Research on Big Data-driven Personalized Teaching Models in Higher Education

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Abstract: Personalized teaching mode has become an important direction of education reform as an effective way to enhance students' learning effect and interest. This study aims to explore how to support personalized teaching through big data technology to enhance students' independent learning ability and learning interest. Through the analysis and mining of students' learning data, combined with the intelligent learning system, the study demonstrates how to customize learning paths and teaching resources according to students' individual needs. The study shows that personalized teaching based on big data can effectively improve the teaching effect and promote the personalization and autonomy of students' learning. The study conclusions show that the big data-driven personalized teaching model provides new ideas and solutions for the future development of higher education.

Keywords: Personalized Instruction; Learning Resources; Big Data; Teacher Competence

1. Introduction

Currently, higher education faces the challenge of students' insufficient initiative, particularly in the context of the information technology environment. Despite the widespread adoption of technology-driven educational models, traditional teaching methods continue to influence students' learning attitudes. Many educators still adhere to conventional approaches, lacking effective interaction and assessment mechanisms, which results in low student engagement and participation. Teachers also face the dual pressures of rapidly evolving knowledge and students' employment prospects, making it difficult to strike a balance between knowledge delivery and effective student supervision, which impacts teaching quality. [1,2] On the other hand, the application of information technology in teaching has its limitations, as many educators are insufficiently trained in its use, and the development of teaching resources remains inadequate. While multimedia courseware is widely used in most universities, an over-reliance on technology at the expense of teaching skills can reduce students' learning efficiency. Information technology offers new opportunities and methods for learning, extending beyond the classroom and enriching educational resources. [3] However, achieving personalized teaching requires a thoughtful integration of technology with traditional pedagogies to innovate educational models. The rapid development of information technology and big data presents a promising solution to current educational challenges, enabling personalized learning tailored to students' individual needs while enhancing engagement and improving outcomes. The key to success lies in effectively analyzing teaching resources, student behavior data, and learning feedback to identify patterns that inform teaching strategies. By mining these data deeply, higher education institutions can develop evidence-based strategies to enhance learning outcomes, improve graduation and employment rates, and strengthen institutional competitiveness. This process demands not only advanced technology but also an innovative approach to education that aims to comprehensively elevate the quality of teaching. This study explores personalized teaching models based on big data, focusing on individual learning needs, fostering independent learning skills, and enriching personalized education in higher learning institutions.

2. Big Data and Personalized Teaching

Big data refers to vast, diverse, and complex datasets that not only include traditional

structured data but also encompass large volumes of unstructured and semi-structured information, such as text, images, and videos. With the rapid advancement of information technology, particularly the widespread adoption of the Internet, the Internet of Things (IoT), and sensor technologies, the scale and sources of big data have expanded significantly, permeating various industries and sectors. Through the use of efficient software tools and analytical platforms, this massive volume of data can be effectively integrated, stored, and processed, providing a solid foundation and data-driven insights for decision-making. [4] Big data is not merely an accumulation of information; it transforms into valuable insights by uncovering patterns, trends, and relationships hidden within. The technology behind big data processing relies on modern electronic information systems that aggregate, clean, analyze, and share data from diverse sources through cloud computing, distributed storage, and efficient computational models. This process not only uncovers new business opportunities and enhances management efficiency but also helps organizations forecast future trends and optimize decision-making. By integrating and sharing big data, organizations can access more precise intellectual resources and knowledge services, fostering innovation and sustainable development. The application of big data is particularly transformative in fields such as education, healthcare, finance, and intelligent manufacturing, where it is reshaping traditional operational and service models. In summary, the widespread use of big data provides unprecedented insights for various industries, driving both social progress and economic development.

The personalized teaching model is an instructional approach developed based on the recognition of individual differences among students, with the primary goal of fostering their holistic development while respecting their unique needs. This model seeks to achieve shared educational objectives through a variety of methods and strategies, while also considering the individual characteristics and developmental requirements of each student. At its core, personalized teaching emphasizes the importance of understanding and accommodating students' interests, abilities, backgrounds, and learning styles throughout the teaching and learning process. It aims to provide each student with the most appropriate learning environment and methods, thereby optimizing educational outcomes. Additionally, the personalized teaching model advocates for the use of diverse teaching methods within a unified framework of educational goals to address the varied needs of students. Such diversity in instructional approaches not only serves to enhance students' motivation but also enables them to identify their strengths and potential across different learning contexts. For instance, in individualized instruction, teachers can offer tailored support based on students' specific characteristics, helping them overcome learning challenges. In group settings, collaborative teaching encourages the development of communication skills and teamwork, allowing students to benefit from cooperation and mutual interaction. By integrating these various strategies, the personalized teaching model fosters a more dynamic and inclusive learning environment. [5,6]

The application of big data technology in education is advancing rapidly and has had a significant global impact. As educational needs diversify and the degree of informatization increases, personalized teaching methods based on big data are emerging as a crucial aspect of educational reform. The use of big data in personalized education primarily involves the monitoring and analysis of students' learning behaviors. By collecting data generated during the learning process—such as study time, progress, knowledge mastery, and interaction feedback—educators can gain a comprehensive understanding of individual learning characteristics and needs. This data enables the development of personalized learning pathways, allowing students to learn at their own pace. The educational system can adapt the content and delivery methods based on data analysis results, ensuring that each student experiences a tailored learning environment. For instance, Intelligent Learning Systems can automatically recommend appropriate learning resources or adjust difficulty levels according to real-time student performance, aligning the learning process more closely with individual needs. Furthermore, establishing a teaching feedback mechanism represents another key application of big data in education. By continuously

collecting and analyzing student learning data, teachers can receive immediate insights into students' progress, enabling them to make dynamic adjustments to instructional content and methods. This data-driven feedback mechanism enhances the flexibility and precision of teaching, providing personalized educational services that address the specific requirements of diverse learners. [7-9] Figure 1 shows the relationship between big data and personalized teaching mode.

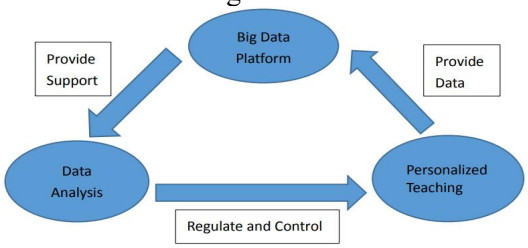

Figure 1. Relationship between Big Data and Personalized Teaching Mode

3. Design of Personalized Teaching Mode Based on Big Data

3.1 Big Data Support for Personalized Education

By collecting and analyzing learners' behavioral data, and integrating data mining, learning analytics, and learning acquisition technologies, big data can provide real-time feedback and accurate predictions across various aspects of the educational process. This not only optimizes traditional teaching methods but also fosters the innovation of personalized teaching models. In contrast to the traditional teaching approach, which often relies on instructors' intuition and experience, the big data-driven personalized teaching model is founded on data-informed decision-making. Teachers can continuously monitor students' learning progress, assess the depth of their understanding, and identify challenges they face, enabling dynamic adjustments to teaching content and strategies. [10]

The application of big data enhances learning activities such as pre-class preparation, in-class instruction, and post-class consolidation, while also supporting the adoption of new teaching models, such as independent learning and blended learning. In this data-supported personalized approach, learners take a more active role in their education. Scientific analysis and insights into learning behaviors significantly improve students' learning outcomes. Personalized teaching emphasizes adapting to the diverse needs of students. With big data, various types of student data, including quiz results, assignments, and test scores, are systematically recorded. Based on students' mastery of knowledge, the system can recommend tailored learning resources, such as targeted practice questions, supplementary textbooks, and videos, allowing students to address specific knowledge gaps more effectively.

Evaluation and learning alerts are key components of personalized teaching. By focusing on students' mastery of content, cognitive skills, and emotional engagement, teachers can assess students from a holistic perspective. Unlike traditional teaching, which often prioritizes final outcomes, data-driven evaluations provide detailed insights into every stage of the learning process, enabling true monitoring and feedback on each student's personalized learning journey. Additionally, when students' performance in a specific learning module or task does not meet predetermined standards, the system can automatically trigger an early warning, prompting teachers to intervene with personalized support. By tracking and analyzing the learning process, teachers can adjust their teaching strategies more effectively, correct learning deviations in real-time, and ensure continuous improvement in learning quality.

3.2 Personalized Educational Design Requirements Based on Big Data

The design of personalized teaching based on big data should begin with the comprehensive digitization of the teaching process, including the continuous recording of teaching activities, the labeled management of teaching resources, and the multi-dimensional analysis of learning data. This approach ensures the thorough collection and precise analysis of data, enabling the precision and personalization of instruction.

To effectively implement big data-driven personalized teaching, the design process must adhere to several fundamental principles. First, the teaching process should be fully digitized. Data from all stakeholders—teachers, students, education administrators, and even parents—should be collected in real time through digital means. Comprehensive data recording lays the

foundation for subsequent personalized teaching, enabling accurate monitoring of the teaching process and providing effective support for students' personalized development. The digitization of the teaching process involves not only the quantitative collection of data but also the detailed documentation of the entire instructional process in a timely manner. This necessitates that the instructional design encompasses all aspects of teaching activities, such as lesson planning, classroom interactions, homework assessment, and test evaluations, as well as the digital management of teaching resources, software, and hardware.

The core of personalized teaching lies in the precise analysis of students' individual learning characteristics. Therefore, the digitization of the teaching process should not be confined to isolated stages but must extend across the entire educational activity. Labeling teaching resources and conducting multi-dimensional analysis of learning data are essential tools for realizing personalized teaching. In a big data environment, all teaching resources—such as test questions, course materials, and teaching programs—should be labeled according to the subject knowledge system. This labeling ensures that each resource can be accurately aligned with a specific knowledge point, facilitating targeted teaching by educators. Concurrently, the learning data collected should be categorized at various levels, including joint examination data, school-level data, classroom learning data, and individual student data. This structured data enables teachers to analyze student performance from both macro and micro perspectives, gaining insights into students' mastery of different knowledge points, promptly identifying learning difficulties, and providing targeted, personalized guidance to enhance teaching effectiveness.

3.3 Personalized Teaching Model Based on Big Data

Big data-driven personalized teaching can accurately pinpoint the relevant knowledge points and chapters associated with various educational resources (e.g., courseware, teaching materials, assignments, test papers, teaching videos) by labeling these resources throughout the teaching process. This labeling approach enables teachers to deliver more targeted resources and guidance, ensuring that the teaching content aligns with each student's individual learning needs. A comprehensive learning data system can be established by systematically collecting data across various stages of the teaching process, including teachers' lesson preparation, students' pre-study activities, classroom teaching, interactive quizzes, after-class homework practice, and test evaluations. These data provide detailed digital records of students' learning progress, offering a holistic view of their performance throughout the learning process. Figure 2 shows the big data-based personalized teaching model system.

Leveraging advanced technologies such as cloud computing, semantic web, and data visualization, the collected learning data can be analyzed and processed to construct dynamic learning models for each student. These models allow for precise, data-driven teaching management and enable personalized support, enhancing the effectiveness of instruction. By analyzing learning data and labeling knowledge points, the system can reveal detailed insights into students' learning behaviors, particularly highlighting differences in their mastery of specific knowledge points. Based on these analyses, the system can automatically recommend personalized learning resources, helping students identify and address their learning gaps, thereby improving both learning efficiency and outcomes. This big data-driven personalized teaching model offers students more flexible and precise learning support, significantly enhancing their academic performance and overall learning experience.

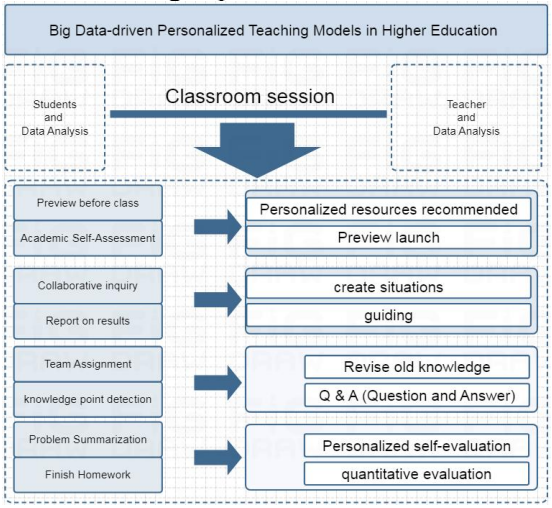

Figure 2. Big Data-Based Personalized Teaching Model System

4. The Realization Path of Personalized Teaching Mode Based on Big Data

4.1 Utilizing Large-Scale Online Courses to Ensure Authentic and Reliable Data

The integration of traditional group instruction with Massive Open Online Courses (MOOCs) holds significant potential for enhancing both teaching quality and student competence. By combining these approaches, teachers can not only effectively monitor and document students' learning activities but also develop personalized course plans based on data analysis. This enables the adaptation of teaching to meet the diverse needs of students, thereby maximizing their overall capabilities.

In Bloom's taxonomy of learning objectives, learning needs are categorized into conceptual, comprehension, and application levels. Within the MOOC environment, students begin by acquiring foundational knowledge and, as their learning progresses, gradually engage with more advanced content and deeper cognitive processing. By categorizing and clustering knowledge at various levels, teachers can employ techniques such as association rule analysis to provide personalized learning paths, thereby enhancing the precision of instruction. Moreover, the interactive nature of the MOOC platform offers students numerous opportunities for engagement, particularly encouraging learners with shared interests to collaborate and interact within learning communities. Through collective discussions and resource sharing, students not only deepen their understanding but also contribute to the evolution and enrichment of knowledge.

To effectively implement this MOOC-based teaching model, a thorough overhaul of the existing course teaching system is necessary. This includes expanding the availability of teaching videos from renowned educators, enhancing the test question bank, and optimizing learning materials, all of which are crucial for systematically recording students' progress and assessing learning outcomes. Such improvements will provide teachers with robust, data-driven insights to support their instructional decisions. The widespread use of domestic mainstream MOOC platforms also facilitates cross-school learning interactions, enabling students from diverse regions and institutions to collaborate on a shared platform. This cross-institutional learning model not only enhances the efficiency of resource sharing but also fosters students' ability to independently construct a cohesive knowledge system. Additionally, collaboration with enterprises—particularly through joint development of curricula that align with real-world applications—offers substantial support for educational innovation. Enterprises can provide case studies and practical examples that ensure course content meets market demands, thereby enhancing the relevance and effectiveness of the teaching. This University-Industry collaboration creates a dynamic ecosystem in which teachers, students, and industry professionals engage in mutual support, driving improvements in educational quality and better preparing students for success in the workplace.

4.2 Cultivating Teachers with Data Analysis Capabilities

In the era of big data, teachers should actively respond to national policies and school requirements, keenly perceive the needs of learners, and continuously enhance their information retrieval capabilities, knowledge reasoning capabilities, and the aggregation ability of specific knowledge. To meet the challenges of this era, teachers not only need to enrich their knowledge reserves, covering ontological knowledge, conditional knowledge, and practical knowledge, especially practical knowledge, but also strengthen their grasp of informationized teaching. The significance of practical knowledge in informationized teaching is particularly prominent, as it helps teachers better understand and apply modern technological tools, combining theory with practice to improve teaching outcomes. Moreover, in the context of informationized teaching, teachers need to continuously improve their data analysis skills, understand and handle educational data, thereby more accurately identifying students' learning needs and behavioral patterns, optimizing teaching strategies, and thus achieving improvements in educational quality.

Higher education should construct teacher communities and actively carry out teacher training, teaching teachers how to extract valuable educational content from complex data environments. In the context of big data, the transformation of the teacher's role is

particularly significant, shifting from a traditional "teacher, preceptor, and problem solver" to a "facilitator of learning and growth. " This transformation requires teachers to not only possess solid subject knowledge but also interdisciplinary thinking and technical application skills, guiding students to utilize various online resources, adopt task-driven methods, and implement innovative teaching models like flipped classrooms. Through this teaching approach, teachers can effectively integrate theoretical knowledge, practical teaching, and workplace education concepts, helping students better prepare for the challenges of the future workplace. With the support of modern technologies like cloud computing, teachers can more efficiently aggregate educational resources, using group collaboration, master teacher teaching videos, and other methods to provide personalized learning experiences for students, laying a solid foundation for the development of a learning-oriented society.

5. Conclusion

This article analyzes the potential of big data-based personalized teaching models and explores the potential of big data in improving the effectiveness of higher education teaching. The study shows that big data technology can help teachers accurately identify students' learning progress and personalized needs, provide real-time feedback and personalized learning paths, thereby improving students' learning effectiveness and interest. However, this study also has some shortcomings, such as insufficient attention to data privacy protection and challenges in the application of data in actual teaching environments. In the future, it is recommended that universities strengthen the data analysis training of teachers, promote the deep integration of education and technology. At the same time, explore more effective personalized teaching strategies to meet the ever-changing educational needs. In addition, future research can focus on the application of big data in other educational fields, further expanding the practical effects and implementation strategies of personalized teaching.

Acknowledgments

We sincerely thank the support and funding from the National Higher Education Institution Computer Foundation Education Research Association Computer Foundation Education Teaching Research Project (2024-AFCEC-313) and the Guangdong Province Higher Education Teaching Management Association Private Colleges Teaching Quality Management Professional Committee Project (GDZLGL2430), both of which are indispensable to this paper.

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