African Journal of Emerging Issues
Peer reviewed | Double blind | Interdisciplinary

African Journal of Emerging Issues
(AJOEI)
Online ISSN: 2663 - 9335
Available at: https://ajoeijournals.org

TECHNOLOGY AND
INNOVATION

CRITICAL LITERATURE REVIEW ON CURRENT STATE-OF-THE ART IN PREDICTING STUDENTS' PERFORMANCE USING MACHINE LEARNING ALGORITHM IN BLENDED LEARNING ENVIRONMENT

[1*]Francis Ofori, [2]Dr. Abraham Matheka & [3]Dr. Elizaphan Maina

[1]PhD Candidate, Kenyatta University

[2]Lecturer, Kenyatta University

[3]Lecturer, Kenyatta University

***Email of the Corresponding Author: apoe12@yahoo.com**

Publication Date: August 2023

ABSTRACT

Background of the study: Predicting and analyzing the performance of the student in a blended learning environment is important to help educators identify poor performing students and improve their academic score. Meanwhile, achieving accurate predictions require selecting machine learning techniques that can produce optimum score. However, there seems to be no critical literature review on current state of art in predicting students' performance using machine learning algorithms in blended learning environment.

Methodology: This critical literature review focuses on, studies on the current state of the art in predicting students' performance in the blended learning for past 10 years, sources of dataset used by various authors and the machined learning algorithm with high prediction accuracy.

Findings: Naïve Bayes was the most frequently used algorithm for predicting students' performance. Authors mostly used online data for their student's performance prediction. Finally, artificial neural network was found to give higher prediction accuracy of 98.7%.

Keywords: *Students' Performance, Machine Learning Algorithm, Datasets, Moodle, LMS, Blended Learning*

1. INTRODUCTION

The early prediction of student performance is useful for taking necessary correction measures in terms of learning and teaching approaches (Kumar et al., 2019). Understanding the trend of students' performance from past academic data is one of the most popular applications of educational data mining; therefore, it is a valuable source of information for educational policymaking (Buenaño-Fernández et al., 2019). A high prediction accuracy of student performance is helpful in identifying low-performing students at the beginning of the learning process. According to Hussain et al. (2019), the prediction of students' success helps education institutions adjust learning and teaching methodologies by identifying instructional methods that suit students from various socioeconomic backgrounds.

Researchers are resorting to using machine learning algorithms to predict and track student performance (Umer, et al., 2017). A machine learning algorithm is a method by which the Artificial Intelligent system performs its task, generally predicting output values from the given input data (Sandra et al., 2021). Many machine learning models exist today, including decision trees, artificial neural networks (ANN), logistic regression, naive Bayes, support vector machines, random forest, K-nearest neighbor, linear regression, stochastic gradient descent binary classifiers, K-Means, Dimensionality Reduction Algorithms and others.

The COVID-19 pandemic led to the closure of universities and colleges throughout the world, with the hope that public health officials' suggestions for social distancing would help flatten the sickness curve and reduce the overall mortality from the outbreak (Alturki & Aldraiweesh, 2021). To reduce the spread of the disease, many learning institutions have introduced a blended learning model that involves online and face-to-face interactions between tutors and students. Online learning was implemented using a Learning Management System (LMS). A learning management system is a software owned and managed by an educational institution where lectures post learning materials and students' login to access the materials. Students can access tutorials, assignments, quizzes, and chat with their lecturers/tutors. Predicting student performance in a blended learning environment requires important variables in both face-to-face and LMS activities. The variables include class attendance, availability of the Internet, and access to electricity, access to learning and teaching materials, assignment attempts, chats etc. The LMS activities include the number of

hours students attend online lectures, how often students download lecture notes and submission of assignments (Ahmed & Mesonovich, 2019).

Currently, there seems to be no critical literature review on the current state of the art in predicting student performance using machine learning techniques in a blended learning environment. It is expected that the outcome of this study can provide insight into the current state of the art in predicting students' performance using machine learning algorithms in a blended learning environment. This study focused on important studies from 2013 to 2023.

1.1 RESEARCH OBJECTIVES

1. To explore the current state of the art in predicting students' performance using machine learning algorithms in the blended learning environment for the past 10 years
2. To find out sources of datasets used by various authors to predict student performance
3. To find out the machine learning algorithm with high prediction accuracy

2.0 MACHINE LEARNING TECHNIQUES

The term machine learning is often referred to as an analytic process designed to discover data patterns and relationships between data variables. Moreover, a key feature of machine learning is the capacity to analyze complex nonlinear relationships, given that complex input variables are expected (Yadav & Pal, 2012). Depending on the applicability of the data collection and the goals of the data analysis process, many machine learning models, including classification, clustering, and association rule mining, can be used to analyze the data. Machine learning is helpful in monitoring and analyzing the learning process in schools; predicting learners' performance by offering necessary academic assistance, academic guidance, and mentoring; examining the efficiency and effectiveness of learning methods; providing meaningful feedback for teachers and learners; and changing learning environments for the benefit of students (Hussain et. al, 2019). Examples of machine learning algorithms includes decision tree, Naïve bayes, support vector machine and artificial neural networks.

2.1. Classification of machine learning algorithms

Machine learning algorithms can be classified based on supervised, unsupervised and reinforcement learning.

2.1.1. Supervised machine learning algorithm

An algorithm, known as supervised learning, learns from labeled training data to predict results from unforeseen data (Bhutto et al., 2020) It is suitable for problems involving classification (using algorithm to accurately assign test data into specific categories) and regression (using algorithm to comprehend the relationship between dependent and independent variable). Examples of supervised algorithms includes, Logistic Regression, Random Forest, Naïve Bayes and Support Vector Machine.

2.1.2. Unsupervised machine learning algorithm

Unsupervised machine learning is a self-organized learning that helps find previously unknown patterns from unlabeled data (Kehinde et al., 2022). It discovers patterns that help solve for clustering (grouping unlabeled data based on their similarities or differences, association) and association problems (using different rules to find relationships between variables in a given dataset). Examples includes hierarchical, k-means and Gaussian mixture models.

2.1.3. Reinforcement machine learning

Reinforcement learning is a machine learning technique that trains model to respond to actions in an environment to maximize rewards or minimize penalties based on feedback (Kim et al., 2022 & AlMahamid & Grolinger, 2021). Examples includes State-action-reward-state-action (SARSA), Q-learning, Deep Q-Networks (DQN)

2.2 Related literature review

Fahd et. al. (2021) conducted research on Predicting student performance in a blended learning environment using learning management system interaction data. The study performed analysis of data generated from student interaction with learning management systems (LMSs) in blended learning (BL) environments. The study developed a new approach harnessing applications of machine learning (ML) models on a dataset that is publicly available, relevant to student attrition to identify potential students at risk. The dataset consisted of the data generated by the interaction of students with LMS for their BL environment. The study found that identifying students at risk through an innovative approach promotes timely intervention in the learning process, such as for improving student academic progress. To evaluate the performance of the proposed approach, the accuracy was compared with other representational ML methods. From the study, random forest

had an accuracy of 85% which was the highest among the algorithms tested, hence, was selected to support educators in implementing various pedagogical practices to improve students' learning.

Buschetto et al. (2019) undertook a study on predicting students' success in a blended learning environment by evaluating different interactions from Learning Management Systems. The researchers presented a comparative study aimed to find the best combination of datasets (set of variables) and classification algorithms. Data was collected from Moodle logs of Introductory Programming courses of Information and Communication Technologies (ICT) undergraduate program at the Federal University of Santa Catarina (UFSC). The data collected was used to generate 13 distinct datasets based on different aspects of student interactions (cognitive presence, social presence and teaching presence) inside virtual environment. The results showed that there is no significant difference between models generated from the different datasets and that the counts of interactions together with derived attributes were sufficient for the task. The performances of the models varied for each semester, with the best of them being able to detect students at-risk in the first week of the course with AUC ROC from 0.7 to 0.9. Moreover, the use of SMOTE to balance the datasets did not improve the performance of the models.

Conijn (2016) conducted research on students' performance prediction in a blended learning environment using machine learning algorithm. The researchers provided an overview of the theoretical arguments used in learning analytics research and the typical predictors that have been used in recent studies. They analyzed 17 blended learning courses with 4,989 students in a single institution using Moodle LMS. Student performance were predicted from LMS predictor variables using both multi-level and standard regressions. The analyses showed that the results of predictive modeling, notwithstanding the fact that they are collected within a single institution, strongly vary across courses.

Dervenis et al. (2022) undertook research to predict students' performance using machine learning algorithms. The researchers took into account both past semester grades and socioeconomic factors using the Student Performance Data Set from the University of California, Irvine (UCI) repository, which is publicly available at (https: //archive.ics.uci.edu/ml/datasets/student + performance). Classifiers such as KNN, SVM, and random forest were used. The researchers ran two models: a 2-class model, which predicted a "pass" or "fail" result, and later expanded it to a 5-class model,

where they predicted grading group that a student will fall in the next semester. The results showed accuracy of 90.5% for Random Forest, 87.1% for KNN, and 82.2% for SVM, respectively.

Ashraf, Anwer and Khan (2018) conducted a study looking at the present state of the art in predicting learners' performance utilizing data mining procedures. The motivation behind the paper was to determine the frequently used attributes for prediction of learners' performance and determine which parameters are ideal to further develop the prediction model in the school system. The prediction accuracy was highest with Alternating Decision Tree (ADTree) (97.30%), followed by non-Nested generalization (NNge) (96.90%), One Rule (OneR) (93.70%), logistic regression (83.88%), J48 (82.30%), Naïve Bayes (77%), iterative dichotomiser 3 (ID3) and C4.5 (75.15%) in that order.

Agrawal, Vishwakarma, and Sharma (2017) intense on the present state of the art by utilizing a machine learning classifier to foresee undergraduate students' performance. Four classifiers were utilized for the students' performance prediction. They includes decision tree, random forest, Naive Bayes, and rule reduction. Various algorithms showed various precisions. The datasets were examined and utilized to forecast the learners' upcoming grades and key characteristics (such as availability of Internet, study period, and so on) which influence the students' academic performance. The outcomes uncovered the precision expectation of student performance with 90.00% precision by decision trees, 84.00% precision by Naive Bayes, 85.00% precision by random forest and 82.00% precision by induction rule.

Gerritsen (2017) embraced a review to forecast student performance utilizing neural network. A Moodle log document including log data from around 4601 students in approximately 17 undergraduate programs served as the study's dataset. The research tried to access the performance of neural network against the other classifiers. With an accuracy score of 66.1 percent, the Neural Network performed better than the other classifiers, while Logistic Regression came in second with a score of 62.4 percent. The study came to the conclusion that neural networks did well in prediction compared to k-Nearest Neighbors, Naive Bayes, Support Vector Machine, Logistic Regression, Decision Tree, and Random Forests. Naive Bayes had a prediction accuracy of 57.1 percent, SVM 59.7 percent, Decision Tree 52.8 percent, and Random Forest 56.8 percent.

Vinod and Bhatt (2019) utilized artificial neural networks to explore learners' performance prediction for postgraduate students. The test results revealed that the anticipated accuracy for

Regression was 12.339%, accuracy for Random Forest was 28.101%, and accuracy for Deep Learning was 97.429%. In the research, it was stated that Artificial Neural Networks demonstrated a more predictable behavior over other classifiers based on prediction accuracy. Moreover, ANN showed excellent qualities, such as efficacy, generality, and simplicity. Hence, ANN is a desirable option for complex and precise model.

Jayaprakash, Balamurugan and Chandar (2018) focused on the present state of the art for learners' performance prediction utilizing the Naive Bayes technique. The data was obtained using feedback rating-scale questionnaire. 2014 academic year dataset from 700 candidates of Blue-Crest College, Ghana was used. The outcome showed that Naive Bayes Algorithm accurately predicted learners performance 92.2 percent of the time within 2 seconds. The outcome from internal examination scores proved that Naive Bayes classifier gave a higher prediction output. This was determined using confusion matrix. This study demonstrated the positive effects of effective application of data mining on student achievement can be effective to discover unseen information from large dataset, which can be utilized by the leaders of educational institutions for policymaking. This enables the schools to foresee the weaker students and set up particular methods to raise their grade. The study identified Naive Bayes as the most effective model in students' performance prediction.

Usman and Adenubi (2013) conducted research using artificial neural network (ANN) model for predicting students' academic performance. In the research, Artificial Neural Networks (ANNs) were used to develop a model for predicting the final grade of a university student before graduating the student. The data used in this study consisted of thirty (30) randomly selected students in the Department of Computer Science, Tai Solarin University of Education in Ogun State, who had completed four academic sessions from the university. Test data evaluation showed that the ANN model is able to correctly predict the final grade of students with 92.7% accuracy. All ANN models used were trained and simulated using Moodle of MATLAB (2008a) software.

Research was conducted by Singh and Pal (2020) on Application of Machine Learning Algorithms to Predict Students Performance. In the research, data from Bachelor of Computer Applications programme, were collected from United Institute of Management, Prayagraj. Also, five different data mining techniques were applied, namely, Passive Aggressive Classifier (PAC), Support Vector Machine (SVM), Linear Discriminant Analysis (LDA), Radius Neighbour Classifier

(RNC) and Extra Tree (ET) and then compare the results of five machine learning algorithms to choose the best performing algorithm. The results obtained showed that, Support Vector Machine (SVM) gave the highest accuracy of 94.86%. These results can be applied on the new coming students to check whether they perform well or not and by knowing the non performing students.

Hussain et al. (2018) conducted research, using machine learning to predict student difficulties from learning session data. The objective of the study was to predict the difficulties that students encounter in a subsequent digital design course session. The researchers analyzed the data logged by a technology-enhanced learning (TEL) system called digital electronics education and design suite (DEEDS) using machine learning algorithms. The machine learning algorithms included an artificial neural network (ANNs), support vector machines (SVMs), logistic regression, Naïve bayes (NB) classifiers and decision trees. The input variables of the study were average time, total number of activities, average idle time, average number of keystrokes and total related activity for each exercise during individual sessions in the digital design course; the output variables were the student(s) grades for each session. The researchers, then trained machine learning algorithms on the data from the previous session and tested the algorithms on the data from the upcoming session. They performed k-fold cross-validation and computed the receiver operating characteristic and root mean square error metrics to evaluate the models' performances. The results show the following prediction accuracies; ANNs was 64%, SVM was 80%, LR was 58%, NB was 40% and DT was 37%. SVM achieved higher accuracy than other algorithms

The table 1 below shows a summary of the various studies reviewed

Table 1: Summary Literature Review

Source	Machine learning algorithms used	High performing Model	Dataset/data source	Prediction accuracy of the high performing model
Fahd et. al. (2021)	Random forest, J48, OneR, NBTree and decision stump	Random forest	LMS (University of California, Irvine)	85%
Dervenis et al. (2022)	SVM, KNN and Random Forest	Random forest	Online	90.5%
Ashraf, Anwer and Khan (2018)	Decision Tree, Naïve Bayes, Multilayer Perceptron Algorithm, Logistic Regression, K-Nearest Neighbor	Alternating Decision Tree (ADTree)	Online	97.30%
Usman & Adenubi (2013)	Artificial Neural Networks	Artificial Neural Networks	Secondary data from Tai Solarin University of Education	92.7%
Jayaprakash, Balamurugan and Chandar (2018)	Naïve Bayes	Naive Bayes	Primary data (Students dataset from Blue-Crest College, Ghana)	92.2
Agrawal, Vishwakarma, and Sharma (2017)	Decision Tree, Random Forest, Naive Bayes,	Naive Bayes	Primary data (Undergraduates' students' data)	85.00%
Gerritsen (2017)	Artificial Neutral Network	Artificial Neural Network	Moodle log (students demographics)	66.1%
Vinod and Bhatt (2019)	Artificial Neural Networks, Regression, Random Forest	Artificial Neural Networks	Online	97.429%.
Singh & Pal. (2020)	PCA, SVM, LDA, RNC and ET	SVM	Institution database (United Institute of Management, Prayagraj.)	94.86%
Hussain et al. (2018).	ANN, SVM, LR, NB and DT	SVM	Students logs	80%
Conijn (2016)	multi-level and standard regressions.	Null	Moodle LMS at Eindhoven University of Technology	Null

3.0 METHOD

This study used a critical literature review method. This method was chosen because, it helped the researchers to explore the current state of knowledge in machine learning algorithms for predicting students' performance in blended learning environment, from 2013 to 2023 published papers.

3.1 Inclusion and exclusion criteria

Empirical studies which were directly relevant to student's performance prediction using machine learning algorithms, published between October, 2013 and March, 2023, were included in this study. Because the researchers wanted journals that had in-depth knowledge about machine learning algorithms for predicting students' performance, only published papers in computer science, Artificial intelligence, information technology, and engineering journals were selected. Examples includes IEEE, Journal of Computer Engineering, journal for Applied Computing and Informatics, International Journal of Engineering Sciences and Research Technology etc. However, studies that were not related to students' performance prediction using machine learning algorithms and published before 2013 were excluded.

3.2 Study selection

Studies were chosen for the first round of screening based on "title and abstract" in relation to the inclusion and exclusion criteria. Studies were chosen for the second stage based on analysis of the "full-text" version. When there were any doubts, studies were also taken into consideration for a full-text review.

4.0 RESULTS AND DISCUSSION

Current state of the art in machine learning algorithms for predicting students' performance

From the empirical data reviewed, several machine learning algorithms have been used by different authors from 2013 to 2023. These include decision tree, Naïve bayes, Support vector machine, random forest and artificial neural networks. Figure 1 below shows the distribution of the various machine learning algorithms that were reviewed in this study.

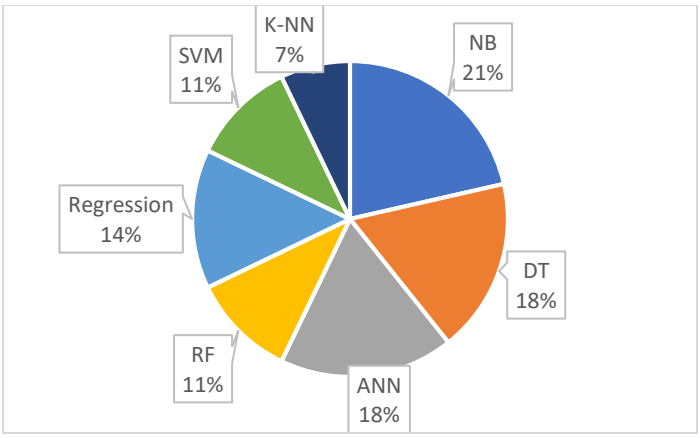

Figure 1: distribution of machine learning algorithms

According to the figure above, Naive Bayes has been used by authors to predict students' performance the most often (21%), followed by Artificial Neural Networks and Decision Trees, each with 18%. Regression has a 14% accuracy rate, followed by support vector machines (11% each), random forests (11%), and k-nearest neighbors (7%).

Sources of datasets to predict student performance

Throughout this study, the researchers explored the various sources of data that have been used by various authors. The figure 2 below shows the distribution of the various sources of data for predicting students' performance reviewed under this study.

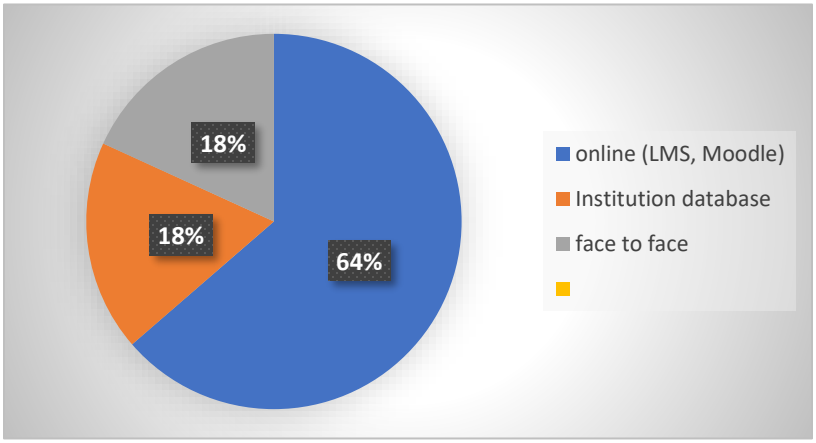

Figure 2: distribution of sources for predicting students' performance

From the figure above, 64% of authors used online data (LMS, Moodle), with face-to-face and institutional databases following closely behind with 18% each.

Machine learning algorithm with highest prediction accuracy

From the studied literature, artificial neural networks had a superior prediction accuracy of 98.5%.

5.0 CONCLUSION

Many machine learning techniques have been applied in recent years to predict students' performance in a blended learning environment. The objectives of this critical review of the literature were to establish the present state of the art in predicting students' performance using machine learning algorithms in a blended learning environment, sources of datasets used, and the machine learning model with higher prediction accuracy. The most popular method for predicting student performance, according to 21% of the papers reviewed, was naive Bayes. Findings of the literature also demonstrated that authors frequently exploited online data to predict students' performance. Artificial Neural Network technique produced the highest prediction accuracy, at 98.7%. The findings of this study can help researchers quickly understand the current state of the art in predicting students' performance using machine learning algorithms in a blended learning environment.

REFERENCES

Agrawal, S., Vishwakarma, S. K., & Sharma, A. K. (2017). Using data mining classifier for predicting student's performance in UG level. *International Journal of Computer Applications*, *172*(8), 39-44.

Ahmed, K., & Mesonovich, M. (2019). Learning Management Systems and Student Performance. *International Journal for E-Learning Security*, *8*(1), 582–591.

Albreiki, B., Zaki, N., & Alashwal, H. (2021). A systematic literature review of student performance prediction using machine learning techniques. *Education Sciences*, *11*(9), 552.

AlMahamid, F., & Grolinger, K. (2021). Reinforcement learning algorithms: An overview and classification. In *2021 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE)* (pp. 1-7). IEEE.

Alturki, U., & Aldraiweesh, A. (2021). Application of learning management system (Lms) during the covid-19 pandemic: A sustainable acceptance model of the expansion technology approach. *Sustainability (Switzerland)*, *13*(19).

Ashraf, A., Anwer, S., & Khan, M. G. (2018). A Comparative study of predicting student's performance by use of data mining techniques. *American Academic Scientific Research Journal for Engineering, Technology, and Sciences*, *44*(1), 122-136

Baashar, Y., Alkawsi, G., Ali, N. A., Alhussian, H., & Bahbouh, H. T. (2021). Predicting student's performance using machine learning methods: A systematic literature review. In *2021 International Conference on Computer & Information Sciences (ICCOINS)* (pp. 357-362).

Bassi,J. S., Dada,E. G., Hamidu, A., A. & Dauda, M., E. (2019). Students Graduation on Time Prediction Model Using Artificial Neural Network, *Journal of Computer Engineering, 21*(3), 28-35.

Bhutto, E. S., Siddiqui, I. F., Arain, Q. A., & Anwar, M. (2020). Predicting students' academic performance through supervised machine learning. In *2020 International Conference on Information Science and Communication Technology (ICISCT)* (pp. 1-6). IEEE.

Buenaño-Fernández, D., Gil, D., & Luján-Mora, S. (2019). Application of Machine Learning in Predicting Performance for Computer Engineering Students: A Case Study. *Sustainability*, *11*(10), 2833-2851.

Buschetto, L. A., Cechinel, C., Batista Machado, M. F., Faria Culmant Ramos, V., & Munoz, R. (2019). Predicting students' success in blended learning—evaluating different interactions inside learning management systems. *Applied Sciences*, *9*(24), 5523.

Conijn, R., Snijders, C., Kleingeld, A., & Matzat, U. (2016). Predicting student performance from LMS data: A comparison of 17 blended courses using Moodle LMS. *IEEE Transactions on Learning Technologies*, *10*(1), 17-29.

Fahd, K., Miah, S. J., & Ahmed, K. (2021). Predicting student performance in a blended learning environment using learning management system interaction data. *Applied Computing and Informatics*.

Gerritsen, L. (2017). Predicting student performance with Neural Network, Tilburg University, Netherlands.

Hussain, M., Zhu, W., Zhang, W., Abidi, S. M. R., & Ali, S. (2019). Using machine learning to predict student difficulties from learning session data. *Artificial Intelligence Review*, *52*, 381-407.

Jayaprakash, S., Balamurugan E. & Chandar, V. (2018). Predicting Students Academic Performance using Naive Bayes Algorithm**,** BlueCrest College Accra, Ghana.

Kehinde, A. J., Adeniyi, A. E., Ogundokun, R. O., Gupta, H., & Misra, S. (2022). Prediction of students' performance with artificial neural network using demographic traits. In *Recent Innovations in Computing: Proceedings of ICRIC 2021, Volume 2* (pp. 613-624). Singapore: Springer Singapore.

Kim, H., Ko, S., Kim, B. J., Ryu, S. J., & Ahn, J. (2022). Predicting chemical structure using reinforcement learning with a stack-augmented conditional variational autoencoder. *Journal of Cheminformatics*, *14*(1), 83

Olaniyi, A. S., Kayode, S. Y., Abiola, H. M., Tosin, S. I. T., & Babatunde, A. N. (2017). Student's Performance Analysis Using Decision Tree Algorithms. *Annals. Computer Science Series*, *15*(1), 55-62.

Oloruntoba, S. A., & Akinode, J. L. (2017). Student academic performance prediction using support vector machine. *International Journal of Engineering Sciences and Research Technology*, *6*(12), 588-597.

Sandra, L., Lumbangaol, F., & Matsuo, T. (2021). Machine Learning Algorithm to Predict Student's Performance: A Systematic Literature Review. *TEM Journal*, 10(4), 1919-1927.

Sekeroglu, B., Dimililer, K., & Tuncal, K. (2019). Student performance prediction and classification using machine learning algorithms. In *Proceedings of the 2019 8th International Conference on Educational and Information Technology* (pp. 7-11). ACM.

Shaziya, H., Zaheer, R., & Kavitha, G. (2015). Prediction of students' performance in semester exams using a Naïve Bayes classifier. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(10), 9823-9829.

Singh, R., & Pal, S. (2020). Application of machine Learning Algorithms to predict students' performance. *International Journal of Advanced Science and Technology*, *29*(5), 7249-7261.

Soule, P. (2017). Predicting Student Success: A Logistic Regression Analysis of Data from Multiple SIU-C Courses.

Sultana, M., J. Rani,U. & Farquad, M.A.H. (2019). Student's Performance Prediction using Deep Learning and Data Mining Methods, *International Journal of Recent Technology and Engineering*, 8(1S4), 1018-1021.

Swamy, M. N., & Hanumanthappa, M. (2012). Predicting academic success from student enrolment data using decision tree technique. *Int. J. Appl. Inf. Syst*, *4*(3), 1-6.

Umek, L., Tomaževic, N., Aristovnik, A., & Keržic, D. (2017). Predictors of Student Performance in a Blended-Learning Environment: An Empirical Investigation. *International Association for Development of the Information Society*.

Usman, O. L., & Adenubi, A. O. (2013). Artificial neural network (ANN) model for predicting students' academic performance. *Journal of Science and Information Technology*, *1*(2), 23-37.

Vinod K. P. & Bhatt, V. K. K. (2019). Performance Prediction for Post Graduate Students using Artificial Neural Network, *International Journal of Innovative Technology and Exploring Engineering*, 8(7S2),446-454.

Yadav, S. K., & Pal, S. (2012). Data mining: A prediction for performance improvement of engineering students using classification. *arXiv preprint arXiv:1203.3832*.