated hospitals and pharmaceutical enterprises, and improve the authenticity and application value of cases; Second, rely on AI technology to realize the push of personalized learning paths, optimize the learning situation analysis model, and achieve an intelligent teaching closed-loop of "real-time learning behavior analysis - dynamic resource recommendation - instant effect feedback"; Third, explore the cross-course integration mode of "Python + medical professional courses" (such as collaborative design of teaching content for medical imaging and processing technology courses), and provide a more systematic solution for the cultivation of medical engineering compound talents. At the same time, the model constructed in this study can be further combined with technologies such as virtual simulation and digital humans to construct immersive learning scenarios such as "virtual patients" and "AI research tutors", and finally form a lifelong "medicine + AI" intelligent learning ecosystem that runs through undergraduate, postgraduate and even continuing education stages.

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