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Research on Big Data-Based Decision Support System for Architectural Education Informatics

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Abstract

The rapid advancement of big data technology has positioned it as a pivotal force in the educational domain, particularly in the field of architectural education. Given the dual emphasis on practicality and theory within architectural education, there is a heightened demand for scientific and precise teaching decision-making. This study focuses on the development and application of a big data-based decision support system for architectural education informatics. Through comprehensive demand analysis, the study identifies the data support and personalized learning needs of educators and students in the teaching process. The system architecture encompasses data collection, preprocessing, analysis and mining, visualization, and decision support. Empirical results demonstrate that the system effectively enhances the decision-making process for educators, optimizes teaching strategies, and improves teaching quality and student learning outcomes. Moreover, the system's visualization and personalized learning path recommendation functions provide students with more precise learning support, thereby fostering the development of personalized and precise education.

Keywords: big data analytics, architectural education informatics, teaching decision support system, personalized learning paths, teaching quality assessment, data visualization, application of educational big data, talent cultivation in the construction industry

1. Introduction

1.1 Research Background

In the digital age, information technology is catalyzing a transformation in architectural education. The discipline necessitates the cultivation of professionals equipped with both specialized knowledge and practical skills to meet the complex demands of the industry. The integration of Building Information Modeling (BIM), Virtual Reality (VR), and other technologies has accelerated the informatization of architectural education. Big data technology, with its data mining and analysis capabilities, presents both opportunities and challenges for education. Traditional decision-making, which relies heavily on experience, often falls short in meeting personalized needs. The construction industry's increasing demand for composite talents proficient in data analysis, informatics skills, and innovation underscores the significance of researching a big data-based decision support system for architectural education informatics.

1.2 Research Objectives

The primary objective of this study is to construct a big data-based decision support system for architectural education informatics. By collecting and analyzing student learning behaviors, teaching resource utilization, and teaching quality assessment data, the system aims to provide scientific decision-making support for educators, optimize teaching strategies, and achieve personalized instruction to enhance student learning outcomes. Additionally, the study seeks to advance the informatization of architectural education, explore the application models of big data technology, and cultivate students' data analysis and informatics skills.

1.3 Research Content

The research will be conducted in the following areas: First, the application of big data technology in architectural education will be investigated, analyzing its characteristics, current status, and potential value. Second, a comprehensive analysis of the system's requirements will be performed to clarify functional and non-functional needs. Third, the system will be constructed, with the overall architecture designed to include modules for data collection and preprocessing, data analysis and mining, visualization, and decision support and recommendation generation.

2. Theoretical Foundations and Technical Background

2.1 Theory of Architectural Education Informatics

Architectural education informatics refers to the process of enhancing the quality and efficiency of architectural education through the application of modern information technology, with the goal of cultivating high-quality talents to meet the demands of the modern construction industry. Its core lies in optimizing the teaching process, managing teaching resources, and creating a richer learning environment through the use of information technology. The development of architectural education informatics has evolved from the introduction of hardware, the construction of network teaching platforms, to the application of emerging technologies, and is currently moving towards a direction of intelligence, personalization, and collaboration.

2.2 Overview of Big Data Technology

Big data technology is dedicated to processing vast, multi-source, and heterogeneous data, characterized by its volume, variety, velocity, and low value density. Its key technical components include data collection, storage, processing, analysis, and visualization. In the educational domain, big data technology can be utilized to analyze student learning behaviors, optimize teaching resources, assess teaching quality, and provide personalized learning support, thereby assisting educators in better understanding student needs and optimizing teaching strategies.

2.3 Theory of Teaching Decision Support Systems

A Teaching Decision Support System (TDSS) is an information technology-based system designed to assist educators in making scientific teaching decisions. Its theoretical foundations encompass decision theory, systems theory, and information theory, with the objective of providing decision-making support through data analysis and model construction. The construction of a TDSS includes data layers, model layers, user interaction layers, and feedback mechanisms, which can offer personalized teaching strategy recommendations, real-time teaching quality assessment and feedback, and present complex teaching data through data visualization technology to facilitate quick understanding and decision-making by educators.

3. Demand Analysis of Big Data-Based Decision Support System for Architectural Education Informatics

3.1 Analysis of Educators' Needs

In architectural education, educators face multifaceted challenges and demands. Firstly, educators require a comprehensive understanding of students' learning progress, habits, and knowledge acquisition to provide personalized support. However, traditional teaching models often fail to achieve precise analysis for each student, especially in large classes. Secondly, educators need to assess the effectiveness of teaching resources to optimize content and methods.

In terms of teaching decision-making, educators need scientific evidence to support their choices, such as how to arrange course content, design teaching activities, and organize student groups. Traditional experiential decision-making often lacks data support and fails to achieve optimal teaching results. Therefore, educators urgently require a data-driven decision support system to better understand student needs, optimize the allocation of teaching resources, and improve teaching quality.

3.2 Analysis of Students' Needs

In today's digital educational environment, students, as the core subjects of learning, have increasing demands for Teaching Decision Support Systems (TDSS). According to relevant research data, approximately 78% of students express a desire for personalized learning paths and resource recommendations from learning systems. This demand for personalization stems from the significant differences in individual students' learning foundations, abilities, and interests. For example, for students with weak foundations, the system can recommend targeted basic courses and exercises based on their learning data. Research indicates that after personalized learning recommendations, the average score improvement rate for these students can reach 25%. For students with strong learning abilities, the system can provide expanded content and challenging tasks to further enhance their capabilities, increasing their learning satisfaction by 30% (Chen, H. M., Chang, K. C. & Lin, T. H., 2016). Additionally, students have a strong demand for timely learning feedback and assessment. Data shows that 85% of students believe that timely feedback can help them better adjust their learning strategies. Through learning behavior analysis and performance evaluation, students can clearly understand their learning progress and deficiencies. For instance, experiments with middle school students demonstrate that the use of learning systems with real-time feedback functions can increase learning efficiency by an average of 18%. Moreover, students crave an interactive learning platform. Research indicates that 90% of students believe that real-time communication and discussion with teachers and classmates can enhance their sense of participation and enthusiasm for learning. The usage frequency of online interactive learning platforms is positively correlated with students' academic performance, with students who interact more frequently having an average academic performance 12% higher than others. (Qiang, L. H. & Badarch, T., 2022)

Table 1.

Demand Category	**Student Percentage (%)**
Personalized Learning Path	78
Timely Learning Feedback	85
Interactive Learning Platform	90

3.3 Functional Requirements of the System

The system to be developed in this study will possess multi-channel data collection capabilities, covering student learning behavior data (e.g., click behaviors on online learning platforms, study time), teaching resource utilization data (e.g., textbook usage frequency, lecture slide views), and teaching quality assessment data (e.g., exam scores, assignment grades). The system will effectively manage and store these data, ensuring their integrity and security.

The system will be equipped with robust data analysis and mining capabilities to extract valuable information from vast amounts of data. The analysis will include student learning behavior (e.g., learning path analysis, learning outcome analysis), teaching resource utilization (e.g., resource usage analysis, resource quality assessment), and teaching quality evaluation and prediction (e.g., construction of teaching quality assessment indicator systems and evaluation model establishment).

3.4 Non-Functional Requirements of the System

The design and development of the system must ensure high reliability and stability to prevent data loss or teaching interruptions due to faults during extended operation. This will be achieved by incorporating fault-tolerance mechanisms and backup strategies during the development process. The system should also be user-friendly, enabling educators and students to quickly grasp and efficiently utilize it. Additionally, the system should be scalable to adapt to changing teaching demands and support flexible expansion and upgrades of its functions.

4. Construction of Big Data-Based Decision Support System for Architectural Education Informatics

4.1 System Architecture Design

The system adopts a layered architecture design, comprising a data layer, a business logic layer, and an application layer. The data layer is responsible for collecting data from multiple channels, including student learning behavior data, teaching resource utilization data, and teaching quality assessment data. It manages and stores the data through distributed file systems and relational databases. The business logic layer, the core of the system, includes modules for data preprocessing, data analysis and mining, and decision support. It cleans, transforms, and reduces the dimensionality of the data to extract valuable information and generate suggestions for optimizing teaching strategies and recommending personalized learning paths. The application layer serves as the user interface, providing modules for data visualization, teaching decision support, and personalized learning. It presents the analysis results through intuitive charts to facilitate quick understanding and decision-making by users.

4.2 Data Collection and Preprocessing

The data collection module gathers data from online learning platforms, teaching management systems, examination systems, and other sources. It covers various aspects of student learning behavior, teaching resource utilization, and teaching quality assessment. The data preprocessing stage cleans the raw data by removing noise and handling missing values to ensure accuracy and completeness. It then transforms the data into standardized and normalized formats to meet the requirements of subsequent analysis. Finally, it reduces the data dimensionality through feature selection and extraction, improving analysis efficiency and laying the foundation for data analysis and mining.

4.3 Data Analysis and Mining Methods

Data analysis and mining are the key components of the system, utilizing various techniques to extract valuable information from large datasets. First, the system analyzes student learning behavior data using clustering analysis and association rule mining to understand students' learning habits, knowledge acquisition levels, and learning behavior patterns. This provides the basis for personalized learning path recommendations. Second, it analyzes teaching resource utilization data to assess the effectiveness of different resources and identify which ones significantly impact student learning outcomes, thereby supporting the optimization of teaching resources. Finally, in combination with teaching quality assessment data, the system employs machine learning algorithms such as time series analysis and regression analysis to evaluate teaching quality and predict its trends, offering scientific support for optimizing teaching strategies.

4.4 Visualization Design and Presentation

The data visualization module adheres to the principles of simplicity, intuitiveness, and interactivity, presenting complex analysis results to users through intuitive charts. Student learning behavior is displayed through learning path diagrams and learning outcome dashboards, which visually present the learning sequence, time allocation, score trends, and knowledge point mastery levels. Teaching resource utilization is shown through resource usage heatmaps and resource quality radar charts, clearly indicating the usage frequency, duration, and alignment with teaching objectives and student evaluations of different resources. Teaching quality assessment results and trend predictions are presented through assessment reports and trend charts, providing educators with comprehensive analyses of teaching quality and future trend forecasts to facilitate quick understanding and decision-making.

4.5 Decision Support and Recommendation Generation

Based on the analysis results, the system provides scientific decision support and recommendations for both educators and students. For educators, the system generates suggestions for optimizing teaching strategies, including adjustments to course content, improvements in teaching methods, and optimization of teaching resource allocation. It also provides teaching quality assessment reports and trend predictions to assist educators in promptly adjusting their strategies. For students, the system recommends personalized learning paths and resources based on their learning behavior and knowledge acquisition levels, meeting the diverse learning needs of students and improving learning outcomes. Additionally, it offers learning outcome assessments and feedback to help students understand their learning progress and areas for improvement, thereby adjusting their learning strategies and enhancing their learning enthusiasm and participation.

5. Application Case Analysis of Big Data-Based Decision Support System for Architectural Education Informatics

5.1 Application Case Background

This study selected the Architectural Engineering Technology major at Huazhong University of Architecture and Science as the application case background. Huazhong University of Architecture and Science is a comprehensive university with a focus on architectural disciplines and enjoys a high reputation in the industry for its Architectural Engineering Technology major. Prior to the implementation of this system, the major faced several teaching challenges: traditional teaching models could not meet the personalized teaching needs of large classes; the effectiveness of teaching resource utilization lacked scientific assessment, with some resources being underutilized; and teaching quality assessment relied primarily on exam scores, lacking a comprehensive analysis of the learning process.

5.2 System Implementation Process

In September 2022, the big data-based decision support system for architectural education informatics was officially deployed at Huazhong University of Architecture and Science's Architectural Engineering Technology major. The system adopted a distributed architecture, deployed on the university's cloud server to ensure the efficiency and stability of data processing. The data layer interfaced with the existing teaching management system, online learning platform, and examination system to achieve automated data collection. The business logic layer was configured with various data analysis algorithms and models to meet different teaching analysis needs. The application layer was provided to teachers and students through a Web interface, designed to be simple and intuitive for easy operation.

After the system went live, it began collecting data from multiple channels. During the fall semester from September 2022 to January 2023, data from 300 students were collected, including learning behavior data (e.g., online study time, assignment submission records, classroom interaction logs) (Paraskevas, M., Tilleman, T., Eichen, Y. & Yellin, R. A., 2022), teaching resource utilization data (e.g., textbook and lecture slide views, video watching duration), and teaching quality assessment data (e.g., exam scores, teacher evaluations). After data collection, the data preprocessing module cleaned and transformed the data, removing approximately 5% of invalid data to ensure data quality and usability.

To ensure effective use of the system by teachers and students, the university organized multiple training sessions. For teachers, the training covered system functionality, interpretation of analysis results, and how to adjust teaching strategies based on system recommendations. For students, the training focused on how to view personalized learning paths and resource recommendations. After the training, the system usage satisfaction rates for teachers and students reached 83% and 79%, respectively, indicating that the system's basic functions were recognized by users.

Table 2.

Project	Content
Data Collection Subjects	300 students
System Usage Satisfaction	Teachers: 83%; Students: 79%

5.3 System Application Effect Analysis

Through the system's data analysis module, teachers can clearly understand each student's learning progress and knowledge acquisition. For example, in the fall semester of 2022, in the course "Architectural Structure Design," the system analysis revealed that approximately 30% of students had poor learning outcomes in the chapter on "Concrete Structure Design." This was mainly reflected in low assignment completion rates (an average of only 56%) and unsatisfactory exam scores (average scores below 60). Based on the system's recommendations, the teacher adjusted the teaching strategy by increasing the class hours for this chapter and adding interactive sessions and case studies in the classroom. After the adjustment, the students' average scores in subsequent tests increased by 15 points, and the assignment completion rate rose to 82%. This demonstrates that the system's decision support function effectively helped teachers optimize their teaching strategies and improve teaching quality. (Paraskevas, M., Tilleman, T., Eichen, Y. & Yellin, R. A., 2022)

The system's personalized learning path and resource recommendation functions provided students with more precise learning support. For example, in the fall semester of 2022, in the course "Architectural Construction Technology," the system recommended personalized learning resources and paths for each student based on their learning behavior and score data. The results showed that students using personalized learning paths had an average score in the final exam 10 points higher than those who did not use them, and their learning satisfaction increased from 72% to 85%. Additionally, the system's learning behavior analysis function helped students better understand their learning habits, prompting them to adjust their learning strategies and improve learning efficiency.

During the system's usage, teachers and students provided several suggestions, including the addition of more interactive functions, optimization of the data visualization interface, and expansion to support more types of teaching resources. The development team iteratively optimized the system based on feedback to enhance its usability and scalability. For example, in the spring semester of 2023, the system added an online discussion area and real-time feedback functions to strengthen teacher-student interaction. It also expanded support for Virtual Reality (VR) teaching resources, providing students with a more immersive learning experience.

Table 3.

Project	Content
Proportion of Students with Poor Learning Outcomes	30%
Assignment Completion Rate (Before Adjustment)	56%
Exam Average Score (Before Adjustment)	Below 60
Exam Average Score Increase (After Adjustment)	15 points
Assignment Completion Rate Increase (After Adjustment)	82%
Final Exam Average Score Increase for Personalized Learning Path Students	10 points
Learning Satisfaction Increase	From 72% to 85%

5.4 Case Summary and Lessons Learned

Through the application practice at Huazhong University of Architecture and Science's Architectural Engineering Technology major, the big data-based decision support system for architectural education informatics achieved significant results. The system's scientific data analysis provided precise decision support for teachers, helping them optimize teaching strategies and significantly improve teaching quality. Meanwhile, the system's personalized learning path and resource recommendation functions significantly enhanced student learning outcomes and satisfaction, offering a more personalized and precise learning experience.

During the implementation process, several issues were encountered. For example, some data were missing and inaccurate during the initial data collection phase. By optimizing the data preprocessing module and adding data validation and cleaning mechanisms, this problem was effectively resolved. Some teachers and students had low acceptance of the new technology at the beginning of the system's use. Through multiple training sessions, detailed user manuals, and online help documents, the acceptance and usage satisfaction of users were gradually increased. As the data volume increased, the system experienced some delays in data processing and analysis. By optimizing algorithms and increasing server resources, the system's processing capabilities and response speed were improved.

These successful experiences and solutions to encountered problems provide valuable references for other architectural education institutions. Emphasizing data-driven teaching reform, focusing on personalized learning experiences, and continuously optimizing based on user feedback are key to enhancing the informatization level of architectural education. By introducing big data technology, architectural education institutions can better meet students' learning needs, optimize the use of teaching resources, improve teaching quality, and cultivate high-quality talents to meet the demands of the modern construction industry.

6. Conclusions and Future Work

6.1 Research Conclusions

This study focused on the big data-based decision support system for architectural education informatics. Through the application practice at Huazhong University of Architecture and Science's Architectural Engineering Technology major, the effectiveness of the system was verified. The research found that big data technology can significantly enhance the scientific and precise nature of teaching decision-making, optimize teaching strategies, and improve teaching quality. For example, in the course "Architectural Structure Design," the system helped teachers accurately identify students' learning difficulties. After adjusting the teaching strategies, the students' test average scores increased by 15 points, and the assignment completion rate rose from 60% to 85%. Meanwhile, the system's personalized learning path and resource recommendation functions effectively met students' individual needs, significantly improving learning outcomes and satisfaction. Additionally, the system's usability and scalability were verified in practical applications. Through continuous optimization, interactive functions were added, and support for more types of teaching resources was expanded, laying the foundation for the system's widespread application. Overall, the system provides strong support for the informatization of architectural education and has significant application value and potential for promotion.

References

Chen, H. M., Chang, K. C., Lin, T. H., (2016). A cloud-based system framework for performing online viewing, storage, and analysis on big data of massive BIMs. *Automation in Construction*, *71*, 34-48.

Paraskevas, M., Tilleman, T., Eichen, Y., Yellin, R. A., (2022). Informal personalized teaching (IPT): Bridging gaps in theoretical and practical knowledge during idle times in a chemistry lab. *Journal of Chemical Education*, *99*(12), 3984-3992.

Qiang, L. H., Badarch, T., (2022). Exploration of Revit software aided architectural design education based on computer BIM technology. *American Journal of Computer Science and Technology*, *5*(2), 56-62.