

Another "invisible teacher" in the classroom - the new educational ecosystem under personalized learning and human-machine collaboration

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Abstract

Along with the rapid development of information technology, educational field has experienced unprecedented changes. As an important part of education informatization, personalized learning and human-computer cooperative teaching system have become the key force of education innovation. In this paper, we discuss the overall framework, design and application of AI based personalized learning and human-computer collaborative teaching system. An innovative teaching model is put forward in order to optimize educational resources distribution by means of IT. The system is able to enhance students' learning outcomes and teaching efficiency significantly, providing powerful support for the modernization of education. As technology advances and educational concepts are being updated in the future, personalized learning and human-machine collaborative learning systems will play an important role in wider educational settings.

Key words

AI+ Education Personalized learning Human-machine collaboration Teaching

1. Introduction

The rapid development of Information Technology brings unprecedented opportunities and challenges in today's digital era. Traditional teaching methods have shown their limitations to meet students' diversified needs and personalized development, while personalized learning system based on IT provides a new way to

solve these problems. Personalized learning emphasizes the provision of content and learning paths tailored to students' learning progress, interests, and learning styles. On the other hand, HCAI integrates advanced AI and big data technology in teaching so that teachers can cooperate effectively with intelligent systems in order to improve teaching quality and efficiency^[1]. Recently, as AI technology is becoming more mature and education informatization is becoming more and more popular in education field. In this paper, there are three aspects: system framework, each level design, main function application. This paper aims at providing beneficial reference and inspiration for educators and researchers, as well as promoting the development and application of personalized learning and human-computer collaborative teaching systems.

2.The current development trend of information-based education - the original intention of developing this system

2.1 The Global Wave of Educational Informatization and Technology-driven

In the world, education informatization is becoming the inevitable trend of education reform. These trends are driven by technological progress as well as the strategic choice of education adapting to social change and meeting the needs of talents in the future. With Internet, Big Data, Artificial Intelligence and other new technologies developing rapidly^[2], the education field has experienced unprecedented profound changes. These technologies transform not only educational resources and teaching methods, but also transform teaching patterns and learning experiences. For example, AI technology provides personalized learning path design, and big data technology can accurately analyze students' learning behaviors and needs, providing tailor-made learning plans for each student. Such technology-driven educational transformation prompts educators to rethink education's nature and goal, and explore how to cultivate students' innovative and practical abilities in digital age.

2.2 The Rise and Demand of Personalized Learning

Under educational informatization background, personalized learning has become an important direction in education reform as a student-centered teaching concept. Traditional educational models often adopt "one size fits all" approach, which can not satisfy the students' diverse learning needs and individual differences. However, along with the growing demand of innovative talents, education should attach great importance to cultivating students' individualized development and autonomous learning ability^[3]. Personalized learning focuses on providing customized learning content and teaching strategies according to students' learning progress, interests, interests and learning styles. The model enhances students' learning achievement and interest as well as stimulate students' creativity and critical thinking. As a result, it is important to develop a system to support individualized learning..

2.3 The Potential and Challenges of Human-Machine Collaborative Teaching

As one kind of teaching mode integrating AI and teacher's professional capability, Human-machine Collaborative Teaching is showing great potential. The intelligent system not only accepts some teaching tasks such as automatically grading homework and providing learning advice, but also provides real-time feedback and data analysis for teachers. However, HMI is facing many challenges such as how to make sure its teaching suggestion is consistent with teacher's teaching concept, how to keep teacher's leading role in human-machine collaboration, and how to deal with technology and education. To solve these problems, educators, technology developers and policy makers need to work together on a human-machine collaborative approach which fully uses technology advantages while preserving the essence of education^[4].

2.4 The practical significance and long-term goals of developing this system

Based on the developing trend and challenge of information technology in education, our research team aims at developing personalized learning system based on IT. This system is aimed at satisfying the demand of personalized learning and human-computer collaborative teaching in current educational field. Through the integration of AI, Big Data, Cloud Computing and other advanced information technologies, a highly efficient, intelligent and personalized teaching platform is provided. At the level of practice, it helps teachers to better manage teaching activities, improve teaching efficiency and quality^[5]. At the same time, students will be provided with personalized learning paths and rich learning resources so as to stimulate students' interest in learning and autonomous learning. In the long term, it is hoped that its application will promote innovation and change of education models and provide powerful support for training talents with high quality.

3. Design of Personalized Learning and human-machine collaborative Systems Based on AI+ Education

3.1 Overall System Design

In order to construct personalized learning system based on AI technology, we adopt Integrated Development Environment (IDE) and Java and Python programming language. Relational database MySQL is used in the database and non-relational database MongoDB. This system widely applies artificial intelligence (AI) and big data technologies to assist teaching. For instance, we can analyze students' learning behavior and academic performance data to create personalized learning paths and teaching content recommendations. By means of deep learning models, this system is able to identify students' learning patterns and preferences in order to provide more precise learning advice^[6]. Using big data technology, massive amounts of data are processed and analyzed, including students' study records and teachers' teaching activities. The system is able to extract valuable information through data mining and

analysis in order to support teacher's teaching decision-making and optimize the algorithm to generate personalized learning path. In addition, the system provides an interactive platform of human-computer interaction with the intelligent teaching system. On the platform, teachers can plan and carry out teaching activities with intelligent tools. At the same time, the intelligent system is capable of providing real time teaching advice and assistance based on teaching goal and student feedback. The model can make full use of teachers' professional advantages and improve teaching efficiency with high efficiency and precision. Moreover, HMI has strong online collaboration features, which supports resource sharing and exchange of experience among teachers^[7].

3.2 Design at all levels of the system

3.2.1 Data Layer Design

The data layer is the base of the whole system in personalized learning and human-computer cooperative teaching system. Whether its design is reasonable or not relates directly to system running stability and data processing efficiency. Data layer is mainly responsible for the storage and management of student learning data, teaching data of teachers as well as various kinds of information produced in operation. In order to guarantee data integrity and security, data layer adopts distributed database structure, which combines the merits of relational database and non-relational database^[8]. A relational database is used for storing structured data, for example, students' basic information, course scores and teaching plans. These data are clearly structured and related. Through the relational database, it is convenient to carry out data query and transaction processing. A non-relational database is used for storing unstructured data such as student assignment file, classroom interaction record and learning behavior log. These data are more flexible and scalable, so they are more suitable for processing large quantities of complicated data. Data encryption technology has been adopted to protect students' and teachers' privacy during data storage. At the same time, in order to deal with data loss or damage risk, a comprehensive backup and recovery mechanism was designed in the data layer. Periodically backing up data, which can be quickly restored if necessary to ensure that system functions normally^[9].

3.2.2 Logic Layer Design

Logic layer plays a key role in data processing, business logic realization, and personalized learning path generation. In logic layer design, OOP is used to divide system functions into multiple independent modules, each responsible for specific business logic. For example, the personalized learning module analyzes students' learning data, using machine learning algorithms and data mining techniques to create personalized learning paths and teaching content recommendations^[10]. In this module, students' learning progress, knowledge mastery and learning style preferences need to be taken into account in a complex algorithm model in order to achieve an accurate personalized learning plan. Collaborative teaching module takes charge of interaction logic between teacher and intelligent system to implement teaching activity plan, implement and monitor. The module helps teachers to better manage classrooms,

evaluate students' learning outcomes, and adjust teaching strategies based on real-time feedback. Take teaching assistance for example^[11]. By use of Python programming, the student learning data set includes the characteristics of the students and their grades. Data set format: [Learning Time, Test Results, Homework Completion Rate, Learning Style]. By big data analysis technology, students' academic performance can be predicted, and teachers can be provided with teaching advice. The program code is as follows:

```
import numpy as np
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
students_data = np.array([
    [5, 90, 85]
    [3, 80, 70]
    [7, 95, 90]
    [2, 70, 60]
    [6, 92, 88]
    [4, 85, 75]
    [8, 98, 92]
    [1, 60, 50]
    [5, 88, 80]
    [6, 90, 85]
])
suggestions = generate_teaching_suggestions(model, X_test, y_test)
for suggestion in suggestions:
    print(suggestion)
```

At the same time, the logic layer is designed to optimize algorithm and improve performance. Through efficient algorithm design and code optimization, the system is able to handle large data and complicated business logic quickly and stably. Furthermore, a high efficient data interaction interface between data layer and application layer has been established in logic layer to ensure smooth data flow among layers^[12].

3.2.4 Storage Layer Design

Application layer is an interface for direct interaction between system and user. Its user experience and promotion effect are directly affected by its friendly and user-friendly design. Application layer provides different user interfaces for students, teachers and system administrators^[13]. Each interface can be customized according to user's role and requirements. For students, the Application Layer provides a intuitive learning interface that includes course learning, assignment submission, on-line testing, and learning progress tracking. These functions can guide students to complete learning tasks easily through simple and clear interface design and operation process, and provide real-time feedback on learning outcomes. UI places great emphasis on teaching management functions, such as curriculum management, resource upload, students' study situation analysis, and online teaching interaction. It

is convenient for teachers to plan and carry out teaching activities and adjust teaching strategies according to students' study data^[14]. System administrator interface provides advanced functions such as system configuration, user management, data backup and recovery. Application layer design also emphasizes to optimize user experience. Through user interface friendly design, simplified operation process, variety of interaction methods to improve user satisfaction. At the same time, an application layer supports access from a variety of terminal devices including a computer, a tablet computer or a mobile phone, so that users can learn and learn at any time at any time^[15].

3.3 Security Layer Design

The storage layer plays an important role in personalized learning and human-computer cooperative teaching system. Its rationality and efficiency directly affect the performance, reliability and scalability of system. The storage layer takes charge of the management and maintenance of large quantities of data generated during system operation, including students' study records, teachers' teaching materials, system configuration information, and all kinds of temporary data. Considering the variety of data types and usage requirements, it adopts hierarchical storage strategy that integrates multiple storage technologies in order to ensure efficient data storage, fast access, and secure protection. According to structure degree, access frequency and importance of data, different storage media and technology are used respectively. For structured data such as students' basic information, course grades and learning progress, RDBMS is used to organize and store them in form. A relational database has powerful data integrity constraints, transaction processing capabilities, and a mature Query Language (SQL) to efficiently support complex data operations and query requirements. For example, by using relational databases, it is easy to analyze students' academic performance, ranking calculation, and query operations under multiple conditions.

For non-structured data such as instructional videos, courseware, assignment files, and students' learning behavior logs, this system adopts NoSQL and Distributed File System (DFS). Unstructured data is typically characterized by large volumes and various formats, which makes it difficult for efficient storage in conventional relational databases. With its flexible data model, high scalability and high performance, NoSQL database is suitable for such data storage. As a popular NoSQL database, for example, MongoDB supports document storage mode. It is convenient to store and retrieve the metadata of teaching resources and student's learning behavior. On the other hand, we use distributed file system to store large-capacity multimedia files such as instructional videos and courseware. A distributed file system can enhance storage capacity scalability, improve data reliability and access speed by distributing files between nodes. The Hadoop Distributed File System (HDFS), for example, ensures high data availability through multiple replica storage mechanisms for data blocks in unexpected situations like hardware failure. At the same time, its highly efficient parallel I/O capability can satisfy the requirement of fast accessing multimedia resources.

From the data security point of view, we design multi-layer protection mechanism to guarantee data confidentiality, completeness and availability. First of all, the system uses encryption technology to encrypt sensitive information during data storage. As to the sensitive data such as the student's personal information and grade, the encryption algorithm is used to encrypt the data, which can only be decrypted by authorized users. Moreover, the system strictly restricts access rights of data through access control mechanism so as to make sure that only authorized users and applications have access to relevant data resources. At the same time, in order to prevent data loss and damage, the system implemented regular data backup policy. The backup strategy includes both full backup and incremental backup. Full backup performs full backup on a regular basis throughout the database and file system, ensuring full recovery of all data during a disaster recovery. Incremental backup will backup newly added or modified data between two full backups in order to increase backup efficiency and reduce storage space usage. Backup data is stored on remote backup servers to avoid losing data if local data centers go down. Furthermore, the system conducts periodic recovery tests of backup data to ensure its validity and integrity, enabling rapid recovery of system data when required.

Optimization of storage performance: In order to improve storage layer performance, many optimization measures have been taken. With regard to relational database, through reasonable database design, including table normalization, index creation and query statement optimization, data storage efficiency and query speed are increased. For example, creating an index for a frequently queried field can significantly speed up a query's response time. At the same time, database caching technology is adopted to cache frequently accessed data into memory, which further improves the speed of data reading. For distributed file system, through optimizing data block size, copy number, layout of storage nodes, etc., the storage performance is improved greatly. For example, adjusting block size according to actual application requirements can strike a balance between storage space utilization and access speed. The reasonable number of replica can ensure data reliability and avoid unnecessary waste of memory space. Furthermore, load balancing technology is used to allocate data access requests rationally among different storage nodes in order to avoid overload of individual nodes and enhance concurrent processing capability and stability.

As far as data scalability is concerned, data volume will continue to increase as education informatization progresses and system users increase. Therefore, it is essential to design scalable storage layer. Distributed storage technology is used in the system's storage structure. The architecture could easily expand the storage capacity and improve the performance of the system through the addition of storage nodes. Both Relational and Distributed File System support horizontal scaling, i. e., adding more servers to increase storage capacity and computing power. For example, in a relational database, data could be distributed across multiple database instances using database sharding technology, with each instance running on different servers, thus achieving linear expansion of storage and computing capabilities. In distributed file system, adding storage nodes and allocating data blocks reasonably can easily deal

with increasing data volume. Additionally, the system reserves interface for cloud storage services. Some data can be transferred to cloud storage platform when local storage resource is not enough, which makes storage resources more flexible and scalable. Such a scalable design enables the storage layer to adapt to the rapid growth of education data and ensure long-term stability.

To sum up, the system's storage layer design takes into account classified data storage, security protection, performance optimization and scalability. Through the adoption of multiple storage technologies and strategies, a highly efficient, secure, and reliable storage structure is built. The structure meets the requirement of data storage and management in current system, and provides solid base and wide space for future development.

3.4 Security Layer Design

Data security and privacy protection are indispensable to the design of system in today's digital era. Security layer design aims at providing comprehensive security protection to students and teachers' data from leaking, tampering or abuse. Security layer adopts multiple layers of security protection measures including network firewall, intrusion detection system, data encryption technique and user identity authentication. A network firewall and an intrusion detection system have been set up on network boundary for real-time monitoring of network traffic so as to guard against malicious attacks and illegal intrusion. Data encryption technology is used in data storage and transfer process, encryption sensitive information is used to ensure data safety in storage and transfer. In order to prevent unauthorized access, User Identity Authentication Mechanism strictly verifies user identity by user username, password, SMS authentication code. Additionally, Security Layer conducts regular security audits and security scans to promptly identify and correct security vulnerabilities in the system, ensuring its security and stability. Through these multi-level security measures, the security layer builds a solid security line for personalized learning and human-machine collaborative teaching system.

4. Application of the main functions of the system

4.1 Intelligent teaching assistance and human-machine collaborative teaching

One of the key innovations in this system is intelligent teaching assistant and human-machine cooperative teaching. The goal is to achieve an efficient and intelligent teaching process through the integration of AI technology and teachers' professional teaching skills. The intelligent system provides rich teaching tools and assistant functions such as intelligent teaching assistant, classroom interaction tool, real-time learning analysis dashboard etc. Intelligent teaching assistant is able to recommend appropriate teaching resources and methods based on syllabus and curriculum objectives in order to quickly design high quality teaching plans. Classroom interaction tools help teachers to conduct diverse teaching activities such

as online voting, group discussion, real-time Q&A etc. The real-time learning analysis dashboard provides teachers with real-time feedback on students' learning situations, including learning progress, learning points, and learning behaviors. Moreover, the intelligent system provides individual teaching advice according to student's study data so that teachers pay more attention to each student's learning needs so as to realize teaching in accordance with individual aptitude. This model takes full advantage of teachers' professional advantages and makes full use of intelligent system's high efficiency and high efficiency in teaching.

4.2. Personalized Learning Paths Generation and Optimization

In information technology based personalized learning and human-computer collaborative teaching system, personalized learning path generation and optimization is key to realize personalized teaching. By analyzing the students' study data in depth, such as learning progress, knowledge mastery, learning style preference, learning motivation, etc., Python programming, advanced machine learning algorithms and data mining technologies are used to tailor each student's learning path. The program code is as follows:

```
import numpy as np
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler
students_data = np.array([
    [5, 85, 90, 1]
    [3, 70, 80, 2]
    [7, 90, 95, 1]
    [2, 60, 70, 3]
    [6, 88, 92, 1]
    [4, 75, 85, 2]
    [8, 92, 98, 1]
    [1, 50, 60, 3]
    [5, 80, 88, 2]
    [6, 85, 90, 1]
])
student_id = 0
learning_path = generate_personalized_learning_path(student_id, student_clusters,
students_data)
```

Not only does it cover knowledge points and skills, but it also dynamically adjusts learning content according to students' learning progress. For example, if students perform well at certain points of knowledge, the system will automatically skip the basic content and move directly to higher learning modules. For students with difficulty in one area, the system provides more supplementary materials and practice questions so that students can gradually grasp the knowledge. Moreover, the system is able to optimize learning path according to students' learning feedback and evaluation results so as to make sure that learning path is scientific and effective. It not only

enhances students' learning efficiency and efficiency, but also stimulates students' interest in learning and autonomous learning.

4.3 Evaluation and feedback in real time

Real-time learning evaluation and feedback function is an important guarantee to guarantee personalized learning results. The function assesses students' learning performance comprehensively and objectively using various assessment methods, including online tests, homework corrections, and classroom performance assessments. Intelligent Assessment Engine is designed to automatically grade standardized test questions and generate detailed analysis reports in response to students' questions. These reports cover students' scores as well as analyze the students' mastery of knowledge, pointing out their strengths and weaknesses. For non-standardized assignments and projects, the system provides online comments and suggestions for teachers. Furthermore, it provides real-time learning feedback based on assessment results, including reminders about learning progress, improving knowledge points, and adjusting learning strategies. The timely and accurate feedback mechanism helps students to understand their learning situation better by adjusting their learning methods and plans so as to achieve better learning objectives. At the same time, teachers are able to get a better understanding of the overall learning situation through assessment results so as to adjust teaching progress and content in order to make sure that teaching is effective and targeted.

4.4. Sharing and Teaching Resource Management

Management and sharing of teaching resources plays a very important role in supporting personalized learning and human-computer collaboration. The function provides rich teaching resources for teachers and students, including electronic textbooks, videos, courseware, exercises and case analysis. Intelligent resource management system is designed in this system. It can automatically classify and organize teaching resources according to teaching outline and objectives so as to make it easier for teachers and students to find and use them quickly. According to teaching plan, teachers could select appropriate teaching resources, integrate them into teaching activities. At the same time, teachers can upload their own teaching resources so as to enrich their resources library. In order to promote resource sharing and exchange experiences among teachers, the system provides online resource sharing platform for teachers to share teaching resources and experience. The resource sharing mechanism can enhance the utilization ratio of teaching resources, promote teachers' professional growth and innovation in teaching methods. Moreover, the system is able to recommend personalized learning resources according to students' learning styles and needs in order to improve students' performance.

4.5 Compatibility Design and System Scalability

With the rapid development of educational informatization, its scalability and compatibility is key to ensure its long-term stability and continuous optimization. During the design process, the system took full account of future technology

developments and educational requirements. Its modular architecture and open standards guarantee easy expansion and upgrade of functions of the system. Modular structure makes each function module relatively independent. When it is necessary to add a new function or optimize an existing function, it is possible to develop and test these modules independently without affecting others in the system. The design not only improves the system development efficiency, but also reduces maintenance cost. Furthermore, the system follows internationally accepted open standards and protocols such as HTML5, CSS3, JavaScript, etc., ensuring stable operation on various operating systems and browsers, and supporting multiple terminal devices such as PC, tablet, mobile phone etc. The excellent compatibility makes the system adapt to different users' usage habits and equipment conditions. It provides powerful guarantee for wide application. At the same time, the system reserves interfaces to external systems such as MIS and Online Learning Platform so as to make it more convenient to integrate IT system with other IT systems so as to achieve sharing and collaborative work on education resources.

5. System application case analysis

5.1 Case Summary

In order to test the application effect of information technology based personalized learning and human-computer collaborative teaching system (hereinafter referred to as "teaching system"), two parallel classes were selected for study. These two classes do not differ significantly on basic knowledge level, learning ability and teaching progress. Therefore, there is a high degree of comparability. One class has been designated as observation group, which has been used in teaching activities. Another class served as a control group, using traditional teaching methods. The aim of this study period is to evaluate the effectiveness of teaching system through comparing students' learning results.

5.2 Application Methods

The control group adopted traditional teaching methods: teachers taught in accordance with unified teaching outline and teaching plan, students studied according to teacher's arrangement. In the process of teaching, teachers evaluate students' learning outcomes through class lectures, homework assignments and periodic tests. The teaching model emphasizes on knowledge transfer and passive acceptance among students, but not on individual differences among students and design personalized learning paths.

Compared with those in observation group, this teaching system was fully used. At the start of each semester, teachers create a personal study profile for each student, recording basic information, learning style and initial level of knowledge. Based on these data, the system creates personalized learning paths for each student and recommends appropriate learning resources. In teaching process, teachers make use of

intelligent teaching assistance function to monitor students' learning progress and learning outcomes, and adjust teaching strategies based on feedback. For example, students with learning difficulties at one point may be offered additional tutoring and practice through personalized learning advice provided by the system. Meanwhile, students will be able to choose what they want to learn on their own, self-evaluate themselves, and track their progress through online learning platforms. The model fully embodies individual learning characteristics and human-machine collaborative teaching to better satisfy students' individual needs and improve their learning outcome.

5.3 Results

After one semester's teaching practice, we found that the learning effect of observation group was better than that of control group. To be more specific, students from observation group scored 10 points higher than control group, 15 percent higher pass rate, 20 percent higher than excellent scores, as shown below. These data indicate that application of this system can improve students' academic achievement and improve their learning progress. Moreover, students from observation group showed higher enthusiasm on learning interest and motivation, and improved students' ability to participate in class and study independently. These non-quantitative indicators further demonstrate that teaching system plays an important role in promoting students' comprehensive development.

Table 1. Academic Performance of the Two Groups of Students

Evaluation index	Control group (traditional teaching)	Observation group (teaching system),	difference (Observation group - Control group)
Average score (points)	75	85	10
Pass rate (%)	70	85	15
Excellent rate (%)	20	40	20

6. Conclusion

Personalized learning based on IT and its application provide a new idea and method for modern education. Through system framework design and function implementation, the system is able to satisfy students' personalized learning need effectively, enhance teachers' teaching efficiency, and improve education quality. However, we should clearly realize that research and application in this area is still being developed and perfected. As artificial intelligence, big data, cloud computing, and other technologies are further developed, and educational concepts are constantly being updated. Personalized learning and human-computer collaborative learning systems will play an even more important role in educational settings. We expect that through continuous research and practice research, we will continuously improve the

function of system and optimize teaching model in order to make great contributions for educational modernization and training of high quality talents..

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