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Predictive Analytics and Machine Learning Models for Student Performance Evaluation

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Abstract

The integration of predictive analytics and machine learning (ML) in education is transforming the landscape of student performance evaluation, offering new opportunities for personalized learning and targeted interventions. Predictive models, by analyzing historical and real-time data, enable educators to forecast student outcomes with remarkable accuracy, facilitating timely interventions for at-risk students. This chapter explores the application of predictive analytics and ML techniques in optimizing resource allocation, enhancing student engagement, and improving academic success. Key machine learning algorithms, such as K-Nearest Neighbors (KNN), support the classification of student performance, while advanced data preprocessing and feature engineering techniques ensure the efficacy of these models. Moreover, the chapter highlights the challenges associated with the use of educational data, including ethical concerns, bias mitigation, and the interpretability of complex models. Through a comprehensive review of current practices, this work provides valuable insights into how data-driven approaches can reshape educational practices, supporting evidence-based decision-making and promoting equitable learning environments. The chapter concludes with a discussion on future directions for predictive analytics in education, focusing on the increasing role of artificial intelligence (AI) and big data in shaping personalized learning systems.

Keywords: Predictive Analytics, Machine Learning, Student Performance Evaluation, K-Nearest Neighbors, Resource Allocation, Feature Engineering.

Introduction

The integration of predictive analytics and machine learning (ML) into the education sector has become a transformative force, reshaping how student performance is evaluated and understood [1]. Traditional methods of performance assessment, primarily based on exams and assignments, often fail to provide a comprehensive and timely picture of a student's academic journey [2]. These traditional techniques are inherently limited, as they typically capture performance at a single point in time, offering no insight into a student's progress or challenges until the final grades are released [3]. In contrast, predictive analytics leverages vast datasets generated by students, including academic records, behavioral patterns, engagement metrics, and demographic information, to forecast future outcomes and identify at-risk students [4]. The growing availability of such data and advanced computational tools has empowered educators and institutions to move beyond reactive approaches, embracing a proactive strategy that focuses on improving learning outcomes through timely interventions [5].

Predictive models allow educators to forecast student performance with remarkable precision, enabling interventions that address potential challenges before they impact a student's academic success [6]. By analyzing patterns in historical and real-time data, these models can predict not only student performance but also specific areas where students might struggle, such as in particular subjects or skills [7]. Machine learning algorithms, such as K-Nearest Neighbors (KNN), decision trees, and support vector machines, can be trained on past performance data to develop predictive models that identify correlations between student attributes and outcomes [9]. These algorithms learn from data patterns and generalize insights to predict future performance, creating a foundation for personalized learning paths [10]. With these insights, educators can tailor their instructional strategies to meet the individual needs of students, providing additional resources or modifying teaching methods to support those at risk of underperforming [10].

The application of predictive analytics and machine learning extends beyond individual student performance prediction to enhance overall resource allocation within educational institutions [11]. Resource distribution, such as faculty assignments, budgeting, and material provisioning, was often based on fixed patterns or historical data [12]. However, with the power of predictive models, educational administrators can optimize these processes by forecasting areas of demand [13]. For instance, predictive analytics can highlight courses with an increasing number of at-risk students, allowing for the deployment of additional support such as tutoring or adjusted class schedules [14]. In the same vein, predictive models can assist in faculty resource management, enabling institutions to allocate instructors more efficiently based on projected enrollment and demand for specialized courses. By aligning resources with student needs, institutions can enhance both student outcomes and operational efficiency, making the best use of limited resources in a more dynamic and adaptive manner [15].