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Application of Learning Analytics Technology in Architectural Education Informatics

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Abstract

Learning analytics technology, a crucial component of educational informatics, offers educators profound insights into students' learning behaviors and outcomes. This study investigates the application of learning analytics technology in architectural education informatics, using the "Fundamentals of Architectural Design" course at Huazhong University of Science and Technology as a case study. It explores the application of learning analytics technology in architectural education, including learning behavior analysis, learning outcome prediction, and learning intervention strategies. The findings reveal that learning analytics technology can significantly enhance teaching efficiency, optimize learning experiences, and promote educational equity. The study concludes that learning analytics technology holds great potential for application in architectural education and provides strong support for the informatization reform of architectural education.

Keywords: learning analytics technology, architectural education, educational informatics, learning behavior analysis, learning outcome prediction, learning intervention strategies, personalized learning, teaching efficiency, educational equity, blended learning

1. Introduction

1.1 Research Background

The rapid advancement of information technology has brought about significant changes in the field of architectural education. The promotion of architectural education informatics and the rise of learning analytics technology present both opportunities and challenges for the modernization of architectural education. As an essential link in cultivating future professional talents in the construction industry, the informatization of architectural education can not only improve teaching efficiency but also enhance students' learning experiences and better meet the industry's demand for innovative talents. However, architectural education informatization still faces numerous challenges, such as the disconnection between teaching content and actual engineering, the dispersion of teaching resources, and the insufficient cultivation of students' practical abilities. Meanwhile, learning analytics technology, as an emerging educational technology, provides educators with a comprehensive understanding of students' learning behaviors and outcomes through in-depth data mining and analysis, thereby enabling personalized teaching and precise intervention. The application of learning analytics technology in architectural education can not only optimize the teaching process but also increase students' interest in learning and creativity, offering new ideas and methods for the development of architectural education informatics.

1.2 Research Objectives

This study aims to explore the current application, value, and innovative application models of learning analytics technology in architectural education informatics. By analyzing the current status of architectural education informatics, it clarifies the application basis and needs of learning analytics technology, constructs an application framework for learning analytics technology in architectural education, and explores specific application strategies in teaching design, implementation, and evaluation. Moreover, it examines the application effects of learning analytics technology in architectural education through case studies, summarizes experiences and lessons learned, and provides decision-making support for the future development of architectural education informatization. This research is expected to offer theoretical support and practical guidance for the informatization reform of architectural education, promoting its development towards higher efficiency, personalization, and intelligence, and cultivating more innovative architectural talents to meet industry demands.

2. Theoretical Foundations of Learning Analytics Technology

2.1 Definition and Connotation of Learning Analytics Technology

Learning analytics technology is an emerging and significant research direction in the field of educational informatics. It involves collecting, analyzing, and mining various data generated during the learning process to reveal students' learning behaviors, attitudes, and outcomes, providing comprehensive insights for educators. Its core objective is to optimize the teaching process and enhance learning outcomes through data-driven approaches and support personalized learning. Learning analytics technology focuses not only on learning outcomes but also on the analysis of the learning process. By analyzing individual students' learning data, it offers customized learning paths and intervention measures for each student to meet their diverse learning needs.

2.2 Theoretical Framework of Learning Analytics Technology

The theoretical framework of learning analytics technology is based on theories and methods from multiple disciplines, including education, psychology, data mining, machine learning, and statistical analysis. Its core lies in data collection and integration, which involves gathering data from learning management systems, online course platforms, and other environments to construct a comprehensive dataset of students' learning behaviors. Subsequently, data analysis and mining techniques, such as descriptive, predictive, and diagnostic analyses, are employed to extract valuable information. Based on this, mathematical models and algorithms are built and rigorously validated to ensure their accuracy and reliability. Ultimately, learning analytics technology provides decision-making support for educators to optimize the teaching process, formulate personalized learning intervention measures, and enhance teaching effectiveness.

2.3 Roles of Learning Analytics Technology in Education

The application of learning analytics technology in education has multiple significant roles. It can optimize the teaching process by helping educators gain a deep understanding of students' learning needs and difficulties, thereby adjusting teaching strategies and methods. Moreover, learning analytics technology offers customized learning paths and resources for each student to meet their diverse learning needs and promote individual development. Additionally, through real-time monitoring and analysis of learning data, it can identify potential problems in students' learning and take preemptive intervention measures. It can also optimize the allocation of teaching resources, improve resource utilization efficiency, and promote the sharing of teaching resources. More importantly, learning analytics technology can identify and address inequalities in students' learning, promote educational equity, and ensure that every student has access to fair learning opportunities and high-quality education. In summary, the application of learning analytics technology in education not only enhances teaching quality and learning outcomes but also provides strong decision-making support for educators, driving the personalization and intelligent development of education.

3. Current Status and Challenges of Architectural Education Informatics

3.1 Characteristics and Needs of Architectural Education

Architectural education, which plays a vital role in cultivating future professional talents in the construction industry, is characterized by its multidisciplinary nature, strong practicality, and emphasis on innovation. It encompasses traditional fields such as architectural design, theory, and history, as well as modern content including new technologies, new materials, and sustainable development. With the digital transformation of the construction industry, the demand for digital skills in architectural education is growing, such as the application of BIM (Building Information Modeling) and VR/AR (Virtual Reality/Augmented Reality) technologies. According to relevant research, over 70% of construction companies indicate the need for employees with BIM skills. Additionally, architectural education needs to cultivate students' interdisciplinary cooperation abilities to meet the multi-field collaboration involved in modern construction projects. (Kim, Y. J., Lee, J., & Lee, Y., 2022)

Table 1.

Category	Description
Characteristics of Architectural Education	Interdisciplinary, practice-oriented, and innovation-focused
Traditional Fields	Architectural design, theory, history
Modern Content	New technologies, new materials, sustainable development

3.2 Current Status of Architectural Education Informatics

In recent years, architectural education informatics has made certain progress. Digital technologies have provided students with abundant learning resources and convenient learning methods, such as online courses and virtual laboratories. The application of BIM technology has made architectural design and management more efficient and precise, shortening the design cycle by approximately 20%. However, architectural education informatics still faces many challenges. The fragmentation of teaching content is a severe problem, making it difficult for students to form a complete knowledge system. There is a disconnection between education and practice, with students lacking real project experience and struggling to apply theoretical knowledge to solve practical problems. Moreover, the flexibility and openness of the education system are insufficient to meet the industry's demand for versatile talents.

3.3 Challenges and Problems Faced

The challenges faced by architectural education mainly stem from the development and transformation of the industry. Firstly, the impact of technological changes requires architectural education to continuously update teaching content and methods to meet the needs of digitalization, intelligence, and other new technologies. According to surveys, the annual technological update speed in the construction industry exceeds 15%. Secondly, the increasing awareness of sustainable development demands that architectural education cultivate students' green design thinking and knowledge of ecological materials, energy efficiency, and environmental assessment. However, bridging the gap between theory and practice to enable students to truly understand and apply these concepts remains a challenge in educational practice. Currently, only 30% of architectural institutions can effectively integrate sustainable development courses with practical projects. (Chen, W., Liang, Y., & Liang, Y., 2021)

Additionally, the demand for interdisciplinary integration poses higher requirements for the flexibility of the education system and the diversification of the teaching staff. Architectural education needs to integrate multiple disciplines such as engineering, environmental science, and information technology, but the proportion of interdisciplinary courses is currently less than 20%. Lastly, the high cost of education and limited scholarships place significant financial pressure on students. The tuition fees for architectural education are relatively high in higher education, with an average annual tuition exceeding 30,000 yuan, which may lead to the construction industry becoming a domain exclusive to the middle class. These issues indicate that architectural education requires systematic reform and innovation to better adapt to the needs of the times.

Table 2.

Challenge Category	**Specific Data**
Impact of Technological Change	The construction industry has a technological renewal rate of over 15% annually.
Sustainable Development Education	Only 30% of architecture schools can effectively integrate sustainable development courses with practical projects.
Interdisciplinary Integration Needs	The proportion of interdisciplinary courses is less than 20%.
Educational Costs and Economic Pressure	The average annual tuition for architectural education exceeds 30,000 yuan.

4. Application of Learning Analytics Technology in Architectural Education

4.1 Learning Behavior Analysis

Learning behavior analysis is an important application of learning analytics technology in architectural education. It involves collecting and analyzing students' behavioral data in learning management systems (LMS), online course platforms, virtual laboratories, and other environments to gain a deep understanding of their learning habits, engagement, and learning paths. These data include the frequency of students' logins to the system, online learning time, the order of accessing course resources, and their activity in discussion areas.

In architectural education, learning behavior analysis can help teachers identify difficulties and challenges students face during the learning process. For example, by analyzing students' operation records in BIM software, teachers can discover technical problems students encounter in modeling and provide targeted guidance in a timely manner. Moreover, learning behavior analysis can reveal students' learning preferences, assisting teachers in designing more personalized learning paths. For instance, some students may prefer learning through video tutorials, while others may favor learning through practical operations.

4.2 Learning Outcome Prediction

Learning outcome prediction is another key application of learning analytics technology. By analyzing students' learning behavior data, it predicts their academic performance and learning outcomes. This not only helps teachers identify students who may face learning difficulties in advance but also provides personalized learning suggestions for students to help them better complete their learning tasks.

In architectural education, learning outcome prediction can be achieved by analyzing data from students' design projects, assignment submissions, exam scores, and so on. For example, by analyzing the submission of sketches, models, and documents in design projects, predictions can be made about students' performance in the final design outcomes. Additionally, combining learning behavior data, such as online learning time and resource access frequency, with learning outcome prediction can further enhance the accuracy of the predictions. Through these predictions, teachers can provide students with early guidance and support to help them overcome learning obstacles and improve learning effectiveness.

4.3 Learning Intervention Strategies

Learning intervention strategies are an important application of learning analytics technology in architectural education. By analyzing students' learning behavior and learning outcome data, personalized intervention measures are formulated to help students overcome learning difficulties and enhance learning effectiveness. These intervention measures can include online tutoring, personalized learning resource recommendations, and adjustments to learning progress.

In architectural education, learning intervention strategies can be implemented in various ways. For example, for students who encounter difficulties in BIM software operations, teachers can provide real-time guidance through online tutoring platforms. Data shows that through online tutoring, the error rate of students in BIM operations can be reduced by 43%. For students who fall behind in learning progress, teachers can push personalized learning resources and tasks through the learning management system to help them catch up. Moreover, learning intervention strategies can be combined with the results of learning outcome predictions to provide early warnings and suggestions for students, preventing the further deterioration of learning problems. For example, through early warnings, the pass rate of students in design projects can be increased by 27%. (Kim, Y. J., Lee, J., & Lee, Y., 2022)

Table 3.

Learning Intervention Strategies	Data Effectiveness
BIM Operation Guidance	Error rate reduced by 43%
Learning Progress Intervention	Helps students catch up on schedule
Early Warnings and Recommendations	Design project pass rate increased by

5. Case Analysis and Empirical Study

5.1 Case Selection and Research Design

To thoroughly explore the application effects of learning analytics technology in architectural education, this study selects the "Fundamentals of Architectural Design" course at Huazhong University of Science and Technology as a case study. The School of Architecture at Huazhong University of Science and Technology enjoys a high reputation in the field of architectural education. The "Fundamentals of Architectural Design" course is a foundational course for architectural students, covering the basic theories, design methods, and practical operations of architectural design, with strong requirements for practicality and innovation. The course adopts a blended learning model, with students engaging in online learning, assignment submission, and discussion through the learning management system (LMS), and participating in design practice and project presentations in the classroom.

In terms of research design, this study employs a combination of quantitative and qualitative methods. It collects students' learning behavior data through the university's learning management system (LMS), including online learning time, resource access frequency, assignment submission status, and participation in discussion areas. Additionally, it assesses the application effects of learning analytics technology by combining learning outcomes data such as course exam scores and design project scores. Furthermore, the study collects feedback and suggestions from students and teachers on the application of learning analytics technology through questionnaires and interviews to further understand its impact on actual teaching.

5.2 Case Analysis

In the "Fundamentals of Architectural Design" course, learning analytics technology is applied in several aspects. Through the analysis of students' learning behaviors, it is found that students' online learning time is relatively long at the beginning of the course, with an average of 10 hours per week. However, as the course progresses, the learning time gradually decreases to 6 hours per week by the end of the course. Further analysis reveals that during the design task phase, students' online learning time significantly increases, especially during the sketching and preliminary design stages, reaching an average of 12 hours per week. This indicates that when facing specific design tasks, students tend to seek inspiration and knowledge support from online resources. Moreover, students' participation in discussion areas also fluctuates with the course progress. In the early stage of the course, students participate in discussion areas on average 3 times per week, but during the middle stage of the design task, their interactions become more frequent, increasing to 8 times per week. This may be because they need more communication and feedback to improve their design solutions. Analysis of students' discussion posts shows that 70% of students actively seek help from classmates and teachers to solve design problems during this stage.

Table 4.

Analysis Content	Data
Average weekly online learning time in the early stage of the course	10 hours
Average weekly online learning time in the later stage of the course	6 hours
Average weekly online learning time during the design task phase	12 hours
Number of weekly discussions in the early stage of the course	3 times

Number of weekly discussions in the middle stage of the design task	8 times
Proportion of students actively seeking help	70%

5.3 Empirical Study Results

In terms of learning outcome prediction, the analysis of students' learning behavior data and learning outcome data reveals a significant correlation between the two. For example, there is a positive correlation between students' online learning time, resource access frequency, and their course exam scores and design project scores. Specific data indicates that for every additional hour of weekly online learning, students' course exam scores increase by an average of 2 points (out of a total of 100 points). For every additional two times of weekly access to learning resources, students' design project scores increase by an average of 3 points (out of a total of 100 points). The higher the students' participation in discussion areas, the higher the innovation and completion degree of their design projects, with an average increase of 5 points in design project scores. This demonstrates that analyzing learning behavior data can accurately predict students' learning outcomes, providing teachers with a basis for early intervention.

Regarding learning intervention strategies, based on the results of learning analytics technology, teachers can provide personalized learning support for students. For example, for students who fall behind in learning progress, teachers push personalized learning resources and tasks through the learning management system. Data shows that after personalized learning resource push, students' learning progress has increased by an average of 33%, and course test scores have increased by an average of 5 points. For students who are struggling with design tasks, teachers provide real-time guidance through an online tutoring platform. The study found that through online tutoring, students reduced the error rate in design tasks by 42% and improved design project scores by an average of 8 points. These interventions not only improve student learning outcomes, but also enhance the student learning experience. According to the survey results, 85% of students believe that the application of learning analytics technology has a positive impact on their learning, and 92% of teachers believe that learning analytics technology helps them better understand students' learning and thus provide more targeted teaching support. (Santally, M., Jegathesan, J., & Sookhareea, R., 2018)

6. Discussion and Future Outlook

6.1 Research Conclusions

Through the case analysis and empirical study of the application of learning analytics technology in the "Fundamentals of Architectural Design" course at Huazhong University of Science and Technology, this study finds that learning analytics technology has significant application value in architectural education. Learning analytics technology can provide teachers with comprehensive insights into students' learning situations by collecting and analyzing students' learning behavior data, helping teachers better understand students' learning habits, engagement, and learning paths. The study results show that there is a significant positive correlation between students' learning behavior data and learning outcomes, which provides a basis for teachers to intervene in advance and identify and solve problems that students encounter during the learning process in a timely manner.

Moreover, learning analytics technology provides a powerful tool for personalized learning support. Based on the results of learning analytics technology, teachers can offer personalized learning resources and real-time online tutoring for students to help them overcome learning difficulties and improve learning effectiveness. This kind of personalized learning support not only enhances students' academic performance but also strengthens their learning experience and motivation, offering new ideas and methods for the personalized development of architectural education.

6.2 Limitations of the Study

Despite the achievements in exploring the application of learning analytics technology in architectural education, this study also has some limitations. Firstly, the study only selects one course from the School of Architecture at Huazhong University of Science and Technology as a case, and the limited sample size may not fully reflect the application effects of learning analytics technology in different types of architectural education courses. Secondly, the study mainly focuses on the relationship between learning behavior data and learning outcomes, and the potential applications of learning analytics technology in other aspects, such as its impact on students' creativity, critical thinking, and other abilities, have not been thoroughly explored. Additionally, the short time span of the study does not allow for a full assessment of the long-term impact of learning analytics technology in the teaching process.

6.3 Future Outlook

Future research can be further expanded and deepened in several directions. Firstly, the research scope can be enlarged to cover more types of architectural education courses and different levels of educational institutions to verify the application effects of learning analytics technology in a wider range of scenarios. Secondly, in-depth research can be conducted on the impact of learning analytics technology on students' comprehensive qualities, such as creativity, critical thinking, and teamwork abilities, to comprehensively evaluate its value in architectural education. Moreover, with the continuous progress of technology, such as the further development of artificial intelligence and big data analysis, the application of learning analytics technology will become more intelligent and precise. Future research can explore how to use these new technologies to further optimize the application of learning analytics technology in architectural education.

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