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Statistical Analysis of Intelligent Systems in Student Performance Evaluation

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Abstract:

Among various goals of educational institutions, some are to improve the level of education, create as well as execute methods that can benefit students, and evaluate student performance through the school year, at completion of the academic year or in the coming years. Artificial intelligence (AI) methods are employed in this discipline to accomplish desired objectives because of their special capacity to build associations and produce correct outcomes. But the variety of publications and the variation in the information they provide lead to misunderstanding and lessen their capacity to lead new research. Therefore, the conducted research work presents a thorough evaluation of the published papers in research that assess student performance from 2019 to 2026. A quantitative analysis is presented by comparing the considered published scholarly articles based on objective, database, dataset size, method used and accuracy of the developed student performance evaluation model. According to the result of this evaluation, there are more studies being conducted in this field, and a wide variety of AI methods are being used. Moreover, the results show that while issues like data privacy and interpretability still exist, DL and hybrid systems perform better than conventional methods in terms of predicted accuracy. However, the research that is now available indicates that AI can be helpful in detecting and enhancing a variety of educational achievement domains.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Hybrid Methods, Student Performance, Prediction Models, statistical review

I. Introduction

Student performance is one of the most important prerequisites for all educational institutions [1]. Students' educational achievements were evaluated over the past years using memory-based and routine exams, and the results were contrasted to determine the variables that anticipate proficiency in school [2], [3]. Nowadays, there have reached their full potential, highly sophisticated tools that allow anyone from every profession to forecast their future data, irrespective of whether they have very little coding expertise [4]. Students' previous educational achievement can be used to predict current and future performance [5]. In the field of learning analytics and educational data mining (EDM), AI has become a game-changing instrument for the evaluation of student data and forecasting performance in school [6], [7], [8]. Administrators and teachers employ student data to estimate the accomplishment of a learner at the moment of enrolment, evaluate a student's overall scope of employment at the stage of successfully completing the semester or dropping out using the overall statistics from the whole student population, or determine a specific student's achievement or dismal performance level in the following evaluations [9]. Modern AI frameworks, comprising ensemble learning algorithms like Gradient Boosting [10] and Random Forest [11], in addition to deep learning (DL) algorithms like Convolutional Neural Networks (CNN) [12], Artificial Neural Networks (ANN) [13] and hybrid systems [14], have developed quickly in the past few years. These algorithms greatly increase predictability by identifying complicated trends and unpredictable interactions in massive databases [15].

Even though AI-driven student achievement assessment has made substantial advances, unbiased comparison is challenging because current research mostly relies on subjective evaluations and requires structured statistical analysis between algorithms, databases and analysis measures. Furthermore, standardized modal data, testing uniformity and problems like applicability and understandability receive less consideration. To close these gaps, the present article offers a thorough statistical and qualitative evaluation of systems implemented between 2019

and 2026. Evaluating current approaches, spotting performance trends and pointing out study requirements are its main objectives. The contribution of the paper is as follows:

- Offers a thorough statistical evaluation methodology for assessing student performance evaluation systems using AI.
- Compares existing algorithms quantitatively published between 2019 and 2026 utilizing standard parameters like accuracy.
- Examines the development and study patterns in AI-driven student performance assessment by conducting a year-by-year examination of scholarly publications, emphasizing the gradual use of sophisticated algorithms.
- Presents an organized comparative table that includes aim, database, dataset size, method used and accuracy of the model.
- Gives information about the top-performing systems and how well-suited they are for practical and academic uses.

II. Methods & Materials

A. Search Strategy & Information Sources

To accomplish the goals and findings of the work, a trustworthy and well-thought-out search strategy and information sources are essential. A thorough and methodical search was carried out in this study. Six different internet databases are used to assess existing studies, such as Google Scholar, MDPI, PubMed, ACM Digital Library, IEEE Xplore, and Science Direct, between 2019 and 2026. The phrases like “Student Performance Evaluation”, “Student Achievement prediction”, “Student performance predictors”, “Educational data mining”, “AI models for academic outcomes”, “Machine learning models for student academic performance”, “DL models for academic achievement”, etc.

B. Criteria for Eligibility

This review paper considered research that was: i) directly associated with the anticipated student performance with a concentration on AI, ii) regardless of degree of education, iii) published in conferences and scholarly journals, iv) published between 2019 to 2026, and v) must be written in the English language.

Similarly, the publications were omitted if: i) using other methods than AI, ii) without concrete results from experiments, iii) publications in the form of conventional, theoretical and surveys, iv) published before 2019 and v) written in a language other than English.

C. Study Selection

1312 publications were found in this search. There were 653 articles left when repetitions were removed. Title and abstract assessment led to the exclusion of 518 papers. Among these papers, 135 publications were gone through retrieval evaluation, and 30 papers were not retrieved. The other 105 publications’ full manuscripts were taken into account and assessed. 62 of them did not fit the requirements for the criteria of eligibility. For the purpose of this assessment, the rest of the 43 pertinent research works were assessed. The ultimate group of chosen research was carefully examined using the PRISMA technique to obtain the information that helps in this statistical review. The entire process of study selection is shown in figure 1.

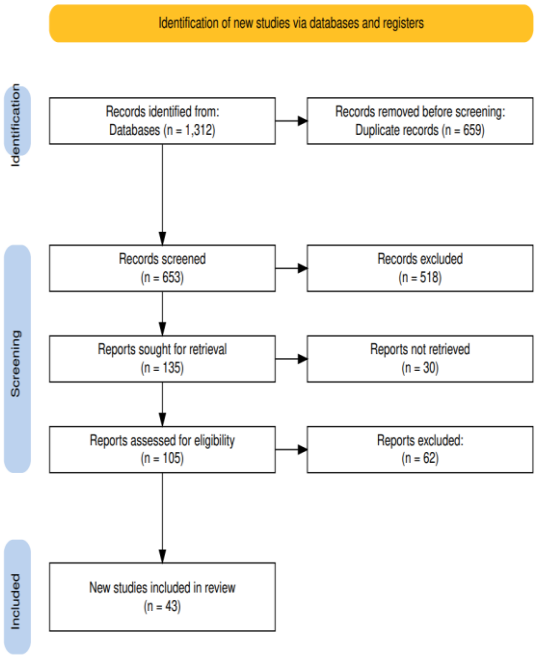

Fig. I. Process of study selection

III. Results

A. Distribution of the Considered Articles by Year

The quantity of studies has risen substantially in the past few years, demonstrating that several researchers are progressively engaged in using AI techniques to determine the performance of students in institutions. The majority of the publications incorporated in this paper were issued in 2024 and 2025, as shown in figure II.

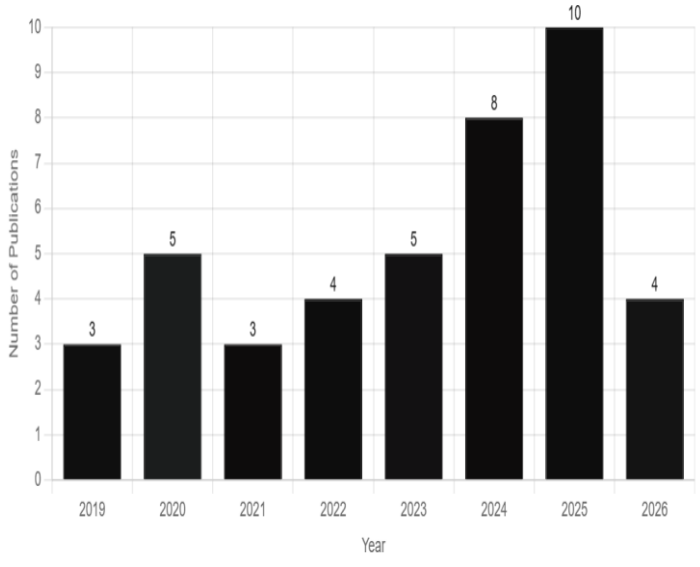

Fig. II. The quantity of articles with respect to years

B. Student Performance Evaluation Models

By employing cutting-edge computational methods, AI-driven systems overcome the limitations of conventional approaches for evaluating student performance in real-time. This part of the review paper presents a quantitative evaluation and thorough analysis of current systems for evaluating student performance based on AI, and significant research is methodically reviewed from 2019 to 2026 in table I.

Table I. Comparison of Existing Ai Models

Reference	Year	Objective	Dataset	Dataset size	Method	Accuracy
(Ahmed, 2024) [16]	2024	To predict the performance of students with ML methods	Student data from Kombolcha Institute of Technology and Wollo University	32582	SVM	96%
(Liu et al., 2020) [17]	2020	To create a deep knowledge tracing system using attention enhancement and multiple attribute integration for student performance evaluation	ASSISTment intelligent tutoring system data	338001	Multiple feature fusion attention mechanism enhanced deep knowledge tracking	98%
(Kala et al., 2024) [18]	2024	To use a hybrid approach for predicting student achievement depending on their educational abilities	Student data from the State University of Turkey	1268	PSO and DNN	63.3%
(Sarker et al., 2024) [19]	2024	To examine Bangladeshi higher student achievement using educational data mining approaches	Student college data and synthetic data	1309	Random Forest	92%
(Gotardo, 2019) [20]	2019	To develop a decision tree system for forecasting how students perform in a course	BSIT 2nd year student data	108	J48	91.67%
(Adekitan & Salau, 2019) [21]	2019	To use educational data mining tools to anticipate and assess engineering students' degree	Student data from Covenant University of Nigeria	1841	Logistic Regression	89.19%

		results from their initial 3-years of academic success				
(Al Mayahi & Al-Bahri, 2020) [22]	2020	To assess a student's academic success using ML based system	Student data from the University of Nizwa	550	SVC	88%
(Cruz-Jesus et al., 2020) [23]	2020	To offer a revolutionary method that predicts the educational performance of almost all Portuguese public high school students employing AI approaches	Student data from Portuguese public high schools	110627	Logistic Regression, KNN, SVM, Random Forest, decision trees, ANN and extremely randomized trees	81.1%
(Lincke et al., 2021) [24]	2021	To evaluate students' skills and success in school using ML techniques	Student data collected from the Hypocampus web-based learning platform	300	XGBoost and gradient-boosted trees	89.5%
(K et al., 2024) [25]	2024	To create a trustworthy framework that uses hybrid intelligence to forecast the educational achievement of learners at the closing of the term.	Self-collected	998	Reinforcement learning with expert teachers' opinions	79.4%
(Karale et al., 2022) [26]	2022	To create an intuitive user interface that uses ML techniques to estimate how well students perform	Kaggle data set	400	XGBoost, ANN and Random Forest	80.29%
(Balachandar &	2025	To present a novel system	UCI dataset	649	ANN and XAI	76%

Venkatesh, 2025) [27]		called the multi-dimensional Student Performance Prediction Systems, using DL attribution optimization and data pretreatment methods.				
(Chavez et al., 2023) [28]	2023	To suggest and create an ANN system that predicts a student's likelihood of passing a particular course without using sensitive data	Open University Learning Analytics Dataset	32593	ANN	93.81%
(Mahafdah et al., 2024) [29]	2024	To design an AI system to improve student performance analysis, boost student participation with flexible instruction, and improve customized educational suggestions.	Kaggle dataset	34	CNN	95.1%
(Chen et al., 2022) [30]	2022	To propose an innovative structure for transparent student performance prediction using DL	Student data from Gadjah Mada University of Indonesia	977	CNN+LSTM	91%
(Islam et al., 2025) [31]	2025	To suggest an EDM model that combines XAI and ML to categorize student academic achievement	Online Student Academic Performance dataset	4424	XGBoost	83%

(Hasib et al., 2022) [32]	2022	To provide a system that uses ML approaches to predict students' achievements in secondary education	UCI dataset	1044	SVM	96.89%
(Hou & Chen, 2026) [33]	2026	To create an equitable and comprehensible algorithm for forecasting high school student achievements	UCI student performance dataset	1044	XGBoosting and SHAP	85%
(Alsubhi et al., 2023) [34]	2023	To determine the attributes that most influence a student's performance using ML	Student data from the Public University of Jeddah	250	SVM	93%
(Al-azazi & Ghurab, 2023) [35]	2023	To offer an ANN and LSTM based day-by-day multi-class system to estimate the performance of students	OULAD dataset	32593	ANN+LSTM	70%
(Zhang et al., 2025) [36]	2025	To create personalized early estimation system that emphasize accessibility, comprehensibility and useful action assistance, and precisely predicts student achievements	Student data from Carnegie-Classified R-1 university	384	CNN	74.5%
(Haron et al., 2025) [37]	2025	To construct a forecasting tool capable of tracking and analyzing the continuous	UPTM student records	150	RepTree Decision Tree	95.50%

		progress of the students.				
(Johora et al., 2025) [38]	2025	To demonstrate an innovative method for applying an XAI methodology to forecast university students' performance	Self-collected	872	Stacking Ensemble Classifier	86.38%
(Qiang et al., 2026) [39]	2026	To suggest an interpretable NN structure that incorporates data from academic fields to enhance the predicted performance and explainability of student accomplishment systems	UCI dataset	395	ANN+SHAP	64.7%
(Aljubaily & Ali, 2025) [40]	2025	To enquire into the viability of using AI methods to predict college students' final academic success	Student records from Imam Mohammad ibn Saud Islamic University	734	Ridge Regression	96.2%
(Adefemi et al., 2025) [41]	2025	To develop a DL system that can predict students' academic achievement	HEI, XAPI and HEST datasets	5049	CNN + BiGRU	97.48%
(Kalita et al., 2025) [42]	2025	To estimate student performance using a DL system with a Bi-LSTM network	Student records from a Middle Western University	6500	BiLSTM	88.23%
(Petra et al., 2026) [43]	2026	To create a hybrid model to assess the performance of students using ML approaches	Student data from the Malaysian Public University	415	Fuzzy C-means + Linear Regression + Subtractive Clustering	85%

IV. Discussion

This statistical review demonstrated that AI-driven student performance evaluation systems have clearly advanced, especially with respect to experimental complexity, size of data sets and predicted accuracy. With an accuracy 98% and employing a huge database, study [17] shows that predictive efficiency rises where varied and broad data are provided. Similarly, publications [30] and [41] have shown that DL and hybrid techniques such as BiGRU, LSTM and CNN regularly exceed the performance of classic ML systems by incorporating complicated as well as dynamic learning models. Excellent performance is not always achieved, though. Certain hybrid approaches, like study [18] and [39], show that attribute characteristics, size of data set, along with pretreatment methods have a significant impact on system success. Conventional approaches such as decision trees and SVM continue to be successful, with some instances of accuracy above 90 percent, particularly when dealing with highly organized data. Furthermore, a rising focus on understanding as well as transparency is seen in the incorporation of XAI approaches. Ultimately, the results of this review paper indicate that even though sophisticated systems operate better, the design of attributes, high-quality data and testing methods continue to be key components of successful outcomes.

Meanwhile, a significant disparity among the studies under consideration was found during the study collection procedure. It was difficult to make a straight comparison since various investigations reported results employing varying standards, resulting in discrepancies in evaluation criteria. Moreover, disparities in expected outcomes were caused by a variety of methods for extracting features and varying interpretations of students' performance. Additionally, there was a lot of methodical diversity because of several equipment formats, acquisition techniques, preparation workflows and different AI approaches were used in the research, thereby impacting the standard of data and the functionality of the models. Since the absence of uniform reporting systems continues to be a major obstacle to obtaining accurate quantitative analysis throughout research, the retrieved data were rigorously processed and analyzed in perspective to deal with such problems.

V. Conclusion

Predicting student achievement can help teachers determine areas where students need to improve in order to raise grades, as well as improve education. The goal of this investigation was to examine the most recent AI models and factors that have been employed to forecast educational achievement in students. 43 publications between 2019 and 2026 were considered in this evaluation. As a result, this analysis indicated a significant increase in current research in this area. According to this paper, DL and hybrid models, especially algorithms that combine historical and diverse data, show the best predicted accuracy. Additionally, excellent results are shown by conventional ML and ensemble learning algorithms, particularly in organized data sets with low dimensionality. In order to facilitate reliable evaluation of algorithms, additional studies must concentrate on creating uniform assessment systems. To guarantee openness as well as equity in academic decisions, more focus must be placed on ethical and XAI frameworks.

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