Exploring of AI-driven Online-offline Blended Teaching in Human and Animal Physiology

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Abstract: To address the key challenges in the online-offline blended teaching of Human and Animal Physiology, this study explored AI-empowered application pathway, including AI-assisted learning analysis and teaching case updating, AI-powered intelligent tutoring, AI agent-driven inquiry-based teaching and AI-empowered competency evaluation in labor education. Practice has shown that integrating AI into pre-class, in-class and post-class teaching activities effectively enhanced teachers' educational and teaching competencies as well as instructional efficiency, promoted the development of students' inquiry abilities, and enriched the dimensions of competency evaluation. Meanwhile, it effectively stimulating students' enthusiasm and initiative for learning, enhancing their innovation awareness and abilities. This study provide a foundation for curriculum reform.

Keywords: Human and Animal Physiology; Blended Online and Offline Teaching; AI-assisted Teaching; Inquiry-based Teaching; Labor Education Literacy Evaluation

1. Introduction

Human and Animal Physiology is a core course of the Biological Science major, which is expected to cultivate students' understanding of the laws of life activities, help them master the basic physiological knowledge, and enhance the ability and comprehensive competence of students. This course is based on the MOOC Teaching resources of *Physiology*, a national level first-class MOOC of Harbin Medical University, offering students high-quality resources for preview and extension. Meanwhile, the teaching team independently developed an online teaching platform on Chaoxing Learning Platform, including teaching resources of chapter content, mind map, course knowledge graph, homework bank, extended resource library, and experimental operation video library, and built labor education practice resources into the professional cours graduallye [1], and established a relatively complete supporting system for online-offline blended teaching. But as blended teaching entered into a normalized stage, some new issues in teaching emerged, including low efficiency in learning analytics, heavy online guidance workload for teachers, inadequate depth in inquiry-based thinking training, and difficulty in quantifying the evaluation of labor education competencies.

With the rapid advancement of Artificial Intelligence (AI) technology, new avenues have been opened up to solve these issues. AI has made technological breakthroughs in various fields, such as natural language processing, learning analytics, intelligent question-answering and affective computing [2,3]. These advancements have been gradually applied in educational scenarios [4,5], showing its application potential in teaching, learning, evaluation and management [6,7], and promoting education to realize the deep integration of smart teaching, personalized learning and intelligent evaluation [8,9].

AI empowered teaching has been given top-level guidance in the successive issuance of policy documents like the *Outline of the Plan for Building a Strong Education Country, the Action Plan for "AI + Education" and the National Strategic Action for Educational Digitization* [10-12]. Under the broader push for AI in education, the teaching team has designed a smart teaching model that integrates AI into the pre-class, in-class, and post-class stages of the Human and Animal Physiology course (Figure 1), in order to solve practical problems of traditional blended online-offline teaching.

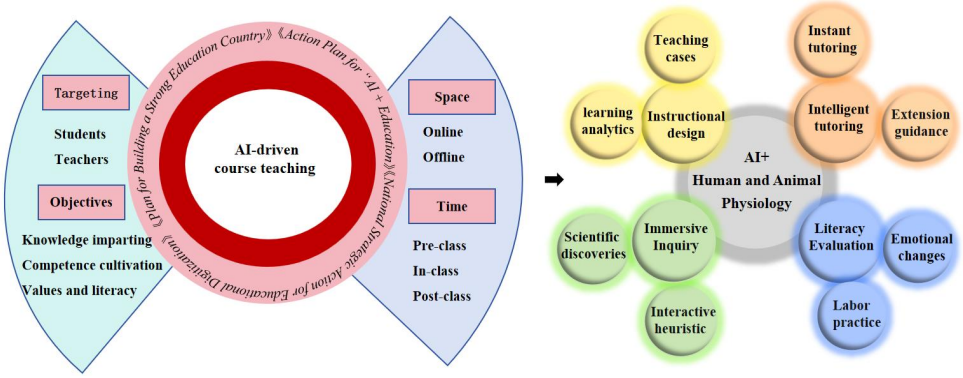


Figure 1. AI-Empowered Blended Online-Offline Teaching Pathway for *Human and Animal Physiology*

2. Main Problems in the Blended Online-Offline Teaching of *Human and Animal Physiology*

First, learning analytics is inefficient and insufficiently precise. The learning data produced in the process of pre-class preview is voluminous and complicated. The Learning Platform does provide teachers with behavioral data, such as submission rates and completion rates, while the content still requires teachers to read and summarize manually. In large class situations (120–140 students per class), it is challenging to reliably assess the common misconceptions in the entire class and individual student differences. Moreover, classroom quizzes can only show the students' real-time understanding, the high-error questions still require teachers to analyze each one individually for the underlying causes. Second, teaching guidance workload of teachers is too much. Students raise a large number of questions, many of which are repetitive across different classes. Teachers need to respond individually on each platform, which consumes substantial time and energy, leaving less room for personalization and higher order instructional design. Third, the training of students' thinking in the process of inquiry is still shallow. For teaching, the virtual simulation experiments are primarily used to verify the experiments, in which students can only repeat the designed experiments in the given procedures, at the same time, there is not enough space for the students to design an experiment. The stories of scientists focus on introducing historical facts and achievements, while students have limited opportunities to follow scientists' thinking paths to re-discover scientific conclusions. An important problem inquiry-based instructional design must address is how to construct a complete scientific inquiry chain within the limited class time and how to foster students' critical thinking and innovation ability. Fourth, the evaluation of labor education competency is difficult to quantify. The course implements labor practice in four field, through fieldwork, feeding experimental teaching with labor outcomes, science popularization and social service, and acting as teaching assistants [1]. In the last 5 years, these practices have involved more than one thousand students and produced 229 practical projects. However, the assessment is mostly based on subjective judgments from peer assessment and teacher observation, while competency elements such as labor attitude, teamwork and innovation awareness are difficult to assess accurately with traditional scores. There is a need to develop new technological approaches to visualize the assessment of labor competency.

3. Implementation Pathways of AI-Empowered Teaching

3.1 AI-Assisted Learning Analytics

Analysis of pre-class preview. Before class, students use chapter learning tasks, mind maps and course knowledge graphs on the Learning Platform to clarify their learning objectives, and then use MOOC videos to do pre-class preview, and submit preview study plans and difficult questions. The AI workbench of the Learning Platform can monitor preview data, read preview study plans and difficult questions, accurately identify students' cognitive difficulties in understanding concepts, push personalized learning resources to students and generate teaching plans containing learning diagnostics, excellent cases and suggestions for interaction for teachers. Taking the Introduction lesson as an example, AI found that Class 1 was confused about the distinction between neural regulation

and humoral regulation, while Class 2's understanding of the integration concept remained superficial, and that both classes had cognitive blind spots on the molecular mechanism of the negative feedback principle. By identifying students' typical confusions and common blind spots, the system pinpointed the key and difficult points of classroom instruction and provided data support for instructional design.

Analysis of classroom knowledge mastery. The AI learning analytics module of the Learning Platform can automatically identify questions with a high error rate from classroom quizzes, and push suggestions for layered explanation. As shown in Figure 2, the platform found that the accuracy of Question 7, the ionic current formation mechanism of the plateau phase of ventricular muscle action potential, was relatively low, and pushed the layered explanation suggestions for this question. Based on this, teachers can adjust their explanation strategies accordingly, making exercise explanations more targeted and improving the efficiency of classroom quiz feedback.

Development of stratified student learning profiles. Based on the students' learning situation indicated by dimensions that include students' quiz scores, students' mastery of knowledge, and students' self-study conditions, the AI workbench classifies students' learning situations into four levels. The stratified profile of Class 2, Grade 2023 (131 students) is shown in Figure 3. During the final review of the semester, teachers focus on the students in the improvement level group, making learning guidance more targeted and feedback more timely and effective.

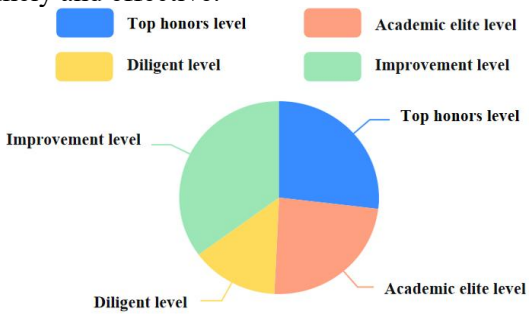
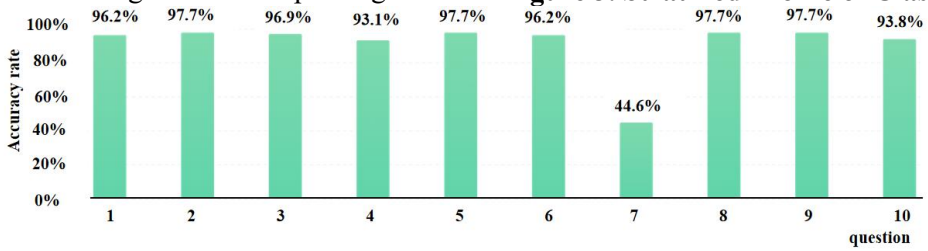


Figure 3. Stratified Profile of Class Students



Weak-Item Explanation Recommendations:

For Question ID 7:

•Core knowledge: Clarify the ionic currents in the ventricular action potential plateau phase.
•Step-by-step analysis: Break down the solution and justify each answer choice.
•Similar question types: Provide additional practice and explain general strategies.

Figure 2. AI-assisted Analysis of Classroom Quizzes Tutoring

3.2 AI Teaching Assistant for Intelligent

Given the high workload of the teachers' tutoring, this course also adopted the AI teaching assistant function, which can identify the students' questions, provide targeted answers and recommend related resources. For instance, when a student reports that she does not fully understand the contraction mechanism and contractile efficiency of striated muscle, the AI teaching assistant explains the issue from two levels, molecular mechanism of the myofilament sliding and functional manifestation of the muscle output, and then suggests learning micro-lectures for further study. In this way, the AI teaching assistant effectively shares the basic tutoring workload, freeing teachers from repetitive tasks. Meanwhile, students' questions are recorded in real time in the background, which can be used for subsequent learning analytics.

3.3 AI-Assisted Updating of Teaching Cases

High-quality cases not only serve as knowledge carriers in the physiology teaching process but also provide an entry point for the integration of ideological and political education into the teaching process. In the traditional lesson preparation, teachers rely on their personal accumulation, and case updating is slow and single source. The AI lesson preparation system automatically correlates classic experiments, frontier discoveries and typical cases with ideological and political content, and realizes the continuous update of teaching cases. When explaining the research levels of physiology, for

instance, AI recommended the case of Academician Chen Yeguang' s team of Tsinghua University, which has been deeply engaged in intestinal organoid research for more than ten years, helping students appreciate perseverance in scientific research. In the teaching, we created five kinds of case materials (Table 1), combining AI-based intelligent recommendation with teachers' educational guidance to help students analyze the scientific spirit, innovation awareness and patriotic feelings embodied in the cases.

Table 1. Types of Teaching Cases and Educational Objectives

Case category	Teaching objective
Nobel Prize scientist cases	Cultivating scientific inquiry thinking
Innovative research by Chinese scientists	Stimulating cultural confidence and innovation awareness
Teachers' scientific research achievements	Research feeding back into teaching
Students' practical achievements	Peer demonstration and motivation
Extracurricular extension materials	Meeting personalized learning needs

3.4 AI Agent-Driven Immersive Inquiry-Based Teaching

To enhance students' inquiry abilities, this course takes the review of scientific discoveries as its basis and creates a blended learning scenario that integrates scientist interaction, student inquiry and peer evaluation. Taking the discovery of the sliding filament theory as an example, the teaching process proceeds in three stages. The first stage is designed to arouse students' interest and give out challenge tasks. Students are guided to consider the basis for proposing the sliding filament theory, to retrace how the scientists developed the theory, and to design an experiment to verify the sliding filament process. AI assisted inquiry and scheme design are performed in the second stage. Students engage with the AI agent for virtual conversations with Huxley, share ideas and plan experiments. In the third stage presentations, mutual diagnosis and iterative optimization are performed. As each group presents and peer-reviews, they learn from each other's strengths to compensate for weaknesses and optimize their schemes, with on-site guidance from the teacher. Through immersive inquiry, the abstract physiological mechanisms are transformed into operational learning tasks. Students learn by doing and think throughout the complete inquiry cycle, from problem posing and scheme design to argumentation and iteration. Through collaboration, they face experimental setbacks, acquire scientific methods, and recognize that the value of inquiry lies in the process itself, rather than the outcome.

3.5 AI-Empowered Competency Evaluation in Labor Education

An AI-assisted evaluation strategy was introduced in the evaluation of labor practice competencies. After the personal information in students' labor prsactice reports and science popularization works and reflection texts is removed, semantic analysis is conducted using the video transcription tool and the ERNIE Bot large language model, noise is removed and the high-frequency words are categorized manually, and a word cloud and a statistical chart of the proportion of value-related keywords are generated by using the Dycharts chart tool. The statistics on the course practice reports of Class 2, Grade 2021 show that words like teamwork, respect for labor, scientific spirit and service to society are widely mentioned in the course practice reports, which visually presents the competency structure of students in communication and collaboration, scientific spirit and innovative thinking (Figure 4).

Figure 4. Word Cloud and Keyword Proportions of Student Competencies Based on AI-assisted Analysis

4. Implementation Effects of AI-Empowered Teaching

4.1 Improvement of Teachers' Educational and Teaching Competencies

Firstly, teachers' educational ideas and teaching skills have been enhanced. The team has kept up with the digital transformation of higher education and has come up with the idea of data-supported precise teaching. AI learning analytics can guide teachers to take differentiated strategies in classroom questioning, assignment arrangement and after-class tutoring based on students' varying learning starting points, focusing on the growth needs of each student. The concepts of student-centeredness, teaching according to aptitude, and fairness of education in practice have been deepened in practice. Meanwhile, the teachers are more and more focusing on cultivating students' critical thinking, innovation awareness, lifelong learning ability as well as their ability to use new technologies, reflecting the educational philosophy of equipping students with the skills to learn independently and empowering them for lifelong growth. Second, the skills of instructional design and classroom implementation have been enhanced. With AI-generated learning analytics, teachers can more precisely identify the key and difficult points of each lesson, provide more targeted explanations of the exercises, and enhance their multi-level teaching ability. In terms of classroom implementation, the pushing of classic cases and frontier achievements, along with the AI agent-driven inquiry activities have enriched classroom teaching methods and forms of interaction. Teachers guided students to think deeply through follow-up questioning, prompting and inspiration, while their classroom organizing and guiding abilities improved. Thirdly, teachers' digital literacy has improved. Through sustained use of tools such as AI learning analytics, AI teaching assistants, and AI lesson planning systems, teachers have continuously enhanced their understanding and proficiency in intelligent educational technologies. Their abilities in tool application, data interpretation, and critical evaluation have been honed through ongoing practice, accumulating valuable experience for the role transformation required in the context of educational digitalization. The team has obtained one second prize and two third prizes in the university's young teachers' teaching competition, and one second prize in the AI-empowered teaching practice group of the Teaching Innovation Competition, which shows the promoting effect of AI-empowered teaching reform on teachers' professional development.

4.2 Improvement of Students' Autonomous Learning Ability

The AI teaching assistant provides instant tutoring, breaking the limitations of time and space. Students can get answers at any time when they encounter difficulties during preview, review or homework. Some students changed from reluctant to ask questions to asking at any time, with markedly increased initiative in asking questions. AI learning analytics and learning suggestions enable students to more clearly see their mastery of knowledge and timely adjust learning progress and learning methods. A questionnaire was given to 131 students from Class 2, Grade 2023 and 131 valid questionnaires were received after the course. Figure 5 shows that 73.19% of the students stated that MOOC materials supported autonomous learning, while 89.13% of the students reported that they would adjust their learning pace and methods based on the feedback data in the Learning Platform. The data generated by AI has been converted into an autonomous learning navigation tool for students' self-diagnosis and self-regulation to enhance their autonomous learning ability.

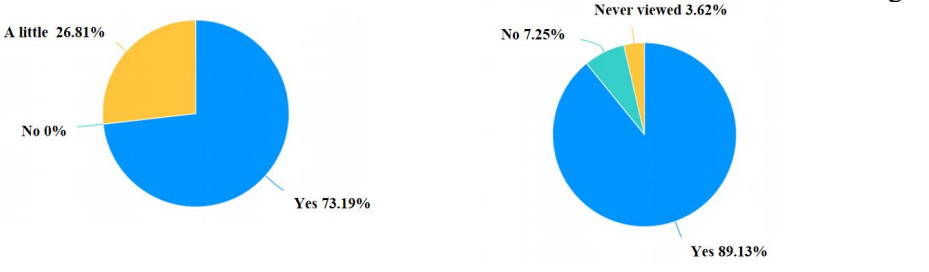


Figure 5. Students' Recognition and Use of online Resources

4.3 Improvement of Students' Inquiry Thinking and Innovation Ability

Students' ways of thinking have changed through the continuous guidance of inquiry-based classes and practical activities. When faced with open-ended inquiry tasks, students are no longer over-dependent on the pre-made answers in the textbook, but little by little, they gradually shift toward designing by themselves, and taking the initiative to consider control of experimental variables, establishment of controls, and selection of observational indicators. For example, in the open experimental design of reflex arc analysis, students were able to identify their own topics, choose onion, ginger and garlic juices as well as acetic acid solution as stimuli, observed the flexor reflex behaviour of the frogs, and investigated the relationship between types and intensities of the stimuli and reflex duration, thereby establishing a logical chain between the experimental conditions and the physiological responses. During discussion and peer evaluation, students persistently questioned the sources of evidence and the implications of the conclusions, indicating that critical thinking was beginning to emerge.

The new ideas produced in the inquiry activities were further transformed into extra-curricular academic activities. The students extended the experimental design and data analysis skills gained in classroom inquiry to various competitions and projects, including the Challenge Cup, China International College Students' Innovation Competition, the life science competitions, the college students' innovation and entrepreneurship training programs, and the Hundred-Thousand-Ten Thousand Project. For instance, the project Code for Tea Roots—Digital Identity Code Design for Intangible Cultural Heritage Herbal Tea received an award at the university's Challenge Cup competition. The implementation of inquiry activities has enabled effective extension from classroom thinking training to an extra-classroom scientific research practice, which has facilitated the development of students' all-round scientific research capacity.

4.4 Diversification of Course Teaching Evaluation

With the establishment of AI-assisted teaching, the teaching evaluation of the course has been improved remarkably in both form and efficiency. Formative evaluation is composed of the following parts, class status and performance (10%,) online MOOC preview and feedback of preview study plan (≤10%), class quizzes (10%-20%), online-offline interaction (10%-15%), experimental inquiry class (40%), and after-class labor practice (10%-20%). The evaluation participants have been expanded to a tripartite synergy of teachers, peers and AI. All segments, such as pre-class preview, online-offline participation, experimental operation and labor practice are included in the evaluation forms. In preview and classroom quizzes, AI automatically grades quizzes and compiles statistics; in classroom inquiry and experimental classes, it helps students with discussion and experimental scheme design; in the labor practice segment, it presents the distribution of competency structures through word cloud analysis; and in discussion areas, it participates in and counts discussions. Regarding summative assessment, AI helps to analyse the final exam result distribution, the difficulty and discrimination of questions, and present an overall learning report of the class, which will be a reference for teachers' teaching reflection and course optimization. The formative evaluation emphasizes the monitoring of learning behavior and ability development while the summative evaluation emphasizes the ability test of knowledge mastery, both of which make up a comprehensive course evaluation system. The use of AI-assisted evaluation enriches the diversity of evaluation methods, enhances the efficiency of process diagnosis in the teaching field and realizes the evaluation goal of promoting learning through evaluation and promoting teaching through evaluation.

5. Conclusion

This study integrated AI technology into the three stages of pre-class, in-class, and post-class in the teaching of *Human and Animal Physiology* and explored application pathways including AI-assisted learning analytics and teaching case updating, AI teaching assistant for intelligent tutoring, AI agent-driven inquiry teaching, and AI-assisted competency sevaluation in labor education. Three years of teaching practice has shown that AI has achieved initial results in improving teachers' teaching abilities, promoting students' inquiry abilities, and enriching the dimensions of

competency assessment. Meanwhile, there are certain aspects of the practice that warrant improvement, including the fact that some students over-rely on AI to obtain answers directly, some of the inaccuracies in AI-generated content, and the need to enhance the collaborative mechanism between AI word cloud analysis and manual evaluation. To address these challenges, future teaching will focus on three areas. First, students' independent thinking will be cultivated, encouraging them to view AI output critically. Second, a library of teacher-vetted AI resources will be built, and training on AI tool usage will be integrated into instruction. Third, a human-machine evaluation linkage mechanism will be established, where AI generates competency profiles and trend alerts, while teachers provide in-depth diagnostic evaluation, together forming a synergistic system.

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