S. Swetha, 2026, 14:4
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

A Machine Learning-Based Adaptive Learning Platform for Class 10 NCERT Using Python and Web Technologies

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Abstract- The traditional approach to education is not capable of meeting the different capabilities and learning requirements of the students, which leads to different learning achievements. In this paper, a ML-based Adaptive Learning Platform for Class 10 NCERT students is proposed. The performance of the students is determined based on quiz marks, accuracy, time, number of right and wrong responses. The obtained performance data is processed using Decision Tree classification model to classify the learners into one of the three levels, namely Easy, Medium, and Hard. Depending on the learner level predicted by the model, suitable quizzes, study materials, video tutorials and AI assistance are recommended to the students. The proposed system was implemented as a web application and tested using learner performance data. The experimental results revealed that the classification accuracy reached 86%, which proves the efficiency of the Decision Tree model in predicting the learner levels. With the help of the adaptive recommendation approach, the involvement of the learners in the learning process increased due to provision of personalized learning content.

Keywords: Adaptive Learning, Machine Learning, Decision Tree.

I. INTRODUCTION

Over the past few years, the education field has witnessed significant changes through incorporation of digital technologies and artificial intelligence in the teaching and learning process. The NCERT Class 10 course has also incorporated technology-assisted learning models for increased engagement of the students and better academic performance [4]. However, despite these changes, the conventional classroom teaching is still prevalent in most educational institutions where the same teaching material and tests are provided to all students irrespective of their learning abilities [1].

There are vast differences among students in their cognitive abilities, speed of learning, pre-existing knowledge, and problem solving skills [7]. Some students will grasp new ideas and concepts easily and will be ready for more difficult learning activities, while others will need more explanations and time in order to grasp the same concepts. Traditional teaching models do not take these factors into account, which leads to decreased efficiency in the process of learning and poor student engagement [3]. As a result, slower learners will find it difficult to follow the pace of classroom learning, while gifted students will lack motivation because of insufficiently challenging material [9].

With the advent of machine learning technologies, adaptive learning systems are developed which personalize the learning experience based on the traits of individual learners [2].

They analyze the student's performance in real-time and dynamically change the learning material, assessment, and recommendations to improve the learning process and engagement of students [8].

Several research works have shown that artificial intelligence can be used effectively in enhancing personalized learning through performance prediction, intelligent recommendation system, and adaptive assessment. But, the current adaptive learning systems mostly cater to higher education or online learning and little work has been done in the domain of school-level education, especially for Class 10 learners under the NCERT curriculum.

In addition to this, most of the existing systems use heavy machine learning models which are hard to interpret and implement in resource-constrained educational settings. Little work has also been done

on incorporating student performance classification, personalized content recommendation, web-based interface, and intelligent assistance system all together in one platform for secondary school students. This problem statement shows the requirement of developing an intelligent, scalable, and lightweight adaptive learning system.

In order to fill these gaps in the literature, this research attempted to build an Adaptive Learning Platform for Class 10 NCERT students through Python and modern-day web technologies. The system suggested by this study utilized a Decision Tree classifier algorithm in order to classify the student's learning status on the basis of his/her score in the quiz, accuracy, time taken, and the number of correct and incorrect answers. On the basis of this learning status, the system then recommended a range of customized quizzes, learning material, video lessons, and AI assistance in order to increase concept clarity.

Fig. 1. Transition from Standard to Adaptive Learning Approach

II. LITERATURE REVIEW

Personalised learning is an important area of research in the field of intelligent educational systems. The primary objective of personalised learning is to personalise the learning content according to the characteristics of the learners. Recent research works clearly state that the traditional uniform learning approach is not effective in dealing with the diversity of the students [1]. Adaptive learning systems apply AI techniques to personalise the learning process according to the learning data.This will help the students to learn better as it is personalised learning.They will improve accordingly.

Machine Learning (ML) is an important area of research in the development of adaptive learning systems. In [1], models for learning style identification were proposed to analyse the interaction data of the learners and personalise the learning content. The importance of classification algorithms in dealing with the identification of behavioural patterns in online learning environments was clearly stated by the authors. Similarly, in [2], the development of AI-based adaptive learning systems using EDM techniques was proposed.

Certain research studies have also utilised classification-based techniques to achieve performance prediction. The authors in [3] proposed a data-based model to predict student performance using supervised learning algorithms. The study demonstrated that quiz results, time spent on tasks, and accuracy levels are effective in recommending adaptive content to students. In addition, [4] proposed various clustering-based techniques that enable categorisation of students with similar learning patterns, thereby delivering effective learning.

Deep learning techniques were also utilised to achieve personalisation in learning. The authors in [5] utilised neural network-based models to analyse student learning patterns and adapt difficulty levels for quizzes. The study demonstrated that adapting difficulty levels is effective in improving knowledge retention. In addition, [6] proposed CNN-based models that can be utilised in scalable learning scenarios, especially when computational capabilities are limited.

Nonetheless, scalability and privacy concerns remain some of the major challenges in the development of intelligent tutoring systems. The study on scalable architectures for machine learning in the development of educational systems, particularly in real-time systems, was presented in [7]. On the other hand, the application of federated learning in the

development of privacy-preserving personalisation in educational systems was presented in [8].

Recent studies also emphasised the importance of the development of multimodal adaptive systems in the development of intelligent tutoring systems. In [9], the development of a hybrid recommendation system that includes behavioural analysis and assessment performance was proposed to improve the learning experience of students in the classroom. The authors were able to show that the application of multiple features in the development of the model improved the accuracy of the model compared to the application of single features in the development of the model, as presented in [9]. Similarly, the development of adaptive quiz systems that adjust the difficulty level in real-time according to the response of the student was analysed in [10].

Based on the above studies, it is clear that machine learning algorithms like Decision Trees, KNN, clustering algorithms, etc., along with neural networks, could be effectively used in the design of an adaptive learning system. The main focus of the design of these learning systems is on higher education or e-learning environments in general.

III. METHODOLOGY

System Overview

In this work, the developed methodology involved the creation of an ML-Based Adaptive Learning Platform targeted at the NCERT Class 10 students. The idea behind the platform was to deliver personalized learning experience based on ongoing analysis of learner's performance and provision of recommended learning material accordingly. Contrary to traditional learning systems that provide the same material for all learners, the proposed platform was aimed at dynamically adjusting the quizzes and other learning material based on the learner's performance. The responses of students provided during the online quiz were then classified using a Decision Tree algorithm and divided into Easy, Medium, and Hard learners.

Machine Learning Model

Algorithm Selection

Decision Tree Classifier algorithm is used as the basic Machine Learning algorithm for student performance classification. The algorithm has been chosen based on the high level of interpretability associated with the algorithm, as the decision-making process can be easily understood. The algorithm has also been chosen as it can be used for classification purposes, which makes it highly applicable when classifying the students based on learning levels.

In addition, the Decision Tree algorithm can be used when dealing with structured quiz data, making it highly applicable when processing student performance metrics. Another advantage of the algorithm is the low level of complexity involved, which makes the algorithm highly applicable as it can be processed quickly.

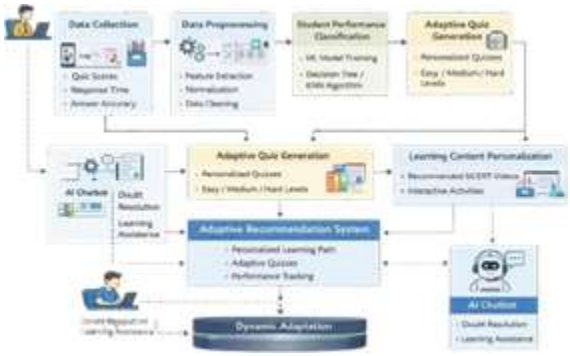

Fig. 3.2 Architecture of the Machine Learning-Based Adaptive Learning System

Feature Extraction

The model utilises the following performance metrics as input features:

- Quiz Score (S)
- Accuracy Percentage (A)
- Time Taken (T)
- Number of Correct Answers (C)
- Number of Incorrect Answers (I)

$X=\{S,A,T,C,I\}$

Target Classification

The output variable Y represents the student learning level:

$$Y \in \{Easy, Medium, Hard\}$$

Where:
Easy → Beginner Level
Medium → Intermediate Level
Hard → Advanced Level

Mathematical Representation
The Decision Tree model partitions the feature space into regions using recursive binary splitting. The classification function is defined as:

$$Y = f(X)$$

where f(X) represents the mapping from input features to output class labels.
The splitting criterion is based on Gini Impurity, given
by:

$$Gini = 1 - \sum(pi)2$$

where pi represents the probability of class i at a particular node. The model selects the feature that minimises impurity at each split to improve classification accuracy.

Dataset And Performance Parameters
The system under consideration made use of data related to the performance of quizzes which was recorded through the use of the web-based learning system. This resulted in various performance metrics being gathered for each quiz conducted such as quiz score, percentage of accuracy, time taken to complete the quiz, number of correct answers, and number of wrong answers. Such metrics formed the input features for the Machine Learning model.

SYSTEM WORKFLOW
The process of the suggested methodology started after the student registered himself/herself to the adaptive learning platform and took the first test quiz that checked the existing knowledge level of the student. Upon completion of the assessment, the algorithm of the platform calculated some performance metrics, such as the score of the test, the level of accuracy, the time spent for the completion of the assessment, and the number of correct and incorrect answers.

Based on the performance analysis, the model estimated the level of the learner's knowledge and put the user to one of the three possible groups, namely Easy, Medium, or Hard.

Module Description

- **User Management Module**

This module manages student registration, authentication, and profile handling. User credentials and academic data are securely stored in the database.

Quiz Management Module
The Quiz Management Module is used to create subject-wise multiple choice question-based quizzes based on the curriculum needs. The responses from the students are assessed based on key performance indicators such as scoring, accuracy, and correctness. In addition, this module tracks the entire history of quizzes for each user, thus allowing continuous tracking of learning progress for each user. The data collected is then sent to the Machine Learning module for further analysis and classification, thus allowing for adaptive learning in the system.

Machine Learning Module (Core Module)
The Machine Learning module acts as the main part of the proposed system and is responsible for intelligent decision-making. The process starts by preprocessing the quiz data for better consistency and quality, followed by feature extraction to identify relevant performance parameters. Next, the processed data is used to run the Decision Tree classification algorithm, which helps in analysing student performance and determining the respective learning levels. In addition, this module also helps in updating the classification results using new data for better improvement in the learning process.

Adaptive Recommendation Module
The Adaptive Recommendation Module uses the learning level to provide students with a personalised learning experience. It provides students with recommendations for quizzes based on different levels of difficulties such as Easy, Medium, and Hard. It provides students with learning material such as video lectures on topics of their weaknesses. It identifies weaknesses in

students' performances and provides them with learning material to help them improve their understanding.

Performance Analytics Module

The Performance Analytics Module offers in-depth insights into students' learning progress through various analytical parameters. The facility of visualising the trends in the score over time is provided by the module, which can be utilised by the students to understand their performance. In addition, the facility of tracking the accuracy level can be utilised by the students to analyse the consistency of their performance. Moreover, the facility of topic-wise analysis can be utilised by the students to understand their performance in different subjects. In addition, the facility of predicting the performance of the students in the future can be utilised by the students.

AI Assistance Module

The AI Assistance Module will include an intelligent chatbot to provide the students with constant assistance in their learning process. This module will be able to answer subject-related queries and provide the students with clear and concise explanations of the concepts, thus helping them understand the concepts better. The module will ensure that there is no interruption in the learning process of the students, as it will provide instant answers.The module will also offer personalised learning assistance to the students.

Innovative Features Of The Methodology

The system proposed has several key contributions that make it more effective. The system includes Machine Learning-based classification of students in real-time to identify their learning levels. The system adjusts the difficulty of learning materials according to the students' performance. The system is able to design learning plans that are personalised to the needs of each student. The system is able to make learning more efficient and engaging. The system is able to identify areas where students need improvement and can help them to improve their knowledge. The system is able to improve the performance of students through data analysis.

IV. RESULTS AND ANALYSIS

Machine Learning-Based Adaptive Learning Platform was assessed in order to find out its usefulness in the classification of student performance and adaptive learning of content. Training and testing of the classifier known as Decision Tree classifier was done using the features such as quiz score, accuracy, time spent, no. of correct answers and no. of wrong answers related to student performance. The results were analyzed using performance measures and graphs.

Performance Evaluation

The classification ability of the Decision Tree model was assessed based on the results obtained from the student performance dataset. The model attained an accuracy rate of 86.0%, while the precision and recall rates were 84.3% and 85.6%, respectively. The individual performance rates of the learners are shown in Table I.

TABLE I. COMPARISON OF STUDENT PERFORMANCE CLASSIFICATION APPROACHES

Category	Accuracy (%)	Precision (%)	Recall (%)
Easy	87.5	85.4	88.2
Medium	86.1	84.7	85.0
Hard	84.3	82.9	83.5
Overall	**86.0**	**84.3**	**85.6**

As shown in Table I, Easy was the category with the highest accuracy at 87.5%, meaning that the classifier performed well in recognizing beginner learners. Accuracy of Medium was 86.1%, whereas the accuracy of Hard was 84.3%. The low accuracy of Hard can be explained by the similarities of features between Medium and Hard learners, causing overlapping in classification. However, the precision and recall values were consistent in all categories.The classifying behavior of the proposed algorithm was further investigated through the use of graphs that are presented in Figures 4.1.1–4.1.3. These graphs depict the correlation between the predicted values and the real values depending on the learning levels. The distribution of the data points depicts the reliability of the prediction results produced by the algorithm. The slight discrepancies observed in some

areas reveal the parts where improvements in classification accuracy are possible.

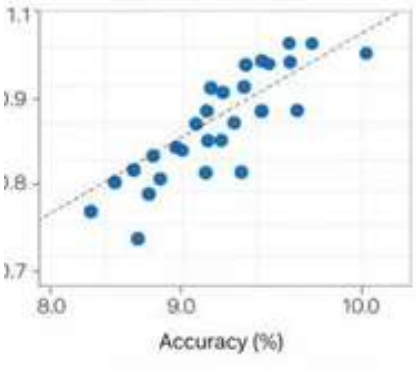

Fig.4.1.1 Easy Classification

As Figure 4.1.1 depicted, the classification results for learners with Easy level were presented. It is evident that most of the graph points lie close to the perfect trend line.

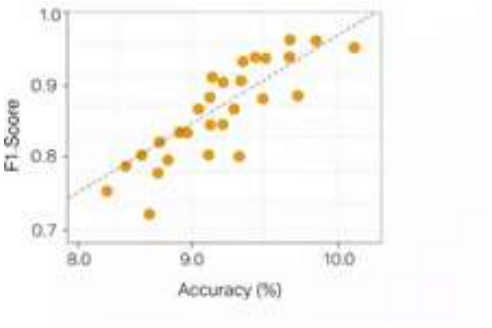

Fig.4.1.2 Medium Classification

Classification results of Medium Learners were shown in Figure 4.1.2 Some data points showed small variations from the perfect trend line, revealing some degree of non-overlap among adjacent learning types. Nevertheless, the performance of the classification process was consistent.

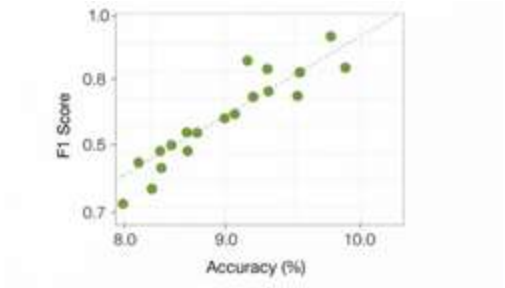

Fig.4.1.3 Hard Classification

The classification results for the Hard-level learners were shown in Figure 4.1.3 The data points were much more dispersed than the points of the Easy and Medium groups, which made classification of advanced learners more difficult. However, despite all the differences, the classifier still achieved acceptable classification results.

Adaptive Learning Analysis

This adaptive recommendation system was tested on the basis of permitting the students to have several quizzes sessions. The difficulty of the quiz session is adjusted automatically depending upon the type of learning category predicted, along with providing the relevant learning material for the learners.

Learners who were categorized under the Easy category were given easy questions along with their relevant learning material and video lectures. Moderate level learners were given moderate questions, while the Hard learners were provided with difficult learning material.

System Efficiency

Performance analysis of the web-based platform was conducted in order to evaluate its functionality. The interaction of the frontend, backend, database, and machine learning model resulted in the successful processing of the quiz input and the generation of recommendations on-the-go. During the test, the system operated uninterrupted without any drop in its performance. Therefore, it can be concluded that the proposed structure is appropriate for building an adaptive learning environment.

Comparative Analysis

The proposed adaptive learning system was evaluated with regards to traditional e-learning systems considering the three aspects of personalized learning for learners, engagement of learners, and efficiency of learning. The difference with the traditional systems was that they offered the same learning material to all learners, but in the proposed adaptive learning system, different learning materials were recommended for each learner depending upon the level of their learning.

Graphical Representation

Overall comparative results of the conventional learning method and the adaptive learning platform are shown in Figure 4.5.1.It can be seen that the adaptive learning platform performed much better in terms of learner engagement, classification accuracy, and learning efficiency than the conventional learning method. It provided the learner with recommendations based on better concept understanding and continuous improvement.

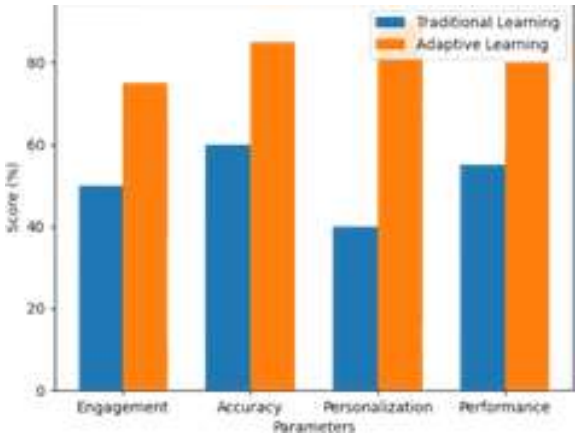

Fig. 4.5.1 Performance Comparison Graph

Discussion

It is clear from the experimental findings that the Decision Tree algorithm accurately classified the learners at different levels of learning with an accuracy rate of 86%. Machine Learning combined with adaptive content recommendation has enabled personalized learning as the educational materials were provided based on their individual performance. The findings have proven that the designed system could provide intelligent learning environments for the NCERT Class 10 learners. Nevertheless, the experiment was performed on a small set of the student's performance data and the accuracy of predictions relied on the quality and variety of the training data.

Future research could involve testing the system on larger sets of real-world data, considering more complex machine learning and deep learning algorithms, and refining AI-enabled tutoring functions.

V. CONCLUSION

In this study, a Machine Learning-Based Adaptive Learning Platform for class 10 NCERT students was designed with the help of Python and web technologies. The designed model would provide a personalized learning experience for individual students depending on the performance of each student. A decision tree classifier was used in the suggested model to classify the learners into the Easy, Medium, and Hard categories according to the quiz score, accuracy, time, and correctness. Depending on the category, which was determined by the algorithm, a personalized quiz, material, video lecture, and artificial intelligence assistance would be provided to the learner allowing them to learn independently.

As per the experimental results, the overall accuracy is found to be 86%.This research is novel due to the fact that it combines the use of machine learning algorithms for classifying students along with providing them with content recommendations in a web-based application tailored for Class 10 NCERT students. But since the current system has been developed based on small-scale student performance data, the accuracy of predictions made by the system depends largely upon the quality of data used for training purposes. Future research will be aimed at validating the current system using large-scale datasets, developing sophisticated machine/deep learning algorithms, and improving AI tutoring features.

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