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Integrating Artificial Intelligence, Performance Prediction and Learning Analytics to Enhance Student Learning In Technical Study

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Abstract

Predicting academic performance in online education poses significant challenges due to the insufficient integration of learning process data, summative assessments, and the absence of precise quantitative relationships between variables and achievements. This study proposes an artificial intelligence (AI)-enabled predictive model for student academic performance, incorporating both learning procedure metrics and summative data. The methodology involves predefined prediction measures to describe and transform learning data from atechnical course. Alatest computation technique is employed to identify the optimal predictive model for academic enactment. Validation is conducted using a second online course employing the same pedagogical framework and technological tools. Results demonstrate a strong alignment between the course result and the model's predictions.

Keyword: Artificial Intelligence, Students Performance Analysis, Higher education · Online learning · Collaborative learning

Introduction

E-learning is an innovative educational approach that leverages telecommunication technology to facilitate the delivery, management, and supervision of educational content in a digital format. It extends beyond conventional computer-based instruction and online information dissemination, integrating both electronic technologies and interactive learning experiences.

The term "e-learning" encompasses both the technological infrastructure and the instructional methodologies employed in digital education. In recent years, there has been a significant surge in the adoption of e-learning, driven by the increasing accessibility of digital platforms and its cost-effectiveness. Key advantages of e-learning include flexibility in scheduling, the removal of geographical constraints, continuous access to learning materials, and the efficient management of educational resources. These benefits have motivated educational and training institutions to integrate e-learning through diverse technology-enabled platforms, transforming traditional teaching and learning paradigms.

"According to a systematic study by the World Health Organization, 29% of studies evaluating knowledge improvement and 40% of studies evaluating skills improvement showed the benefit of e-learning compared to traditional learning" [1]. "Because of the sudden outbreak of the COVID-19 pandemic worldwide, the education system across the globe is forced to switch from traditional learning systems to e-learning systems. UNESCO recommended that educational institutes gear up themselves with online learning tools" [2]. The COVID-19 pandemic has accelerated the adoption of e-learning, making it the most accessible mode of education. Despite its widespread implementation, several challenges persist in the e-learning process, particularly in content transmission, delivery, and the effectiveness of enabling technologies. One of the most critical factors influencing the success of e-learning systems is students' acceptance and engagement, which remains a key challenge in ensuring effective digital learning experiences. Predicting academic performance is a crucial aspect of online education, aimed at assessing students' learning outcomes using learning data and artificial intelligence (AI) algorithms. Various AI-based techniques, including evolutionary computation, deep learning, decision trees, and Bayesian networks, have been employed to develop predictive models. However, existing models face significant challenges in establishing precise quantitative relationships between input variables (learning data) and academic performance outcomes.

Two key challenges hinder the effectiveness of current prediction models. First, the absence of well-defined standards for choosing and converting learning data encompassing both process and performance metrics complicates the development of explainable strictures due to the inherent difficulty of teaching and learning processes. Second, achieving high-precision relationships between learning inputs and performance outcomes remains a challenge. Addressing these limitations and enhancing the accuracy of academic performance prediction models in online education is a critical area of ongoing research.

Related Works

Predicting academic performance is essential in online education as it helps identify students at risk of failure, creates personalized learning pathways, and enhances instructional design and development. Various AI algorithms have been employed in existing studies to predict students' exam performance, utilizing both classification and regression techniques.

Ciolacu et al. [3] introduced a "Machine Learning technique (MLT) to analyze Educational behavior that is rapidly going online, and the contents of the course are accessible in digital format. It allows for data analysis and data usage to evaluate learning processes. Active and engaging students' participation leads to a higher learning level for the 4th Revolution in Education. Machine learning methods have recently taken remarkable strides in the advancement of using data processing and predictions. Thus, it is much less used to measure the level of learning".

"Analysis in Educational Data Mining (EDM) and Learning Analytics (LA) has developed as essential research fields that reveal valuable information from educational datasets for many uses, such as predicting students' progress. In modern educational environments, the ability to anticipate a pupil's success may be useful for behavior" [4].

Existing approaches to academic performance prediction have primarily focused on factors such as academic success, family income, and family assets, while often overlooking family expenses and students' personal details. This study aims to address this gap by analyzing the impact of these

overlooked factors. Data is collected from scholarship-holding students across various universities to evaluate the significance of these variables in academic performance prediction.

Learning Analytics in Technical Education

Learning analytics is the procedure of gathering and analyzing data about learners and their learning surroundings. In technical education, where students' grasp of complex concepts is paramount, learning analytics can provide insights that drive better academic support and decision-making.

- **Data Sources for Learning Analytics**

  Learning analytics involves the collection of various data points, including:

  - Student activity data (e.g., interaction with learning management systems, participation in discussion forums, and completion of assignments)
  - Assessment data (e.g., exam scores, quizzes, and project submissions)
  - Engagement metrics (e.g., time spent on content, frequency of interaction)
  - Behavioral data (e.g., patterns in accessing resources, navigation through the course materials)

- **Impact on Technical Courses**

  In technical education, learning analytics can be used to monitor how students interact with challenging content. For example, if a student is spending an unusually high amount of time on a particular topic, learning analytics can flag this as a potential issue. Educators can then intervene with additional resources or personalized support to help the student progress. Moreover, analytics can assist instructors in identifying which parts of the course need redesigning or optimization based on student performance trends.

Integrating AI, Performance Prediction, and Learning Analytics

The integration of AI, performance prediction models, and learning analytics can be a game-changer for student success in technical courses. These technologies, when used in concert, provide a holistic view of student performance and learning behavior, enabling instructors to deliver more personalized and effective educational experiences.

- **Synergistic Benefits of Integration**

  When integrated, AI and learning analytics create a powerful ecosystem for education. The performance prediction models, powered by AI algorithms, can make use of the rich data provided by learning analytics to generate more accurate predictions. This allows educators to:

  - Predict student performance more accurately and timely
  - Provide immediate feedback to students
  - Identify students' learning habits and regulate course to improved meet their needs
  - Recommend personalized learning pathways based on individual strengths and weaknesses

- **Real-World Applications in Technical Courses**

  In technical courses, where students often work with complex systems and mathematical problems, these technologies can help break down barriers to understanding. AI-based

performance predictions can be used to suggest adaptive learning paths, while learning analytics can pinpoint which specific areas of the course need improvement. For instance, if a student is stressed with a specific algorithm in a computer science course, the system might suggest additional tutorials, exercises, or peer assistance to help that student succeed.

Challenges and Considerations

Despite the promising potential of AI, performance prediction models, and learning analytics, there are several challenges in their implementation in technical courses.

- **Data Privacy and Ethical Considerations**

  The use of student data raises concerns around privacy, security, and ethics. Institutions must ensure that data is handled responsibly and in compliance with regulations like GDPR. Moreover, biases in AI algorithms can lead to inaccurate predictions, which could unfairly disadvantage certain students.

- **Technological and Pedagogical Integration**

  Integrating these technologies into existing educational frameworks requires significant investment in both technology and professional development for instructors. Educators need training on how to interpret predictive models and learning analytics data to make informed decisions about student support.

- **Adaptability Across Diverse Learning Environments**

  While AI and learning analytics can be effective in standardized environments, technical courses often require adaptability due to the diversity of students and subject matter. Personalized interventions and support systems must be tailored to fit the unique needs of each course and student.

Conclusion

The development of prediction models and initial warning systems has turn into a crucial focus in higher education. However, existing models face challenges related to learning data identification and analysis. This study addresses these issues by developing an AI-driven model for the quantitative prediction of academic performance in online engineering education.

Unlike traditional prediction approaches that rely on non-malleable factors (e.g., student demographics) or confounded variables (e.g., early performance), the proposed model overcomes these limitations by identifying and analyzing key learning data. The model quantitatively evaluates the contributions of dominant variables in an online engineering course to enhance prediction accuracy .

The results reveal that the most influential factors in academic performance are knowledge gaining, followed by class contribution and summative performance, whereas precondition knowledge has a minimal impact. Based on these results, this study offersinstructive and investigative insights for improving online course design and refining prediction models. The proposed AI-based measureable prediction model serves as a valuable tool for assessing and forecasting student learning performance in online technical education.

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