

Design and Implementation of Intelligent Tutoring System Based on Artificial Intelligence

Ge Runzhi

*School of Mathematics and Artificial Intelligence, Chongqing University of Arts and Sciences
Yongchuan, Chongqing, China*

Abstract: Traditional educational tutoring modes suffer from limited personalized adaptation, low resource utilization efficiency, and difficulty in capturing real-time learning states of students, failing to meet the diversified and refined learning demands in modern smart education. This study adopts artificial intelligence technologies including knowledge graph, data mining and adaptive learning algorithms to design and develop an intelligent tutoring system. User demand analysis, modular architecture design and functional module development are completed through systematic educational scenario investigation and technical iteration. System functional testing and performance verification are conducted based on actual teaching application scenarios. The results show that the constructed system can realize adaptive tutoring, real-time learning state evaluation and personalized resource recommendation. It effectively optimizes teaching service modes, improves learning efficiency, and provides technical support and practical reference for the intelligent transformation of modern education systems.

Keywords: Artificial Intelligence; Intelligent Tutoring System; Personalized Learning; Educational Informatization; System Implementation

1. Introduction

1.1 Research Background

The rapid iteration of artificial intelligence technology has driven comprehensive digital transformation in the global education industry, fundamentally changing the traditional one-size-fits-all teaching and tutoring paradigm. Modern education development pays increasing attention to individual differences of learners, and the homogeneous teaching resource supply and fixed tutoring rhythm in traditional teaching

modes can no longer adapt to the personalized learning needs of students at different learning stages and ability levels. The integration of intelligent technology and educational scenarios has become a core development trend of educational informatization, which promotes the shift of educational service from standardized batch teaching to accurate personalized tutoring. Intelligent tutoring system, as a typical application carrier of artificial intelligence in the field of education, can break through the time and space limitations of traditional manual tutoring. It realizes automatic analysis of learning behaviors, accurate diagnosis of knowledge loopholes and targeted push of tutoring resources. With the continuous popularization of online education and hybrid teaching modes, learners put forward higher requirements for the intelligence, pertinence and real-time performance of tutoring services. The traditional tutoring system relying on simple data statistics and fixed resource matching lacks dynamic perception and adaptive adjustment capabilities for learning states, resulting in poor matching degree between tutoring content and learner actual needs. It is urgent to construct a more intelligent and systematic tutoring system based on advanced artificial intelligence technologies to solve the pain points of current educational tutoring scenarios.

1.2 Research Significance

The research and development of artificial intelligence-based intelligent tutoring system has important practical value for promoting the high-quality development of modern education. From the perspective of educational practice, the system can automatically record and analyze learners' learning track, learning duration, error types and other behavioral data, accurately identify individual learning weaknesses and knowledge defects. It provides customized tutoring plans and learning guidance for each learner, which effectively makes up for the

deficiency of insufficient personalized guidance in traditional classroom teaching and improves the overall learning effect of students.

From the perspective of educational technology development, this study optimizes the system architecture and functional logic of traditional intelligent tutoring platforms through the integrated application of knowledge graph technology and data mining algorithms. It improves the intelligent decision-making ability and scenario adaptation performance of the tutoring system, enriches the practical application cases of artificial intelligence technology in basic and professional education scenarios. The research results can provide technical reference for the subsequent iterative upgrading of educational intelligent equipment and platform construction, and promote the deep integration of artificial intelligence and educational teaching business.

2. Related Work and Theoretical Basis

2.1 Research Status of Intelligent Tutoring System

Foreign research on intelligent tutoring systems started early, and relevant theoretical systems and technical application frameworks have been initially formed. Early intelligent tutoring systems mainly relied on computer-aided teaching technology to realize simple resource display and exercise training functions, with single functional modules and weak intelligent recognition ability. In recent years, with the development of generative artificial intelligence and multi-agent collaborative technology, foreign research has focused on adaptive learning mechanism and personalized teaching strategy optimization of tutoring systems. Many studies have constructed intelligent tutoring frameworks based on large language models, realizing dynamic generation of tutoring content and real-time interactive teaching, which greatly improves the flexibility of tutoring services.

Domestic research on intelligent tutoring systems has developed rapidly in the context of educational informatization construction. Most existing studies focus on the application of intelligent tutoring systems in specific curriculum scenarios such as programming teaching, basic computer courses and discipline experimental teaching. Some researches explore the application value of intelligent tutoring systems in personalized teaching and student

state early warning, and verify that intelligent systems can effectively improve teaching efficiency and learner learning initiative. However, most existing domestic achievements have problems such as single technical application dimension, insufficient integration of educational psychology theories, and poor system scalability. Few studies construct universal and scalable intelligent tutoring systems combining multiple artificial intelligence technologies, which cannot fully meet the diversified application needs of modern multi-scenario teaching.

2.2 Core Artificial Intelligence Technologies for Educational Application

Knowledge graph technology is one of the core supporting technologies of the intelligent tutoring system in this study. This technology can construct structured knowledge networks according to the logical correlation of educational knowledge points, realize hierarchical classification and correlation association of curriculum knowledge. In the tutoring system, knowledge graph can accurately match the knowledge points corresponding to learners' wrong questions and learning difficulties, clarify the internal logical relationship between different knowledge modules, and provide accurate knowledge positioning support for personalized tutoring resource push. It solves the problem of scattered knowledge presentation and low matching accuracy in traditional tutoring systems.

Data mining technology provides data decision-making support for the intelligent operation of the tutoring system. The system collects massive learning behavior data generated by learners in the learning process, including learning time distribution, exercise error rate, knowledge point mastery degree and interactive feedback data. Through data mining and feature extraction, the system can identify the learning rules and individual learning characteristics of learners, realize dynamic evaluation of learning states, and provide objective data basis for the adjustment of tutoring strategies. Adaptive learning algorithm is applied to realize the dynamic adjustment of system tutoring content and difficulty. The algorithm can automatically adjust the complexity of learning resources and the frequency of tutoring guidance according to the real-time learning effect of learners, realizing the whole-process adaptive tutoring from

knowledge learning to effect detection.

3. Overall System Design

3.1 System Functional Requirements Analysis

Functional requirement analysis is the basic premise of system scientific design and stable operation. Combined with the actual application scenarios of modern educational tutoring and the research results of existing educational intelligent systems, the system needs to meet the core functional demands of student personalized learning, teacher teaching auxiliary management and system background data monitoring. For student users, the system needs to realize autonomous learning, knowledge point diagnosis, personalized resource recommendation, real-time problem answering and learning effect evaluation functions, so as to provide full-process intelligent tutoring services for learners' independent learning.

For teacher users, the system needs to support learning data statistics, student learning state analysis, tutoring plan formulation and teaching resource management functions. Teachers can view the overall learning situation of the class and individual learning problems through the system background, optimize classroom teaching content and targeted tutoring strategies according to system data feedback. At the same time, the system needs to have stable data storage, user rights management, system operation maintenance and other basic background functions to ensure the safe and stable operation of the platform. In addition, combined with the psychological development characteristics of student users, the system needs to set up reasonable learning reminder and state early warning functions to avoid learning fatigue and improve the sustainability of learning.

3.2 Overall System Architecture Design

Based on the results of functional requirement analysis and the technical characteristics of artificial intelligence, this study adopts a layered modular architecture to complete the overall design of the intelligent tutoring system, which is divided into data layer, algorithm layer, functional service layer and user interaction layer. The layered architecture design can effectively isolate the functional modules of the system, reduce the coupling degree between modules, and facilitate the subsequent function iteration and performance optimization of the

system. Each layer performs its own duties and cooperates with each other to jointly realize the intelligent tutoring function of the system.

The data layer is the basic support of the whole system, which is responsible for collecting, sorting and storing all kinds of data generated in the system operation process, including user basic information data, curriculum knowledge data, learner learning behavior data and tutoring resource data. The algorithm layer is the core intelligent module of the system, which integrates knowledge graph matching algorithm, learning state evaluation algorithm and adaptive resource recommendation algorithm. It processes and analyzes the original data transmitted by the data layer to output intelligent decision results. The functional service layer realizes the specific business functions of the system, including learning diagnosis service, personalized tutoring service, data statistics service and resource management service. The user interaction layer provides intuitive and convenient operation interfaces for students, teachers and administrators, realizing human-computer interaction and business function invocation.

4. System Implementation and Technical Verification

4.1 Key Module Implementation

The knowledge diagnosis module is the core functional module of the intelligent tutoring system. Based on the constructed curriculum knowledge graph, this module realizes accurate diagnosis of learners' knowledge mastery status. The system matches the learners' exercise answers and learning behaviors with the knowledge point database, marks unmastered knowledge points and weak knowledge modules, and forms a personalized knowledge defect report. The module adopts dynamic update mechanism, which can synchronously optimize the diagnosis results according to the continuous learning progress of learners, ensuring the real-time accuracy of knowledge diagnosis.

The personalized resource recommendation module is built on the basis of learning state big data analysis. The system constructs user learning portrait through mining learners' learning preference, learning ability and knowledge defect characteristics, and matches high-matching tutoring resources such as course videos, exercise questions and knowledge explanation materials from the resource database.

Different from the fixed resource push mode of traditional systems, this module can dynamically adjust the resource type, difficulty and quantity according to the learning effect feedback, realizing accurate push of hierarchical and personalized tutoring resources.

The learning state early warning and tutoring guidance module realizes intelligent auxiliary teaching management. The system monitors learners' learning duration, learning continuity and exercise accuracy in real time through data mining technology. When abnormal learning states such as long-term inefficient learning and continuous low accuracy occur, the system will automatically send early warning prompts and provide targeted tutoring suggestions. Teachers can view the early warning information through the background, carry out targeted offline auxiliary tutoring for students with learning difficulties, and realize the combination of online intelligent tutoring and offline manual teaching.

4.2 System Performance and Functional Test

To verify the functional availability and operational stability of the designed intelligent tutoring system, this study builds a test environment based on actual teaching scenarios and completes functional test and performance test of each module. The functional test focuses on verifying the integrity and accuracy of core functions such as knowledge diagnosis, resource recommendation, data statistics and state early warning. A certain number of student test users are selected to carry out trial operation tests, and the system operation results show that all functional modules can operate normally, the knowledge diagnosis results are accurate, the recommended resources are highly matched with users' learning needs, and the functional design meets the expected teaching application requirements.

The system performance test mainly detects the system response speed, data processing efficiency and operation stability under multi-user concurrent access. The test results show that the system has fast response speed under conventional user access volume, can efficiently complete batch learning data processing and analysis, and no system crash or data loss occurs during long-term continuous operation. Compared with the traditional tutoring system, the designed intelligent tutoring system has significant advantages in personalized adaptation

ability, data analysis accuracy and scenario application scope, which can better adapt to the intelligent development needs of modern educational tutoring work.

5. Conclusion

This study completes the design and implementation of an artificial intelligence-based intelligent tutoring system by integrating knowledge graph, data mining and adaptive learning algorithms, aiming at the deficiencies of single function and poor personalized adaptation of traditional educational tutoring systems. The system adopts layered modular architecture design, completes the development of core functional modules such as knowledge diagnosis, personalized resource recommendation and learning state early warning through demand analysis and technical iteration. Practical test results verify that the system has stable operation performance and complete functions, can effectively capture learners' learning characteristics and knowledge defects, and provide accurate personalized intelligent tutoring services.

The system optimizes the traditional educational tutoring service mode, breaks through the limitations of homogeneous tutoring resources and fixed tutoring strategies, and provides new technical ideas and practical schemes for intelligent educational teaching. In follow-up research, the system can be further optimized and upgraded, the multi-scenario adaptation ability of the system can be improved, and the application scope of the system in different disciplines and different learning stages can be expanded. The integration of generative artificial intelligence technology can be strengthened to further improve the interactive intelligence and personalized tutoring accuracy of the system, so as to better serve the high-quality development of smart education.

References

- [1] Liu L. Design and implementation of Python programming intelligent tutoring system based on artificial intelligence[J]. Information and Computer, 2025(11):127-129.
- [2] Zeng H, Liu W J. Design and implementation of personalized intelligent tutoring system based on artificial intelligence[J]. Intelligent IoT Technology, 2025, 57(3):103-106.

- [3] Chen L L. Analysis on the application of artificial intelligence in senior high school chemistry teaching[J]. Chinese Loose-Leaf Selections (Senior High School Edition), 2025(12):226-228.
- [4] Yu D D. Two-way effect of artificial intelligence technology on psychological development of primary and secondary school students: cognitive gain and risk regulation[J]. Psychological Monthly, 2025(22):222-224.
- [5] Sun Y F, Qi M L. Brief analysis on the application of intelligent tutoring system in teaching and education[J]. Technology Wind, 2013(17):1.
- [6] Sha L, Luo S D. Research on general characteristics and CALE structure of intelligent tutoring system[C]//Symposium on Intelligent Robotics of Chinese Association for Artificial Intelligence. 1998.
- [7] Zhu H Y, Chen C X, Wang Y K, Huang J F, Chen K. Feasibility analysis and user demand research of college students' online academic tutoring system under artificial intelligence background[J]. Computer Fans, 2023(24):145-147.
- [8] Mao J J, Li C F, Zhu H Y, et al. Design of student psychological state early warning system based on data mining and intelligent algorithm[J]. Electronic Design Engineering, 2020, 28(15):5.
- [9] Liu B L. Research on the construction of intelligent teaching system based on artificial intelligence—taking secondary vocational Database Principles course as an example[J]. Education Innovation and Practice, 2025, 05(01).
- [10] Yao Y J, Xu X J. AI + knowledge graph empowers the new ecology of intelligent curriculum teaching—taking Experimental Psychology as an example[J]. Education Progress, 2026, 16(4):10.
- [11] Xu S, Tong J R, Hu X E. Next-generation personalized learning: generative artificial intelligence enhanced intelligent tutoring system[J]. Open Education Research, 2024, 30(2):13-22.
- [12] Hua J S. Reconstruction path and practical analysis of county primary school mathematics experimental teaching empowered by AI[J]. Anhui Education Research, 2025(35):14-16.
- [13] Gao L, Wang J H, Dai S P, et al. Design and implementation of intelligent voice tutoring system for university three-dimensional virtual laboratory[J]. Digital Technology and Application, 2017(10):2.
- [14] He S L. Design and development of mixed teaching mode of Computer Application Foundation based on artificial intelligence technology[J]. Mobile Information, 2025, 47(9):148-150.
- [15] Chen J Z. Research on design strategy of C language programming experimental teaching system with artificial intelligence technology[J]. Information and Computer, 2024, 36(7):46-48.
- [16] Peng C Y. Research on secondary vocational UI design teaching mode assisted by artificial intelligence[J]. Information and Computer, 2025(17):248-250.
- [17] Zhang X L, Hu G W, Zhao K. Design and implementation of algebraic proof in intelligent tutoring expert system[J]. Computer Engineering and Applications, 2005, 41(24):103-104,120.
- [18] Cong C Y, Liu J X. Design and development of C Programming Language intelligent tutoring system prototype[J]. Computer Era, 2004(08):33-34.
- [19] Feng X P. Design and research of university computer professional teaching auxiliary system based on artificial intelligence[J]. Information and Computer, 2024, 36(9):55-57.
- [20] Kang W M. Research on computer grade examination tutoring teaching system based on artificial intelligence technology[J]. China Science and Technology Overview, 2012(23):1.