Machine Learning Algorithms for Transforming E-learning Systems in HEIs

[1] Meera Joseph, [2] Farshida Jahoor, [3] Tebogo Rakgogo

[1] [2] [3] Varsity College, Independent Institute of Education
Corresponding Author Email: [1] mjoseph@iie.ac.za, [2] fwania@iie.ac.za, [3] trakgogo@varsitycollege.co.za

Abstract— During the COVID-19 pandemic, learners sought a flexible way of learning online in the comfort of their homes, and e-learning systems became very popular. Lecturers can provide learners with course content and training systems through e-learning. Lecturers use the main features such as grading systems, predicting learner performance, uploading course contents, and creating assessments. Machine learning and AI can transform e-learning systems for effective use by lecturers and learners in HEIs. The learners' learning styles, learning interests, and learner performance can be monitored through these learning systems. A qualitative content analysis will explore which machine-learning algorithms and techniques were used in e-learning systems and their purpose. Machine learning algorithms such as Reinforcement learning can assist with providing personalized learning material according to preferences, while other algorithms used are multilayer perceptron (MP), random forest (RF), K-nearest neighbor (KNN), support vector machine (SVM) and naïve Bayes (NB). Some classification algorithms can predict learners' learning styles in the Higher Educational Institutions (HEIs). K-Nearest Neighbor (KNN) and SVM have been used to predict student performance which is one of the features of a learning management system. Some studies indicated SVM has the best prediction results. One of the issues with using e-learning systems is that lecturers and learners should have the skills to use the technology.

Index Terms— Content analysis, E-learning systems, KNN, machine learning, SVM.

I. INTRODUCTION

E-learning systems help lecturers understand learners' learning interests, and learning styles and monitor their performance. Moreover, lecturers use features in e-learning systems to create and grade assessments, upload course content, and provide other training systems. The learners use mainly the online course content and other assessment tabs. MS Teams and Collaborate are incorporated or linked in some of the e-learning systems which helps the learners and the students to collaborate. Machine learning algorithms can be used effectively to transform e-learning systems in HEIs. E-learning systems adoption before and during COVID-19 [1] and how learning styles, learning interests, and learner performance can be monitored is of great significance.

The main research question is: How can machine learning algorithms be used for transforming e-learning systems in HEIs? In this paper, we used qualitative content analysis to explore which machine-learning algorithms and techniques were used and their purpose in e-learning systems. Machine learning algorithms can predict learning style and student performance. A dropout prediction method to accurately identify dropout-prone students in the e-learning course is presented in [2]. A machine learning-based improved recommendation model for E-learning is presented in [3]. Extensive literature on machine learning algorithms, their use in e-learning systems, the methodology and results, and discussions will follow in the coming sections.

II. LITERATURE REVIEW

A. Machine learning algorithms

Machine learning algorithms help to get new data insights, and predict outputs from a given set of input variables. The main categories of machine learning algorithms are supervised, unsupervised, semi-supervised, and reinforcement learning. Supervised learning tries to model relationships and dependencies between target prediction output and input feature. Some of the common algorithms related to this are Naïve Bayes, nearest neighbour, decision trees, linear regression, Support Vector Machine (SVM), and neural networks. Unsupervised learning algorithms help to find patterns, structure or relationship within a dataset using unlabeled datasets. The types of common algorithms related to this are k-means clustering and Association rules. Reinforcement learning is where the agent learns to make successive decisions by interacting with its surroundings.
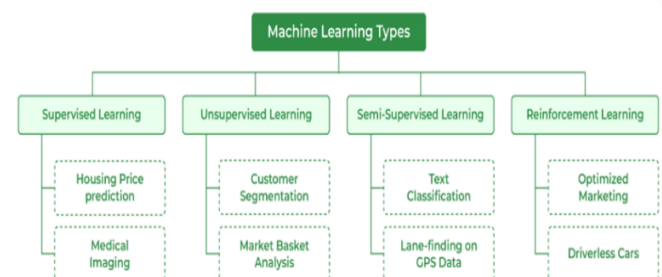

Figure 1. Machine Learning types

In Figure 1 [4] various types of machine learning algorithms are provided. Supervised learning helps make predictions or classifications on new, unseen data. For example, supervised learning can be used to predict housing prices while unsupervised learning can be used for market basket analysis.

B. Machine learning algorithms for e-learning systems

In [5] the other researchers provide a review of the machine learning-based recommendation systems for e-learning. Dropout prediction in e-learning [2], predicting student performance [6], and classification of student performance [7] are some of the ways machine learning algorithms and techniques could transform e-learning systems. In [8] the researchers provide an overview of machine learning technologies and their use in e-learning. Other authors suggest the factors affecting the acceptance of e-learning, using a machine learning algorithm approach [9]. In [1] their paper authors present e-learning systems adoption before and during the COVID-19. KNN is used to recognize real-time student emotional status [10].

III.   RESEARCH METHODOLOGY

This research used a qualitative method. Content analysis [11];[12] was used in this study as it helps identify patterns and helps interpret and understand qualitative content. Convenience sampling was used and reputed publications between 2009-2024 were selected for qualitative content analysis.

Qualitative content analysis was used for data collection and analysis. Figure 2 [13] illustrates a framework for content analysis. The main components are the body of text to analyze, the research question, the context, the analytical construct, inferences to answer the research question and the validating evidence. Qualitative content analysis is used for data collection and analysis of journal articles.
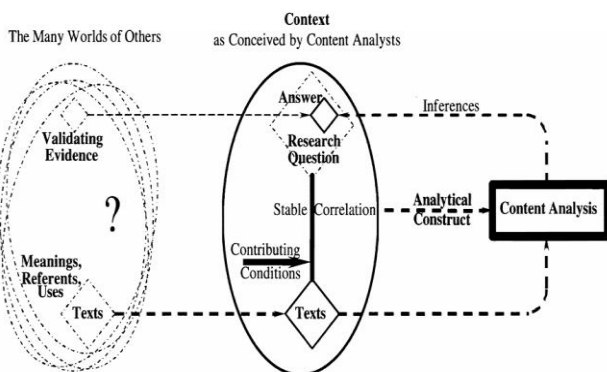

Figure 2. A framework for content analysis

IV.   RESULTS AND DISCUSSION

Based on content analysis of reputed credible conference publications and journals, we explore which

machine-learning techniques were used and their purpose in e-learning systems. Reputed publications between 2009-2024 were selected to analyze the machine learning algorithms those authors used and their purposes (as in Table 1). A single machine-learning algorithm may not accurately classify some e-learning systems [2], so many reputed authors used a variety of algorithms and techniques as in Table 1. Machine learning algorithms are useful for student performance prediction [6]; [14], dropout prediction in e-learning courses [2], and for recognizing real-time student emotional status [10].

Table 1: Machine learning algorithms used and purpose

Citation	Machine learning algorithm/ techniques used	Purpose
Sekeroglu et. al., 2019 [7]	Backpropagation (BP), Support Vector Machine (SVM), Gradient Boosting Classifier (GBC)	Classification of student performance
Lykourentzou et al., 2009 [2]	Feed-forward neural networks, support vector machines, and probabilistic ensemble simplifed fuzzy ARTMAP	Dropout prediction in e-learning courses
Aymane et al., 2024 [6]	Gradient Boosting Regressor	Predicting student performance Also individual learning style
Liu et. al., 2022 [10]	K-nearest neighbours (KNN)	To recognize real-time student emotional status

V.   CONCLUSION

In this paper, we discuss various machine-learning algorithms used in e-learning systems. We discuss the pros and cons of e-learning systems. Online learning platforms can cause social isolation and learners and lecturers need sufficient technology skills to use these systems. Some of the popular machine-learning algorithms used for e-learning systems are multilayer perceptron (MP), random forest (RF), K-nearest neighbor (KNN), support vector machine (SVM), and naïve Bayes (NB). SVM has the best prediction results when it comes to predicting student performance.

REFERENCES

[1] Abdelfattah, F., Al Mashaikhya, N.Y., Dahleez, K.A. and El Saleh, A. 2024. A systematic review of e-learning systems adoption before and during the COVID-19. *Global Knowledge, Memory and Communication*, *73*(3), pp.292-311.

[2] Lykourentzou, I., Giannoukos, I., Nikolopoulos, V., Mpardis, G. and Loumos, V. 2009. Dropout prediction in e-learning courses through the combination of machine learning techniques. *Computers & Education*, *53*(3), pp.950-965.

[3] Ezaldeen, H., Misra, R., Alatrash, R. and Priyadarshini, R. 2019. Machine learning-based improved recommendation model for E-learning. In *2019 International Conference on Intelligent Computing and Remote Sensing (ICICRS)* (pp. 1-6). IEEE.

[4] Geeksforgeeks. 2024. Types of machine learning. Available

online: https://www.geeksforgeeks.org/types-of-machine-learning/ Accessed on 2 August 2024.

[5] Khanal, S.S., Prasad, P.W.C., Alsadoon, A. and Maag, A. 2020. A systematic review: machine learning based recommendation systems for e-learning. *Education and Information Technologies*, *25*(4), pp.2635-2664.

[6] Aymane, E.Z.Z.A.I.M., Aziz, D.A.H.B.I., Abdelfatteh, H.A.I.D.I.N.E. and Abdelhak, A.Q.Q.A.L. 2024. Enabling Sustainable Learning: A Machine Learning Approach for an Eco-friendly Multi-factor Adaptive E-Learning System. *Procedia Computer Science*, *236*, pp.533-540.

[7] 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.

[8] Farhat, R., Mourali, Y., Jemni, M. and Ezzedine, H. 2020. An overview of machine learning technologies and their use in e-learning. In *2020 International Multi-Conference on: "Organization of Knowledge and Advanced Technologies" (OCTA)* (pp. 1-4). IEEE.

[9] Lu, D.N., Le, H.Q. and Vu, T.H. 2020. The factors affecting acceptance of e-learning: A machine learning algorithm approach. *Education Sciences*, *10*(10), p.270.

[10] Liu, X. and Ardakani, S.P. 2022. A machine learning-enabled effective E-learning system model. *Education and Information Technologies*, *27*(7), pp.9913-9934.

[11] Krippendorff, K. 2012. Content Analysis: An introduction to its methodology (3rd ed.). Thousand Oaks, CA: Sage.

[12] Stemler, S.E. 2015. Content analysis. *Emerging trends in the social and behavioural sciences: An Interdisciplinary, Searchable, and Linkable Resource*, pp.1-14.

[13] Krippendorff, K. 1989. Content analysis. *International encyclopedia of communication*, *1*(1), pp.403-407.

[14] Ahmed, E. 2024. Student Performance Prediction Using Machine Learning Algorithms. *Applied Computational Intelligence and Soft Computing*, *2024*(1), p.4067721.