

Exploration and Practice of AI-Enabled Human-Machine Collaborative Teaching Mode in Compiler Courses

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Abstract: Aiming at the problems of interdisciplinary integration, difficulty in personalized learning, and lack of real-time feedback in the traditional teaching of compiler courses, this paper proposes an AI-enabled human-machine collaborative teaching mode and builds an intelligent AI teaching platform. This mode integrates students, teachers, and AI into an organic whole. AI provides students with personalized services such as relevant course knowledge recommendation, learning resource recommendation, and quiz push, and provides teachers with intelligent services such as automatic homework correction and learning data analysis feedback. Teaching practice analysis shows that this mode has improved students' final exam scores and learning experience.

Keywords: Compiler courses; AI empowerment; Human-machine collaboration; Teaching practice

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1. Introduction

The rapid development of artificial intelligence technology is bringing a profound transformation to the field of education. As the core driving force of educational digital transformation, large AI models are reshaping the concepts and practical paths of teachers' teaching^[1]. Compiler principles are one of the core courses for computer majors, which mainly cultivate students' basic abilities in program design, teaching platform analysis, logical thinking, and language processing by introducing the general principles and basic methods of compiler construction. In years of teaching practice, there have always been three major pain points: interdisciplinary integration, difficulty in personalized learning, and lack of real-time feedback. Human-machine collaboration emphasizes the concept of humans and machines working together to complete tasks, so as to give full play to the advantages of humans and machines and improve work efficiency^[2-5]. Based on this, this paper proposes an application framework and a practical path of AI-enabled human-machine collaborative teaching mode in compiler principles courses, providing a feasible scheme for the application of AI in the teaching practice of this course.

2. Current teaching situation and pain points

Compiler principles have always been regarded as a difficult course for computer majors and a hot course for educational reform. In teaching practice, students generally face the following key pain points:

First, high learning difficulty caused by interdisciplinary integration. Compiler principles is a comprehensive and highly theoretical course combining discrete mathematics, data structures, operating systems, computer composition principles, and other disciplines^[6]. It requires students to master the basic knowledge of relevant disciplines and integrate various knowledge reasonably and effectively in the process of compiler design and implementation. Due to the high integration of multidisciplinary knowledge, the compiler principles course is prone to knowledge faults, and it is difficult for students to grasp the key and difficult points of the course and form a complete and mature compiler development thinking.

Second, difficulty in personalized learning. Due to the large differences in students' foundations and uneven learning abilities, and the traditional teaching mode is mainly teacher-centered, the one-size-fits-all teaching form is difficult to take into account students with weak foundations and advanced learning needs, so it cannot provide good personalized teaching.

Third, lack of real-time feedback. In the traditional teaching mode, teachers manually grade students' experimental codes, resulting in an obvious lag.

3. Design of AI-enabled human-machine collaborative teaching mode

3.1. Mode design

The AI-enabled human-machine collaborative teaching mode takes the collaboration of teachers, students, and intelligent platforms as the core, and builds a closed-loop learning environment aiming at "human-machine collaboration, intelligent assistance, and personalized learning"^[7]. Teachers undertake the responsibilities of curriculum design, experimental guidance^[8], learning strategy guidance, and learning feedback analysis in this mode, and play a leading role in professional teaching. Students take the initiative to generate learning data in independent learning, experimental operation, homework submission, and other links, and take the initiative to absorb and apply knowledge with the help of the AI teaching platform to obtain real-time guidance and knowledge push. Based on large language models, course knowledge graphs, and deep learning models, the AI teaching platform provides many functions such as learning resource recommendation, relevant course knowledge push, personalized exercise generation, learning path planning, homework correction, intelligent Q&A, learning data analysis feedback, and teaching resource optimization to realize all-round assistance in the teaching process.

Learning resource recommendation can intelligently push course texts, videos, and experimental cases according to students' learning status and knowledge mastery, realizing the dynamic correlation of different disciplines in experiments or tasks in course knowledge push. Relevant course knowledge push dynamically identifies the required relevant disciplinary knowledge based on the course knowledge graph and students' current learning tasks, and pushes them accurately^[9,10]. Personalized exercise generation generates appropriate exercises according to students' ability differences, which is conducive to hierarchical teaching. Learning path planning dynamically adjusts the order of experimental tasks and reasonably controls the difficulty of learning content based on students' historical learning behavior and knowledge mastery, truly reflecting the idea of teaching students in accordance with their aptitude. The automatic homework correction function automatically scores students' submitted homework, automatically generates error analysis, and

gives improvement suggestions to improve students' learning efficiency. The intelligent Q&A module answers students' doubts in learning and experiments in real time and accurately, effectively enhancing the coherence and initiative of the learning process.

The AI-enabled human-machine collaborative teaching mode organically integrates teacher guidance, student initiative, and AI assistance (**Figure 1**), effectively solving the core pain points of interdisciplinary integration, difficulty in personalized learning, and lack of real-time feedback in compiler principles courses.

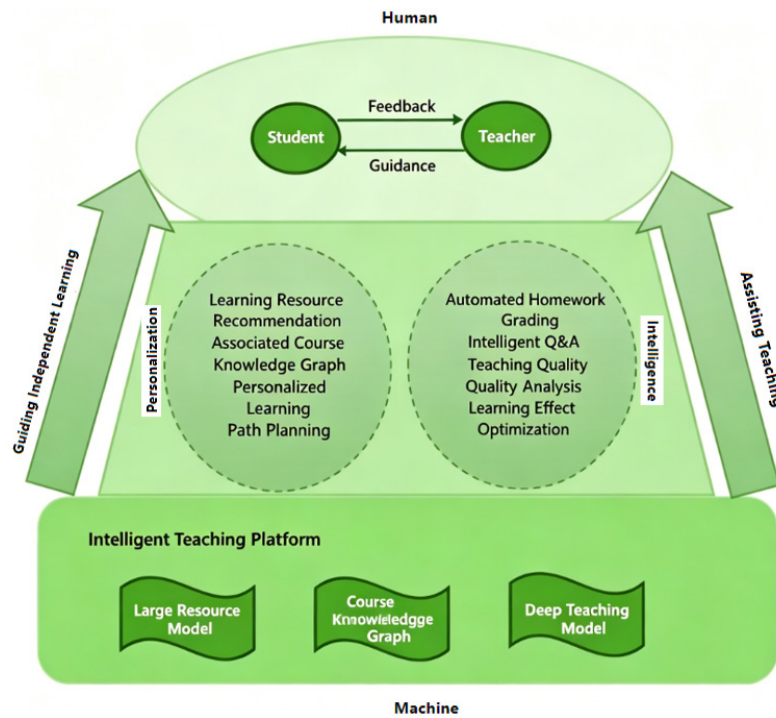


Figure 1. Diagram of human-machine collaborative teaching mode

3.2. Teaching platform architecture

The teaching platform adopts a four-layer architecture design, namely interaction layer, logic layer, storage layer, and data layer, realizing hierarchical management of functional modules, data circulation between layers, and collaborative processing with each other, effectively integrating functions such as teacher guidance, student learning, and AI assistance.

- (1) Interaction layer: The trinity collaborative design mode provides an intuitive interactive interface for teachers and students, covering course browsing, experimental operation, homework submission, intelligent error correction, knowledge recommendation, personalized resource viewing, learning feedback display, and teaching platform management, directly addressing the teaching pain points of compiler principles.
- (2) Logic layer: Reasonably combines Django backend framework with AI technologies such as deep learning models, large language models, and course knowledge graphs. It uses Jieba word segmentation tool and collaborative filtering method to initially select teaching resources with high scores^[11], and then recommends teaching resources through deep learning algorithms; pushes relevant course knowledge points through course knowledge graphs to clarify the correlation between knowledge points^[12,13];

realizes intelligent homework correction, learning data analysis, and feedback through knowledge graph technology platform ^[14,15].

- (3) Storage layer: Responsible for the storage, management, and access of teaching resources and user data. MySQL is used to manage structured data such as student information, experimental records, and grade sheets, and NoSQL database is used to manage unstructured data such as course videos, interactive logs, and knowledge graph information.
- (4) Data layer: Including diverse data such as course texts, videos, and course knowledge graphs, the platform records students' homework submission and learning behaviors, providing data support for personalized recommendation and learning data analysis in the logic layer.

4. Teaching practice process

The AI-enabled human-machine collaborative teaching mode is integrated into the “pre-class–in-class–after-class” teaching process and combined with online and offline hybrid teaching methods, taking SLR(1) syntax analysis as an example for practical teaching.

- (1) Pre-class preparation stage: Teachers release chapter tasks through the intelligent platform and push MOOC videos of bottom-up syntax analysis for pre-class preview. Teachers can also optimize courseware and lesson plans of relevant chapters through AI assistants. In this chapter, AI can be used to dynamically demonstrate the generation process of SLR(1) syntax analysis tree, and analyze and review relevant computer professional knowledge to help students establish connections between fault knowledge points and understand the key and difficult points of the course. The platform records students' video viewing duration, times, and click rates of relevant videos. Viewing duration can detect students' mastery degree, times can monitor students' understanding of knowledge points, and click rates of relevant videos can reflect students' mastery of other professional courses from the side. Collect data and feed back to teachers in time so that teachers can understand students' mastery and adjust teaching progress and priorities.
- (2) In-class teaching stage: In offline teaching, instead of relying on traditional PPT courseware, AI demonstration animations such as the establishment of prediction analysis tables and generation animations of syntax analysis trees are used to improve students' learning interest and enthusiasm and deepen their understanding of relevant knowledge. In-class quizzes are introduced, and the intelligent platform is used to answer questions online to provide feedback on students' mastery in real time and dynamically adjust classroom explanation progress.
- (3) After-class reflection and improvement: The intelligent platform dynamically adjusts learning progress and learning resource recommendation according to the correct rate of each student's in-class exercises. If the error rate of prediction analysis tables is high, learning tasks of this knowledge point are automatically pushed. After-class exercises are released and automatically corrected with detailed reference answers including diversified data such as text descriptions, relevant video resources, and animation demonstrations to help students further understand error-prone points. After class, teaching reflection is carried out according to students' overall performance and mastery of knowledge points, and teaching plans are optimized to improve teaching effect.

5. Teaching practice effect

To understand the actual effect of AI-enabled human-machine collaborative teaching mode in compiler principles courses, teaching practice was carried out on 8 classes of 2022-grade computer science and technology majors in Anhui Institute of Information Technology, and their average final exam scores were compared with those of the previous class without this teaching mode. The results showed that the final exam failure rate decreased significantly, the average score increased by 4 points, and the proportion of medium and good students increased significantly, indicating that students' learning mastery was relatively average, and the scores of students using this teaching mode were closer to a normal distribution. In addition, a questionnaire survey was conducted on 8 classes after the course, mainly evaluating the teaching mode and AI-assisted functions of the intelligent platform. Most students believed that they had a stronger interest in compiler principles courses under this mode. Due to the addition of AI intelligent Q&A and interdisciplinary relevant knowledge push functions, most students said they had a deeper understanding of other computer professional knowledge, and some students said their independent learning ability had been greatly improved.

6. Conclusion

This paper clearly expounds the exploration and practice of AI-enabled human-machine collaborative teaching mode in compiler courses, which can effectively help teachers optimize teaching mode and improve students' learning enthusiasm and initiative. Pre-class resource push, in-class intelligent answering, and real-time feedback, after-class homework correction, and feedback are connected with each other, thus solving teaching problems such as interdisciplinary integration, difficulty in personalized learning, and lack of real-time feedback. The analysis of final exam scores, questionnaire surveys, and other data shows that it has played a positive and effective role in teaching effect and course experience, providing a feasible reference for higher education curriculum reform.

Disclosure statement

The authors declare no conflict of interest.

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