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A Critical Analysis on the Applications of Machine Learning in Education

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Abstract

A category of artificial intelligence (AI) called ma- chine learning aids machines or educators. Machines make wise judgments based on all the prior facts. Automated learning involves gathering and keeping track of a wealth of data and organizing it into an organized knowledge base for usage in diverse disciplines. By implementing machine learning in the educational setting, instructors can save time in their extracurricular activities. Teachers can, for instance, employ virtual assistants who operate remotely from their homes for their students. This type of support can improve kids' academic performance and progress, and student performance should be improved. Personalized learning is supported by machine learning in reference to distributing education. The field of education now includes machine learning as a new frontier. It may change not just how instruction is given but also how pupils are encouraged to study well. By giving real-time feedback based on unique student behavior and other characteristics, machine learning promises to give customized in-class instruction. The likelihood of better learning increases as a result. By eliminating biases, machine learning also contributes significantly to evaluations and assessments. Machine learning, one of the most powerful recent technologies, controls interactions between humans and artificial intelligence. As a result, machine learning enables computers to discover unprogrammed underlying information. Additionally, machine learning is a significant predictor. The authors of this work provide readers with having extensive knowledge of machine learning-based applications in the education system. A general introduction to machine learning is made, and its application in education domain in presented.

Key Words: *Machine leaning, Supervised learning, Unsupervised learning, Reinforcement learning, Education*

1. Introduction

Computer technology has spread its intervention in each aspect of human life including education. Unlike in the ancient era, where knowledge transfer totally depends on the teacher, today's technology has allowed students to self-learn with a greater variety of platforms. Education is no longer merely based on memorization of textbooks and imparting material. Now education has enhanced to the stage where student outcomes are measured against the input. With the radical revolution of the education systems, being physically present in the classroom is not education anymore. This measurement process has evolved both within and outside of the classroom. Which act as a dynamic ubiquitous component which provides quality education whenever and wherever. Additionally, these practices have developed

into a crucial element that contributes significantly to the expansion of the progress of the learning components of the system,

Improving the primary foundations of the course module and allowing both to be resourceful and effective [1]. Machine learning (ML), which is reinventing education, is drastically changing teaching, learning, and research. Teachers are employing ML to recognize challenging students earlier and take appropriate action to boost success and retention. To make fresh discoveries and get new insights, researchers are expediting their research with ML. Earlier days and in some situations in today's world, the education system behaves in the same way by providing material things to students and hoping they understand and learn concepts through provided lecture materials. The ultimate result of this is evaluating students' competency level by how much capacity they could hold in their memory. The main disadvantage and lifelong drawback are this typical education system cannot measure how much students use this stored memory knowledge to face their daily challenges. Over time this methodology leads to very harmful consequences in terms of the economy as well as socio-behavior.

Machine learning is a now becoming critical technique which helps to identify and measure students' output as per the provided input. These technologies have been developed to measure these attributes not only by subject pass-fail rate but also in terms of emotional intelligence and student retention in a particular field. It is possible to gather a variety of information on a learner's behavior, particularly during learning activities, by using digital learning approaches. The metrics gathered include elements like test outcomes, group discussion activity, completion time, and video views. These measures are suitable in the factors of feature engineering-based machine learning techniques. According to experts, algorithms can identify a connection between a learner's particular behavior and how well they learn. This result is utilized to gauge how effectively a specific machine learning program has operated overall.

1.1 Contribution of the Paper

To the best of our understanding, while many surveys exist that concentrate on the general applications of machine learning, there are very few studies that specifically focus on the crucial applications of machine learning in education. Our study is timely given that there is both industry and academia that have a keen interest in using machine learning applications in education.

1.2 Organization of the Paper

The structure of this paper is as follows: The literature review on machine learning in education is included in Section. Section III provides a description of machine learning and its types. Section IV presents the findings and a thorough analysis in the applications of machine learning in education. Section V brings the paper to a close.

2. Literature Review

The study by [2] aims to distinguish the possible consequences of evaluating e-learning models using AI (Artificial Intelligence) strategies like Supervised, Semi-Supervised, and Reinforced Learning. Which advances by examining the benefits and drawbacks of various organizational ways. Researchers examined the cross-sectional effects of e-learning and machine learning algorithms from 1993 to 2020 in the literature and nature and nature and assessed the importance of e-learning attributes to improve the e-learning frameworks with obtain- able techniques in the Machine learning arena. This evaluation is done by peer reviewing various journals books, and good student articles. Search engines retrieve a total of 300 articles, 121 of which have been chosen to assess the evaluation and features of e- learning. The purpose of the study is to review the literature on machine learning systems' use in evaluating E-Learning parameters. However, the current study's focus is on the survey's subsequent research questions, which are specifically intended to examine the research issues surrounding the creation of models, parameter prediction, and optimization. The e-learning models under examination and review will not be the subject of any research hypothesis.

As per the results, researchers conclude that the highest accuracy wasted by Support Vector Machine algorithm and accuracy rate is 97.15%. After that Fuzzy c-means clustering algorithm delivered a 96.89% rate and e deep learning TensorFlow engine denotes 91% accuracy rate. But survey analysis was used to get the whole feature set. Both benefits and drawbacks are unique to it. It might result in sample, coverage, and non-response mistakes. The actual population is not always represented in analyses based on survey results. The makeup of the online learning community significantly changes depending on where the students are located. Considering this, research accuracy may be affected by the categorization accuracy of ML models based on different research surveys from different countries.

On another research conducted by [3], the article dis- cusses Sri Lanka's secondary education system's use of e- learning. Through a general pattern, which is a Learning Man- agreement System that incorporates a variety of online activities, students and teachers can obtain information, resources, and tools. The chatbot, final grade

prediction, and individual weak area prediction are the three key services offered by the proposed model. The major goal of this study is to help children who switch from English to another language in grade 5 to grade 6. whereas when students switch from Tamil or Sinhala to English as their primary language, they must adjust to a new classroom environment. One of the main outputs of the study will be an e-learning platform that makes it simple and efficient for students and teachers to engage in the teaching and learning process. The research team's interviews with students revealed that their inability to conduct independent study, their inability to instantly contact teachers through the available online study modes, their difficulty understanding where they are in their education, and their practice in overcoming challenging subjects are their principal areas of struggle.

Additionally, the results showed that 98% of the questions had accurate responses. In the future, they want to enhance the e-learning platform and use the suggested approach in a range of circumstances. Students in grade 6 have access to the system. However, compared to an adult, a kid in grade 6 may have slightly less computer literacy. Therefore, it would be ideal if this tool were introduced as a mobile user- friendly application. Additionally, it is preferable to examine the outcomes of each system subcomponent. Because research paper says that an Autoregressive integrated moving average is used to train the model but there is no winning evidence about the accuracy of the trained data set. It gives the system an elevated level of precision. Because, as was already noted, analyzing user experience is crucial since this is being taught to grade 6 pupils.

Today's educational institutions can use predictive analytics with different machine learning algorithms and e-learning modules to improve student retention and success rates as well as get a prior evaluation of student performance before exam to reduce the failure risk. The primary goal of the study is to identify the numerous applications of machine learning in educational institutions, including how those institutions can forecast student performance and identify key factors to consider when making predictions for various outcomes. Ad- additionally, the study contrasts the predictions made by several machine learning algorithms. The ability to learn without the help of human intervention is provided by machine learning. Predictive analytics frequently uses machine learning to create complex algorithms and learning frameworks that tend to produce predictions. These models can aid professionals, data engineers, and researchers in producing trustworthy decisions and rating outcomes [4].

By asking 60 students to complete a two-part online survey, real-time data were gathered from the Thadomal Shahani Engineering College Department of the computer-related school. The first section included questions about fundamentals

and results from the previous year, and the second section of the questionnaire included a set of questions to gauge concentration, information, test-taking abilities, and time management processing power of the pupil. The information is included so the first student can digest knowledge and pass tests. To find the correlation, data were collected and stored in a CSV file. After that, data is normalized using Algorithm Minmax. The purpose of the experiment was to determine the statistical correlation between the learning abilities and psychological variables and the pre-final year outcome. The link between these variables was ascertained using the Pearson coefficient of correlation. Neural networks and support vector machines give the most accurate outcomes of all deployed algorithms for numerical prediction and classifier applications. The size used in this research was quite low. Also, students' grades might impact results. Moreover, sampling size might affect the confidence of the proposed treatment. their factors, including inadequate statistical power, inflated effect size estimates, and inflated false discovery rates, may also have an impact on sample size. When there is fewer initial data and each attribute contributes equally to the final prediction, Nave Bayes can do better than the Decision Tree in classification. Before making a prediction, the genetic algorithm might be a useful technique for extracting pertinent characteristics, learning and predictive analytics. It has been shown to be useful tools for identifying opportunities and addressing systemic flaws in education.

The study [5] uses a nursing e-school to depict the typical e-learning environment. This program am identifying each patient's health issues and uses customized recommendations for each. As a case study diabetic portfolio has been used for detection. A customized plan was created for everyone to detect the diabetic profile, and this module contains the physical activity measurement as well as a nutritious impact of the diet. With the machine learning involvement residual deep neural networks are used to notify diabetic retinopathy. Fundus photographs were taken from people who have diabetic retinopathy for analysis purposes. sample data set was provided by an ophthalmology clinic in Qazvin, Iran. As a key detection attribute, retinal lesions were used from the sample data set. Results analysis observed that residual deep neural network extremely effective at early-stage detection of diabetic retinopathy. Convolution neural networks (CNNs) are utilized by the proposed-nurse system to recognize patterns. The human visual brain served as the model for the CNN (Convolutional Neural Network). Fully connected layers combine an activation function and the sum of input weights, whereas convolution layers mix the activation and convolutional input functions. Fully connected layers combine an activation function and the sum of input weights, whereas convolution layers mix the activation and convolutional input functions. However, there may be some negative effects from employing convolution neural networks for training, such as class imbalance, overfitting, and inflating gradient. The model's efficiency can be raised, and these

problems can be significantly avoided with proper understanding and usage of corrective methods [6]. In addition, a substantial amount of data is needed for training. The number of photos in this research article or paper is not specified. The number of pictures used to create a very realistic model effect gratefully to the proposal's confidence. In addition, extensive cross-validation is required to obtain the ideal hyper parameters. Depending on the application, different values are optimal for hyper parameters.

In the research [7], an experiment has been conducted where data from grade 9 EQAO mathematics examinations from 50 schools in Ontario were correlated using the linear regression technique. The program examined how different- score students responded to a multiple-choice survey at the end of the test. The value of each statement was then evaluated based on the variables produced by the machine learning algorithm; this ranking may then provide insights into how students learn and how to more effectively use resources. This project has demonstrated that even a simple machine learning program may yield insightful information about how students learn, and that more work needs to be done to properly interpret the wealth of educational data. The report contends that using machine learning to analyze educational data in this experiment has several draw- backs. The lack of time to apply for data from the EQAO site led to a tiny data collection, which posted the biggest obstacle to doing statistical analysis.

A concept for an AI-based self-learning platform aiming at enhancing students' listening skills with AI support due to the existing ineffectiveness of College English listening classes has been proposed in the study by [8]. The design idea and functional structure of this AI-based learning platform were inspired by the present application issues with AI- assisted English listening platforms. The application proper- ties of the available AI-aided listening platforms for college English listening are examined through a survey. The survey's data analysis reveals that intelligent listening solutions have advantages including a wealth of listening resources, a sizable workout database, and a variety of learning pathways. However, there are also some drawbacks that have been identified in the research, such as the absence of particular and tailored workout instruction, an excessive collection of content without logical classification, and a subpar monitoring and assessment system [8]. The purpose of the study [9] is to determine how instructors can assess students' levels of attention in both traditional and online classroom settings and implement the necessary adjustments to enhance learning outcomes. The writers have concentrated on discussions and analyses of multimodal biometrics, analyses of brainwave signals and psychological states, analyses of eye gaze, studies of facial movements and emotions, and behavioral biometrics such as body movements. The study's analysis of limited datasets is a significant flaw.

Two goals have been set in the research [10] where the first is to use Python to identify the factors that have the least to greatest impact on students' educational outcomes to develop the best possible study schedule for both students and parents; the second is to identify the best classification technique for a given set of data. Numerous elements, such as demographic characteristics, parental influences, and study habits, might be connected to kids' academic results for the first research goal. On two independent sets of data samples, the authors utilize classification and linear regression techniques as parts of applying Machine learning in education.

2.1 Machine Learning Background and its Types

A subset of artificial intelligence is machine learning. Intelligence (AI). Using machine learning, we can: Recognize the structure of the data, then use it to create models that people can use and comprehend. The use of machine learning in artificial intelligence is becoming increasingly significant [11]. Humans gain knowledge through their prior experiences, and machines will obey commands given by humans. In other words, without our involvement at any point in the process, we enable machines to comprehend data and finally train to provide a result. The Figure. 1 below shows how workflow of a machine learning algorithm.

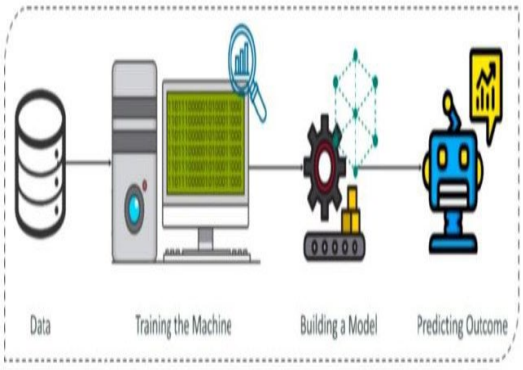

Fig. 1. Workflow of Machine Learning [11]

One of the fascinating subfields of computer engineering that supports academics and innovators in their work is ma- chine learning. It means to draw conclusions from the facts and act accordingly [12]. The study of the human and animal mind in the domains of neuroscience, psychology, and other related disciplines is an exploration area that is strongly associated with machine learning. The investigation

into solving AI problems by using learning techniques for the human brain hasn't produced many results that are particularly encouraging compared to the investigations into factual-computational methods. The collaboration between AI and human learning is growing as some human or animal learning processes are being explained using AI [12]. Machine learning algorithms can be mainly divided into three categories as supervised machine learning, unsupervised learning and reinforcement learning.

2.1.1 Supervised Machine Learning

Direct feedback is used by supervised learning systems to make predictions. Using a labelled collection of data, this technique focuses on training an algorithm that serves as the optimal function for determining the input data selection. Consequently, learners receive inputs and outputs that are comfortable for them and have significance. These datasets will eventually help machines choose the best output for a given input. Two subcategories of supervised learning are classification and regression techniques [13]. DT, SVM, LR, Artificial Neural Networks (ANN), Naive Bayes (NB), and KNN are a few well-known supervised learning algorithms [14]. This category of learning is capable of two different kinds of tasks, including regression and classification. The purpose of a task using regression is to forecast a numerical value output based on unknown input data. Classification, in contrast, aims to forecast a discrete value output [15].

2.1.2 Unsupervised Machine Learning

As the term implies, there is no supervisor present to train the system, and thus, there is no training dataset. Data is not labelled in this kind of learning. It may be applied to market basket analysis, cluster analysis, and the discovery of hidden patterns [16]. Unsupervised ML uses ML techniques to train an algorithm to analyze and cluster unlabeled datasets. Finally, it helps identify a pattern when discussing a model. The input data helps the algorithm in this case extract rules and regulations and identify important patterns. Association and clustering models are the two types of algorithms that are most frequently utilized in unsupervised learning [13].

There is no label, no training data set, and uncertain output data in unsupervised learning. This style of instruction is comparable to self-guided instruction. Some of the clustering techniques used in supervised learning include SVD, PCA, and K-Means clustering [17]. Unsupervised machine learning approaches make it easier to analyze unlabeled data and produce analytical insights [18].

2.1.3 Reinforcement Learning

Sequential decision-making issues have been successfully resolved by reinforcement learning algorithms across a wide range of problem areas. An agent learns to resolve sequential decision-making issues using reinforcement learning [19]. This type of machine learning is about what can be done to maximize the numerical benefit signal is what is meant by reinforcement learning. The reinforcement learning model must ascertain which activities provide the greatest rewards instead of prescribing what should be done. Actions frequently have an impact on the circumstance that follows, which in turn has an impact on future rewards [20].

2.2 Applications of Machine Learning in Education

The direction of human education may be substantially impacted by artificial intelligence and machine learning. We are getting away from the one-size-fits-all approach with machine learning. Since it can alter and deliver specialized curriculum, it is a useful teaching tool. The assessment of a person's present level of comprehension, the identification of learning gaps, and the provision of immediate answers are all made possible by machine learning- enabled technologies. In order to design learning programs that have the greatest impact on the most pupils, the technology may also pinpoint places where students outnumber teachers.
The following applications have been identified as the applications of machine learning in education, throughout an extensive study.

2.3 Prediction of Student Performance

The capability of machine learning to forecast student performance is a significant advantage. By" learning" about each student, the system may pinpoint their areas of weakness and provide useful study aids, like more practice exams, for each one. Recently, there has been a lot of interest in machine learning in education Instance-based learning, Naive Bayes, Decision Trees, Artificial Neural Networks, Support Vector Machines, Classification Trees, and clustering are some of the popular models for forecasting student success. The performance of the student may be examined using a variety of data, including prelude from the previous semester, pre university and examination marks, and demographic characteristics [21]. early signs of the kids' improvement aid academics in focusing and optimizing their study techniques using a variety of instructional techniques to enhance learning effectively gained experience. Application of machine learning can be useful. academics to forecast the anticipated learning deficiencies they can proactively engage such

procedures and improved learning experiences for pupils. We used logistics. K-nearest neigh- bours, regression, and linear discriminant analysis Gaussian Naive Bayes, classification and regression trees, and Using support vector machines on historical student grade data, a model for one of the undergraduate courses and forecast the performance of students enrolled in a similar subject in the future phrase [22]. By pre-processing the student information dataset to identify several label items that have a greater impact on student performance and focusing on using these label items for machine learning, it can also be examined whether the ML model can improve the accuracy of machine learning for student performance prediction [23].

2.4 Accurate Student Grading

By eliminating human prejudice, machine learning can assess pupils fairly as well. While multiple choice examinations are already graded by AI, we are starting to see machine learning begin to evaluate writing using applications like Grammarly. The relative grading system is superior to the absolute grading system in many colleges and universities, but the absolute grading system has some flaws that machine learning is about to address. One of these flaws is the bias in the external marks that absolute grading introduces, which will impact the grades of all the class's students [24]. A multi class prediction model using six predictive models to forecast the final grades of students based on the results of their first-semester final examinations can be one of such application, where a comparison analysis can be conducted to assess the performance accuracy of student grade prediction [25].

2.5 Career Guidance / Career Path Prediction

Applications using machine learning may monitor a student's interests, aptitudes, and dislikes to forecast their professional path. It examines the behaviors and emotions of students. The analysis can properly anticipate the student's potential strengths and areas of interest. After completing upper secondary school and reaching the point where they must select a suitable job path, most students throughout the world are almost always confused. The pupils aren't mature enough to understand clearly what one must do to select a fulfilling job path. Based on the talents evaluated by an objective exam, a computerized career counselling system may be used to forecast the best department for a given person. If a person takes their online exam, they will automatically choose the right course, which will also lower the failure rate due to picking the incorrect career route [26]. The possibility of predicting the proper career route using survey data in a scientifically sound and systematic manner while considering all the factors is examined to help students make the best career decision. Students might be inspired to select a job based on

their natural abilities and qualities by using such an application. To help kids choose the best occupation for their bright future, machine learning may be used to forecast career paths [27]. Along with the uses, machine learning may also aid in effective content organization. Machine learning can better organize material by recognizing its shortcomings. For instance, after mastering one skill, students move on to the next, continuously expanding their knowledge. Furthermore, after the program evaluates the performance of the pupils, it could offer a better strategy for learning new content. It begins with an examination of the curriculum's current body of knowledge. Additionally, if weak areas are found, students are given recommendations for reading mate- rials and other learning strategies, allowing machine learning to advise a course of study for them. Grouping students and teachers based on their needs and availability is another way that machine learning will enhance education.

3. Conclusion

The entire world is moving toward digitalization, and ma- chine learning and artificial intelligence principles are crucial to this process. This survey's research is entirely centered on how new machine technologies are created in the educational system. The machines of today are equipped to pro- vide knowledge-based schooling and oversee raising intellect. Machine learning applications are essential to the development of educational technology. Soon, machine learning in education will revolutionize the field. Additionally, it will open a lot of new possibilities for maintaining control and bridging the effort and knowledge gaps between students and professors. Machine learning will soon be more effective and yield even better outcomes.

Student learning experience improvement. By identifying underachievers early on, machine learning technologies can assist in this process. This will enable teachers to enhance their teaching methods and keep underachievers motivated. Therefore, it can be concluded that the discipline of computer science and engineering greatly benefits machine learning. It offers a very broad range of applications, including so many applications, and the applications in the education field is significant ones.

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