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APPLICATION OF MACHINE LEARNING IN EDUCATION: RECENT TRENDS CHALLENGES AND FUTURE PERSPECTIVE

Abdulgaffar Abubakar Yahaya[1], Faisal Rasheed[2], Babangida Salisu Muaz[3], Usman Haruna[4], Abbas Sani[5], Ismail Abubakar Yahaya[6], Aliyu Hamza Idris[7], and Bashir Muhammad Ahmad[8]

[1,3,4,5] MSc Students, Department of Computer Science, Mewar University Rajasthan, India.

[1]Email: abdulgaffarabubakar40@gmail.com; [3]Email: babamuazu5050@gmail.com

[4]Email: usmanbabany@outlook.com; [5]Email: avvassani@gmail.com

[2]Assistant Professor, Department of Computer Science, Mewar University Rajasthan, India.
Email: faisal@mewaruniversity.co.in

[6]Graduate Estam Formation University Cotonou, Republic of Benin.
Email: ismailabubakaryahaya@gmail.com

[7]Graduate Ahmadu Bello University Nigeria.
Email: hamzattooh@gmail.com

[8]Nigerian Building and Road Research Institute.
Email: bashir1348@gmail.com

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ABSTRACT: *In recent times, Machine learning (ML) is one of the most valuable fields of artificial intelligence (AI) that is transforming education. The application of ML in education provides a promising benefit both to the scientists and researchers and this is the focus of this study. This paper reviews recent trends and advancements of ML in education focusing on areas such as personalisation of learning, predictive analytics, plagiarism detection, intelligent tutoring systems, gamification of learning and recommendation systems. After conducting the literature review we found out the current benefits and challenges of ML in education. The paper also provides insight into the applications and provide the recommendations to address the challenges of ML in the field of education.*

KEYWORDS: Machine Learning, Artificial Intelligence, Intelligent Tutoring System, Recommendation System, Personalization, Applications, plagiarism detection.

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INTRODUCTION

ML is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without being explicitly programmed [1]. ML is a subset of AI that helps or teaches computers how to learn and make intelligent decisions from previous data. With machine learning the computer does not need to be explicitly programmed but rather it can be allowed to learn on its own. Just like the way we teach children how to differentiate between oranges and bananas or between lions and elephants computers are increasingly able to learn patterns and rules by example. Pattern recognition, education, computer vision, bioinformatics, natural language processing, etc. are some of the fields where ML can be applied.

The goal of this research is to assess the usage and application of machine learning in the education area. Before research has been started, we select the following research questions:

- Research question 1: What are the recent applications of machine learning in the education area
- Research question 2: What are the challenges and future perspectives of Machine learning in education

A comprehensive literature study has been done to get answers to these questions. We used the Systematic Literature Review approach (SLR) to collect primary studies and resources concerning the scope of the research. The main aim was to classify studies that are relevant to our topic and the selected studies were then analysed

This paper is structured as follows: The first section was about the introduction to the topic. In the second section, a literature review of the study was presented. In the third section, the research methodology used in this study was introduced. In the fourth section, we reviewed machine learning and its application in the education area. The fifth section includes a conclusion and challenges of ML in education and future research on the topic.

LITERATURE REVIEW

[2] Investigated how AI has been applied in education and explore its potential research trends and challenges in education. By selecting a total of 100 research papers from the educational research category of the Social Science Citation Index (SSCI) database from 2010 – 2020 the study suggested four research trends including (the internet of things, swarm intelligence, deep learning and neuroscience as well as assessment of AI in education) for further investigation. The final result provides a good insight into the AI technique used in the educational domain that helps to strengthen the theoretical foundation of AI in education.

Also, another study [1] reviewed some of the commonly used machine learning algorithms, models and their applications are presented.

[3] Studied the possibility of improving teaching-learning processes and education management at all levels of the educational context through the application of ML and AI. The databases used for the bibliographic search were Web of Science and Scopus and the methodology applied is based on the PRISMA statement for obtaining and analysing 55 articles

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published in high impact journals between the years 2021 - 2023. The results showed that the studies addressed a total of 33 machine learning and artificial intelligence techniques and multiple applications that were implemented in educational contexts at primary, secondary and higher education levels in 38 countries. The conclusions showed the strong impact of the use of ML and AI. This impact is reflected in the use of different intelligence techniques in educational contexts and the increase of research in secondary schools on AI.

[4] Evaluated the possibility of applying and using machine learning in the education area. The goal was to classify studies in the field of machine learning applications in the education area. The result shows that machine learning can be applied in four ways in the education area as follows: Grading students, improving student retention, predicting student performance, and testing students.

[5] Provided a comprehensive overview of the evolution of machine learning to the present day he talks about various ML algorithms, their applications, scope and challenges.

Machine Learning

The emergence of big data, cloud computing, artificial neural networks (ANN), and ML has enabled engineers to create machines that can simulate human intelligence [2]. At its core, ML is a branch of AI that involves the development of algorithms, enabling computers to learn from data and make predictions or decisions without human intervention. This learning process is iterative, allowing the system to continuously refine its understanding and adapt to new information. Machine learning (ML) is used to teach machines how to handle data more efficiently. Sometimes after viewing the data, we cannot interpret the extracted information from the data. In that case, we apply machine learning. With the abundance of datasets available, the demand for machine learning is on the rise [1]. Machine Learning relies on different algorithms to solve data problems. Machine learning algorithms are highly data-driven. They thrive on massive datasets, which can be anything from text and images to numbers and audio recordings. As the algorithm processes this data, it starts to recognise patterns and relationships within the information. The following are some of the commonly used algorithms in ML:

Supervised Learning:

Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs. Under supervised learning, a set of examples or training modules are provided with the correct outputs and on the basis of these training sets, the algorithm learns to respond more accurately by comparing its output with those that are given as input [6]. It infers a function from labelled training data consisting of a set of training examples. Supervised machine learning algorithms are those algorithms which need external assistance.

Unsupervised Learning:

These are called unsupervised learning because unlike supervised learning there are no correct answers and there is no teacher. This technique is appropriate in a situation when the categories of data are unknown. Here, the training data is not labelled. Algorithms are left to their own devices to discover and present an interesting structure in the data. The unsupervised learning algorithms learn a few features from the data. When new data is introduced, it uses the

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previously learned features to recognise the class of the data. It is mainly used for clustering and feature reduction.

Reinforcement Learning:

Reinforcement algorithms are used when a decision is to be made based on past experiences of learning. The machine agent learns the behaviour using trial and error sort of interaction with the continuously changing environment [5]. Reinforcement learning is an area of machine learning concerned with how software agents ought to take actions in an environment in order to maximise some notion of cumulative reward. Reinforcement learning is one of three basic machine learning paradigms, alongside supervised learning and unsupervised learning.

Machine Learning in Education

ML can be considered a part of AI. Machine learning is, at its core, the process of granting a machine or model access to data and letting it learn for itself [4]. Machine learning in education specifically refers to the application of these machine learning algorithms to enhance the teaching and learning experience. By leveraging data on student performance, preferences, and learning styles, machine learning can personalise learning paths, predict areas where students might struggle, and provide educators with valuable insights to improve their instruction.

There are many ways machine learning can be applied in education. According to [4] plenty of business implementations of machine learning exists in the education area which is categorised as follows:

- Predict Student Performance
- Test Students & Grade Students Fairly
- Improve Retention
- Support teachers and institution staff.

In another research by [3] a systematic literature review analysed 55 references on the use of ML and AI in education conducted in 38 countries, with the United States leading the way, from primary school through university levels. The results show that the following intelligent techniques extracted from the studies can be applied in the education sector:

- Detect students' academic performance early
- Improve the educational skills of teachers.
- Facilitate the learning of students with autism spectrum disorders (ASD).
- Predict school dropout and make decisions about it.
- Improve and generate educational content.
- Close educational gaps.
- Implement AI teaching at all educational levels.
- Strengthen the information security of the educational community.

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- Motivate learning through mobile devices.
- Strengthen the field of robotics.
- Improve academic and career guidance for students.
- Prevent the spread of fake news on social networks.
- Understand and reflect on the relationship between humans and machines.
- Develop critical thinking based on computational thinking.

Many applications of machine learning exist in education. According to [7], some of the most impactful benefits of machine learning in education are:

- Personalised Learning
- Early Intervention & Support
- Accessibility & Inclusivity
- Data-Driven Insights for Improvement

Furthermore, Machine learning helps the education industry by providing some impactful applications. According to [8], the ways through which machine learning can be applied in education are:

- Personalised learning
- AI-based Teaching assistance
- Adaptive learning
- Administration of learning processes
- Personal tutor

Applications of Machine Learning in Education

This literature review analysed several sources, articles and references on the use of ML and AI in education. Different ways in which machine learning can be applied in the educational domain have been identified. Many examples of how to apply and use machine earning in education have been proved based on research by [3], [4], [7], and [8].

According to [4], the implementation of machine learning in education is categorised into four groups namely: Predict Student Performance, Test Students & Grade Students Fairly, Improve Retention, Support teachers and institution staff. In addition, this section describes different ways in which ML is applied in education, its advantages, and some studies to support it.

Personalisation of Learning

AI in education is most widely used to personalise learning as noted by the Edtech firms [9]. Personalised learning is a special way to make teaching and training fit the needs of each student. It is a specialised way that enables students to learn at their own pace through special

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training. It supports students' learning goals by allowing them to moderate or change things like the speed at which they learn, the materials they use, the order in which they learn them, the technologies they use, the quality of the materials, the way they are taught, and the materials they use to learn. By leveraging AI technologies, educators can tailor learning experiences to meet the individual needs, preferences, and learning styles of students [10].

Many studies support the application of AI and ML in personalised education. For example, [11] studied the possible ways how to utilise AI-generated characters in the education domain. AI characters can be used to create compelling learning material for all ages, from delivery of content in the classroom to engagement with content at locations like museums, historical monuments or even in nature. In another study by [9], researchers try to investigate how educational technology firms in India are using artificial intelligence to change the ways teachers teach and students learn.

Personalising Education with Machine Learning

Artificial Intelligence is playing a significant role in personalising education for every student [10]. Some of the ways by which AI can be used to personalise education are:

Adaptive Learning: Adaptive learning is an educational approach that utilises technology to provide personalised learning experiences tailored to individual students' needs, preferences, and progress. It leverages data-driven algorithms and artificial intelligence to dynamically adjust the content, the delivery, and the pace of instruction based on learners' performance and engagement. By adapting to the specific requirements of each student, adaptive learning promotes effective and efficient learning, maximises engagement, and enhances educational outcomes. AI-powered adaptive learning platforms analyse student data, such as their performance, strengths, weaknesses, and learning pace. Based on this information, the system can provide personalised learning pathways for each student, offering appropriate content, resources, and activities that align with their specific needs.

Personalised Recommendations: AI algorithms analyse large amounts of students' data, including a student's past performance, interests, and goals, to generate personalised recommendations for educational resources, books, articles, videos, and other learning materials. This helps students discover relevant content that matches their specific needs and preferences.

Natural Language Processing: AI-powered natural language processing (NLP) allows for the development of intelligent chatbots and virtual assistants that can interact with students in a conversational manner. These AI assistants can answer questions, provide explanations, offer feedback, and engage in dialogue to enhance the learning experience.

Intelligent Tutoring Systems

Intelligent tutoring systems are computer systems that can adapt to individual learning needs and provide learning instructions based on the understanding of that student. ITSs can assess student understanding, identify areas of difficulty, and offer targeted explanations, feedback, and practice exercises. They adapt to each student's progress and adjust the learning material accordingly. AI-driven tutoring systems are used to provide individualised guidance and support to students. Intelligent tutoring systems (ITS) provide individualised instruction, by being able to adapt to the knowledge, learning abilities and needs of each student [12].

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Examples of Intelligent Tutoring Systems

There are many ITSs that are available nowadays and they are used to serve a specific function based on the needs of the students. [13] Provide a list of some ITSs and their uses as follows:

Reading English Advanced Learning Program (REALP): This ITS was designed to help student improve their reading comprehension. It provides reader-specific lexical practice by using authentic reading materials that are taken from the web. The system builds a user model according to the student's performance and offers targeted vocabulary exercises to enhance comprehension skills.

Auto Tutor: This ITS is used to teach students about computer hardware, software and the internet in an introductory computer literacy course by simulating the discourse pattern and pedagogical strategies of human tutor.

Eteacher: is an ITS that supports personalised eLearning assistance based on student performance in an online course. It performs a detailed analysis of student performance in an online course and then builds a profile based on the student's learning capability. It then uses the student performance information to design a personalised content that suits the student's understanding

Mathematics tutor: This is another ITS that was designed to help the student learn and solve word problems using fractions, decimals and percentages. It records the success rate while a student is working on a problem and provides level-appropriate problems for the student to work on.

Gamification of Learning

Gamification is the process of incorporating game design elements into non-game contexts in order to engage and motivate the learner. According to [14], a gamified educational system is the act of using game-designed elements in the context of education. The process of gamification is done by making use of different software, video games or computers. The aim of gamification in education is to provide a suitable learning environment that is captivating and improves the engagement of students while learning**.**

Many studies have demonstrated the implementation of gamification and machine learning in education. [14] Presented the use of gamified frameworks, supported by artificial intelligence and machine learning, to enhance student engagement and motivation in learning. The framework was tested and implemented on 120 students from different courses by utilising game mechanics such as challenges, rewards, and competition. It uses the Adaptive Neuro-Fuzzy Inference System (ANFIS) model for intelligent decision-making regarding reward distribution. Final results showed that the gamified framework increased student participation, attendance, and better overall performance in educational settings. [15] Investigated how integrating social learning and gamification techniques can improve student motivation, engagement, and learning outcomes in higher education. They employ the technique of social network analysis and ML algorithms such as logistic regression (LR), linear discriminant analysis (LDA), support vector machines (SVM), and neural networks (NN) in order to predict student success. The overall findings indicate the effectiveness of gamification in education.

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Benefits of Gamification with Machine Learning

According to [15] the act of gamification of the learning path can help increase the motivation and engagement of the students and improve the learning results. Gamification of education through machine learning has many benefits that make learning fun and interactive as mentioned by [16] as follows:

1- It makes learning fun and interactive by creating exciting educational and entertaining content

2- It creates addiction to learning

3- The gamification of learning allows learners to see the real-world applications and benefits of the subject matter. They are able to get a first-hand look at how their choices within the game result in consequences or rewards.

4- Offers real-time feedback

5- Enhance the learning experience

Plagiarism Detection

The process of using someone's work without crediting its author is known as plagiarism. Plagiarism detection is the process of identifying plagiarised content/work. ML has significantly been used to enhance the ability to detect plagiarism by providing powerful methods used in identifying copied or improperly cited content. Various machine learning algorithms like support vector machine (SVM), decision tree (DT), and Naïve Bayes are trained to classify text as plagiarised or non-plagiarised based on the learning patterns.

Various works incorporated machine learning in plagiarism detection in educational settings. [17] Explored the possibility of developing a methodology to detect software plagiarism across different programming languages. By utilising the Principal Component Analysis (PCA) to extract features from source codes without losing crucial information. The normalised principal components obtained from PCA are fed into a Multinomial Logistic Regression model (MLR) to handle multiclass problems, making it suitable for classifying source code documents across multiple programming languages. Findings show that high accuracy and reliability in identifying plagiarised source code have been achieved.

Another study by [18] focuses on computational methods for detecting plagiarism. The research systematically reviews 239 papers published between 2013 and 2018. The aim of the study is to assess the level of advancement in the field, propose new typologies for plagiarism prevention and detection, and identify research gaps. The review focuses on the automated detection of sophisticated and difficult-to-identify forms of plagiarism, highlighting the progress made through improved semantic text analysis, non-textual content feature investigation, and machine learning applications.

Furthermore, [19] proposed a ML approach to detect plagiarism in programming assignments. The model used for the training is XGBoost while the SVM was used for comparison. The result revealed that the XGBoost model demonstrated superior performance with an accuracy of 94% and an F1-score of 0.905, outperforming the SVM model on the given dataset.

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Predicting Students Behaviour

As discussed above, ML is an area of AI that can learn from input (past data) and make decisions or predictions based on that input. It is like teaching the computer to identify some patterns in the input data and then make a guess or prediction about it. Therefore ML has become a useful means of predicting students' activities in school. This includes prediction of students' performance, student at risk, Exam result prediction, student retention and graduation prediction, student drop-out prediction etc. The prediction is done with the help of learning analytics which involves the collection, examination and analysis of students' information in order to reveal certain facts about it. According to [20], Learning analytics is the compilation, measurement and reporting of data about students and their contexts in order to understand and optimise learning and the environments in which it takes place. It also deals with the institutions developing new strategies and involves the collection of student data such as educational records, exam results, student participation in class, age, parent background etc. This data is fed into the ML model and used in predicting student behaviour.

Prediction of student's behaviour with ML involves various processes as follows:

1) Data collection: This phase is concerned with the collection of data to be used by the ML model to make the prediction. Mostly the data can be from student academic achievement to student demography.

2) Data pre-processing: Not all data collected are accurate and free from errors or missing values. This phase involved pre-processing the data by correcting the errors and filling in any missing values.

3) Train-test split: This phase is concerned with splitting the data into two parts which include the train data and the test data. The data can be split into 70% training data and 30% test data or 80% training data and 20% test data.

4) Model Training: Here we select a model like decision tree (DT), Random forest (RF), Neural network (NN) etc. The train data will be fed into the model for training and learning some patterns in it while the test data will be used to test the model in performing the prediction.

5) Prediction: This is the last phase in which the final prediction is performed based on the train data that was fed into the model. Here we use the test data in order to see how the model is going to predict the student performance or behaviour.

Many studies have implemented the ML in prediction of student's behaviour in their work. [21] Analysed a dataset of 15000 students enrolled in different courses of the academic year 2016/2017 and developed a machine learning classifier model using the support vector machine (SVM), random forest (RF) and Linear discriminant analysis. The model can be used to predict dropout of the first-year undergraduate students and to identify the risk of quitting an academic course in the first year or during the student application process.

[20] compared different machine learning algorithms such as Naïve Bayes (NB), K-Nearest Neighbour (KNN), Random forest (RF), support vector machine (SVM) and logistic regression (LR) to predict the final exam grade of the students. The dataset consists of 1854 students who took the Turkish language – I course in a state university during the fall semester of 2019/2020. The proposed model achieved the result of 70 – 75 % prediction accuracy.

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Another research by [22] uses different ML methods to identify students at risk of low achievement who will benefit from the tutor intervention. The dataset involves 4970 instances of undergraduate students in the 2016/2017 academic year at Bangor University. An accuracy of 97% was achieved after combining the different models together.

The benefits of Predicting Students' Behaviour

1. Help to improve the learning/teaching environment

2. Analyse the activities of successful students and those who are at risk of failure, to develop corrective strategies based on student academic performance, and therefore to assist educators in the development of pedagogical methods

3. It helps schools in the efficient use of resources where they are needed

Recommendation System

This belongs to the category of information filtering systems that are designed to predict users' preferences for a certain topic [23]. They try to predict the rating or preference that a user will give to an item. RSs are designed to suggest items or content to users based on their preferences and interests. These systems can be found in various domains such as e-commerce, streaming platforms, social media, etc. [24]. However, in the context of education recommendation systems are used to provide suggestions or personalised recommendations for learning materials based on individual learning interests.

RS are generally based on ML techniques and algorithms and are categorised into 3 according to [23] as follows:

Content-based (CB): Content-based recommendation is based on identifying characteristics that are like those a user has preferred in the past and making recommendations accordingly.

Collaborative filtering (CF): Collaborative filtering recommendation is based on user behaviour or user ratings of recommended items.

Hybrid recommendation (Hybrid RS): is the combination of CB and CF which combines characteristics of both approaches through mergers of individual predictions into one adding content information to a collaborative model or by weighted average of content and collaborative recommendations or getting final recommendations based on the combined rankings.

Several studies attempted the incorporation of machine learning and recommendation systems. [23] Presented a comprehensive review of recommender systems (RS) in the e-learning context. It aims to address the problem of students trying to locate specific information from different online learning materials by utilising personalised recommendation systems. The study tries to categorise the types of recommender systems: Content-Based, Collaborative Filtering, Knowledge-Based, and Hybrid Systems. The final result shows that a taxonomy consisting of essential components for effective recommendation systems in e-learning has been developed.

[24] Explored the application of machine learning in recommender systems by trying to identify recent trends and real-life applications. The study uncovers various domains that can

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utilise recommender systems such as healthcare, e-commerce, digital journalism, education, and manufacturing enterprises aiming to guide researchers in positioning their activities within this domain. Findings show that most of the reviewed papers focused on the educational sectors. This is indicating the importance of the recommender system in the educational sector.

In another study by [25], a recommendation system on educational resources on a distant E-learning platform was introduced by using collaborative filtering and content-based filtering to generate personalised recommendations. It aims to provide a customised learning path for learners by analysing their interaction footprints and recommending relevant educational materials. Results showed the effectiveness of the system in improving the learning process.

Advantages of the Recommender System

The RS has numerous benefits in the educational context be it from the teacher's point of view or from the student's point of view. Some of the benefits of RS are:

1. RS presents the learner with tailored content that caters for the individual strengths, weaknesses and preferences of the student. This is done by utilising technologies such as data mining, data analytics, AI and neural networks (NN) to make insight and personalisation [26].

2. RS helps to create a personalised learning journey where the book isn't just a textbook that is typical for traditional web-based systems but is adapted and unique to each individual. This reduces boredom and helps to boost learners' motivation and engagement as it focuses on relevant content that they need to learn [26].

3. RS helps to alert educators about students needing additional support and guidance. This is achieved by the ability of the system to monitor student progress and identify patterns.

4. RS helps educators save time and effort in searching for resources and the right materials to use. This is possible because the RS provide them with the most effective resources available

Challenges of ML in Education

The implementation of ML in the education domain has proved to be beneficial. However, it is associated with challenges. One of the challenges of ML in education is the lack of resources and capital for implementation especially in the sub-Saharan African areas [27].

Another ethical issue surrounding the use of AI and ML in education is privacy concerns [28]. This is possible because ML algorithms work by using large amounts of data and information to work properly. This data when fall into the wrong hands can result in privacy violations.

Problems also emerge when surveillance systems trigger issues related to autonomy, more specifically, the person's ability to act on her or his own interests and values [28]. This happened as a result of excessive use of the predictive algorithms or systems used in education that deny the teachers or students their right to govern their own lives. The use of algorithms to make predictions about individual's actions based on their information raise questions about fairness and self-freedom [29].

Another issue about the ML algorithms in the case of prediction of student performance or outcomes in schools is that most of the algorithms are practically applied in the developed

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countries most especially the European nations. Also, most of the datasets used are obtained from developed countries. This will not give us a clear view of how the ML algorithms or models are going to perform in developing and underdeveloped countries.

The following efforts are needed to solve the above challenges:

i) Large capital investment should be made in order to implement the ML and AI techniques in the education sector of developing nations

ii) Regarding the privacy issues, the user's data should be collected based on the consent of the owner and informed about how it is going to be used is going to be used

iii) To maintain fairness and prevent bias, excessive use of ML in the prediction of student behaviour should be reduced because; the use of algorithms to make predictions about individuals' actions based on their information raises questions about fairness and self-freedom [29].

Future Direction

The advancements of AI and Machine learning in education are unfolding right before our eyes, unlocking untapped potentials and bridging gaps that once seemed impossible. Machine learning in education is still developing and implemented in different ways that simplify teaching and learning.

In the near future, we can expect machine learning tools and techniques to connect to the internet and continuously retain the most relevant information. This will help in constant retaining of algorithms and there will be no need to train the systems time and again. Personalization could be enhanced and recommendations could be improved leading to more beneficial and successful experiences [5].

Conclusion and Limitation

Machine learning presents solutions to many limitations in the education sector, including academic forecasting, personalisation of learning, plagiarism detection, educational content recommendation etc. thereby assisting the teachers and educational institutions to understand their students' betterment and help them succeed. Although many educational institutions in developing countries seem not ready to adopt machine learning approaches, the changing realities in global education would leave them with no choice but to begin to strategize on how to adopt ML and other emerging technologies. ML and other artificial intelligence solutions have the potential to change the narratives in the education sector. Machines continue to get accepted and incorporated into various domains. Therefore, it is very important to assess its applications in the educational domain as this will help enlighten the researchers and stakeholders to improve the way it is applied in the field.

This review, due to its current subject matter, and broad scope, only studies in English have been analysed. However, it is possible that there is research in ML and AI applied to education in other languages that have not been considered and that could be of interest. Although the Google Scholar, IEEE and Scopus databases have been used to narrow down the study, the research could be extended by consulting other databases, as they could yield interesting results on ML and AI. Our future projects will focus on the development of an ensemble model for academic performance prediction in higher institutions.

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