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THE ARCHITECTURE OF EDUCATIONAL PLATFORM BASED ON MACHINE LEARNING

The paper discusses the architecture of an educational platform based on machine learning (ML) algorithms. Recently, ML algorithms which is subpart of artificial intelligence (AI) have started using in online educational platform. This paper illustrates the architecture of education platform based on ML algorithms. ML algorithms use to identify students' psychological state, to determine the level of knowledge in subjects, to give educational materials suitable for the level of knowledge of the student, and to classify the exam result of a student into classes. The architecture in the paper is designed for the school, however, it is flexible. The architecture is able to apply for the other degrees of education. Thus, the platform based on ML is able to improve students autonomous learning and each subject abilities. In 2024, 280 students from 6th to 11th grades were taught at private school in Tashkent City by the educational platform based on the architecture. Determining the students psychological condition, determining the students knowledge level, assessing the student's knowledge from each subject, moving the student to the next level was performed with the help of SVM, ANN, Naive Bayes, and Decision tree machine learning techniques. The findings illustrate that ML algorithms are highly effective in teaching students.
Key words: artificial neural network, educational platform, machine learning, data mining, educational data mining.

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Машиналық оқытуға негізделген білім беру платформасының архитектурасы

Мақалада машиналық оқыту (МО) алгоритмдеріне негізделген білім беру платформасының архитектурасы талқыланады. Жақында жасанды интеллектің (ЖИ) бөлігі болып табылатын МО алгоритмдері онлайн білім беру платформасында қолданыла бастады. Бұл құжат машиналық оқыту алгоритмдеріне негізделген білім беру платформасының архитектурасын көрсетеді. МО алгоритмдері оқушының психологиялық жағдайын, пәндер бойынша білім деңгейін анықтау, оқушының білім деңгейіне сәйкес оқу материалдарын ұсыну және оқушының емтихан нәтижелерін сынып бойынша жіктеу үшін қолданылады. Мақалада келтірілген білім беру платформасы архитектурасы мектепке арналған, бірақ ол икемді. Архитектура басқа білім деңгейлеріне қолданылуы мүмкін. Осылайша, МО негізіндегі платформа оқушылардың дербес оқуын және әр пәнге қабілеттілігін жақсартуға көмектеседі. 2024 жылы 6-дан 11-ші сыныпқа дейінгі 280 оқушы Ташкент қаласындағы жеке мектепте архитектураға негізделген білім беру платформасы арқылы оқыды. Оқушылардың психологиялық жағдайын анықтау, оқушылардың білім деңгейін анықтау, әр пән бойынша оқушылардың білімін бағалау, оқушыларды келесі деңгейге ауыстыру SVM, ANN, Naive Bayes және Decision tree машиналық оқыту әдістері арқылы жүзеге асырылды. Нәтижелер МО алгоритмдері оқушыларды оқытуда өте тиімді екенін көрсетеді.

Түйін сөздер: жасанды нейрондық желі, білім беру платформасы, машиналық оқыту, деректерді өңдеу, білім беру деректерін өндіру.

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Архитектура образовательной платформы на основе машинного обучения

В статьи рассматривается архитектура образовательной платформы, основанной на алгоритмах машинного обучения (МО). Недавно алгоритмы машинного обучения, которые являются частью искусственного интеллекта (ИИ), начали использовать в образовательной онлайн-платформе. Эта статья иллюстрирует архитектуру образовательной платформы, основанной на алгоритмах машинного обучения. Алгоритмы машинного обучения используются для определения психологического состояния учащегося, определения уровня знаний по предметам, предоставления учебных материалов, подходящих уровню знаний учащегося, а также классификации результата экзамена учащегося по классам. Архитектура в статье предназначена для школы, однако она является гибкой. Архитектура может быть применена и к другим степеням образования. Таким образом, платформа, основанная на МО, способна улучшить автономное обучение учащихся и способности каждого предмета. В 2024 году 280 учеников с 6-го по 11-й классы обучались в частной школе в городе Ташкенте с помощью образовательной платформы, основанной на архитектуре. Определение психологического состояния учеников, определение уровня знаний учеников, оценка знаний учеников по каждому предмету, перевод учеников на следующий уровень осуществлялись с помощью методов машинного обучения SVM, ANN, Naive Bayes и Decision tree. Полученные результаты показывают, что алгоритмы МО очень эффективны при обучении учеников.

Ключевые слова: искусственная нейронная сеть, образовательная платформа, машинное обучение, интеллектуальный анализ данных, интеллектуальный анализ образовательных данных.

1 Introduction

According to the history, we can observe that three factors played main role in the development of society, namely science, art and sport. Education combines these three factors. If we overview the developed countries, we can observe that the mentioned above three aspects had developed well. The main reason of the development is the perfection of education systems in the educational sphere of the developed countries [1]. It is optimal that the development of science, art and sports began with primary education [2]. Therefore, effective methods created for each degree of education.

It is known that Uzbekistan is a multinational country. Therefore, the schools in Uzbekistan teach the students in several languages, such as Uzbek language, Russian language, Karakalpak language, Kazakh language, Turkmen language, and Kyrgyz language. Furthermore, there are the schools which teach the subjects in English. A large percentage of schools are located in villages, because most percent of the population in the country live in the villages. In this case, each student at a school can not get quality education because of some problems, such as lack of highly qualified teachers, quarantines, etc. When we overview educational system of the countries in the World, we can see the following problems: a lack of funding for education, a lack of classrooms in educational organizations, a lack of learning materials, the exclusion of children with disabilities, being the gender, living in a country in conflict or at risk of conflict, distance from home to school, hunger and poor nutrition, the expense of education and so on [3]. The alternative solutions are required to solve above problems. Many of the existing educational methods and techniques can work effectively for offline education [4]. However, Due to the above problems, each student can not attend quality

offline lessons. Therefore, alternative solution is required in order to improve the quality of education. In this scenario, we need to use tools that solves as many educational problems as efficient as possible. AI can help solve the above educational problems [5].

In recent years, artificial intelligence has entered almost all spheres of social society. As a result, AI and ML are being adapted to these areas. A lot of research is being conducted on the application of AI and ML to the educational sphere. Below we will consider the articles of scientists conducting research in this field. The article written by [6] analyzes the articles of scientists from 62 countries who conducted scientific work on the application of AI and ML in the field of education between 2000 and 2021. Research shows that AI and ML are playing a growing role in the educational sphere. The influence of the psychological condition of elementary school students on their academic performance was studied using the Owl Search Optimized Dynamic Deep Neural Network (OSO-DDNN) algorithm [7]. The article used the results of 147,210 elementary school students who took the LegiLexi exam between 2016 and 2021. The results indicate that the model's robustness and potential for predicting primary school students academic performance are rooted in psychological factors. The study [8] uses ML to predict the academic performance of middle- and high-school students by analyzing socio-demographic factors, school-related elements, and student-specific variables. Five ML algorithms, namely multinomial logistic regression, artificial neural network, random forest, gradient boosting, and stacking methods are employed to identify and rank the factors affecting academic performance. The study [9] aims to enhance learners ability to grasp complex concepts swiftly through various activities such as flipped classrooms, online quizzes, learning by doing, and virtual laboratories. It addresses learners challenges and encompasses all learning domains, including knowledge, skills, and attitudes. The fuzzy logic method has been recently applied in education to mitigate these challenges, offering a qualitative rather than quantitative assessment of student achievement. Real-time data from B.Tech Information Technology learners is used. Initially, the prediction models achieved the following accuracies: Naive Bayes (90%), Support Vector Machine (89%), Discriminant Analysis (88%), Decision Tree (86%), and K-Nearest Neighbors (82%), with Naive Bayes showing the highest accuracy at 90%. After factor analysis (FA), the accuracies are: Naive Bayes - 92%, K-Nearest Neighbors - 92%, Support Vector Machine - 90%, Discriminant Analysis - 89%, and Decision Tree - 88%. Naive Bayes and K-Nearest Neighbors demonstrate the highest accuracy at 92%. Aiming to adapt Machine Learning for students of all proficiency levels, we investigated how accurately specific spelling errors can be predicted among primary school students in Germany who are not yet proficient in spelling. This study examines the prediction accuracy across different skill levels and explores the content-related reasons for incorrect predictions [10]. To achieve this, we developed a web application to track the spelling efforts of 685 first- and second-graders in Bavaria, Germany, capturing a total of 18,133 different misspellings. Using this data set, we trained and compared the performances of six Machine Learning models to predict misspellings. Among all the Machine Learning models used in this study, the Random Forest algorithm proved to be the most effective in predicting spelling errors. It excelled in predicting errors at the syllable and morpheme levels, while errors at the basic phoneme-grapheme level were predicted with slightly less accuracy. Frequently, confusions arose in linguistically ambiguous cases or complex error entanglements. The implications of these findings are discussed in detail. Based on 177 responses [11] from university students, the proposed model is validated using a hybrid structural equation

modeling and artificial neural network (SEM-ANN) approach. The findings show that effort expectancy is positively influenced by both individual technology fit and task technology fit. Moreover, performance expectancy is significantly influenced by task technology fit but not by individual technology fit. The results also highlight the impact of performance expectancy, social influence, facilitating conditions, and hedonic motivation on behavioral intention, explaining 65% of its variance. The ANN results, with a normalized value of 94.5%, indicate that social influence is the most crucial factor in robot adoption. These empirical findings contribute theoretically and assist higher education institutions in encouraging students to adopt robots, enhancing their practical value. This paper [12] introduces a Decision Support System (DSS) utilizing a hybrid data mining model to analyze educational data and reveal hidden patterns and rules. The DSS is designed to assist decision-makers in improving the operational efficiency of academic institutions by accurately determining student eligibility for particular courses. For thorough analysis, various supervised algorithms were applied, comparative evaluations were performed, and association rule and unsupervised algorithms were used to uncover concealed patterns. The article [13] provides an overview of various cognitive computing technologies applied in education to improve learning and teaching processes. It identifies three conceptual system architectures: Layered Architecture, Agent-Based Architecture, and Hybrid Architecture, and details their components. Additionally, the study examines notable platforms in the educational sector, including IBM Watson, Knewton, Carnegie Learning, and DreamBox Learning. This study [14] identifies modern challenges and suggests three educational strategies for transitioning to a digital model of architectural education, considering the opportunities presented by the Covid-19 pandemic. The study presents a model employing an instructional approach that envisions post-pandemic architectural education and highlights challenges for educators and institutions for further research. This study addresses the pandemic's impact on traditional architectural education. This paper [15] performs a topic modeling analysis of articles related to educational data mining and learning analytics to uncover thematic features of both fields. Using structural topic modeling, we identified topics from the abstracts of N=192 articles on educational data mining and N=489 articles on learning analytics. Five-topic models were derived for both fields. The findings indicate that, despite some disciplinary differences in research focus, there is little evidence of a clear distinction between the two disciplines beyond their historical development. The trend suggests a convergence in educational research towards the use of advanced statistical learning techniques to derive actionable insights from large data sets, optimizing teaching and learning. EDM is the combination of AI and education. EDM which is illustrated at Fig. 1 depicts the study of a relevant field by applying data mining (DM), ML, and statistics to information obtained from educational institutions. EDM is one of computer science subject. [16].

Education 4.0 refers to the integration of advanced technologies into the field of education, transforming traditional educational systems [17]. Education 4.0 includes the use of data-driven education and learning analytics to enhance learning and teaching processes. EDM is main part of Education 4.0 by analyzing large datasets to identify patterns, trends, and insights that can inform educational practices [18]. EDM helps in understanding student behavior, predicting performance outcomes, identifying at-risk students, and personalizing learning experiences [19]. Today, the scientists are creating a lot of new educational projects based on EDM, such as Quiz generation, EdApp, Khan Academy, Coursera, etc [20] and they

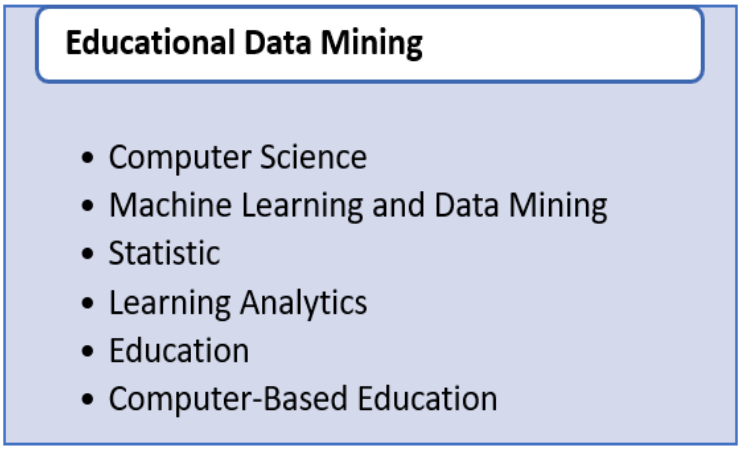

Figure 1: Educational Data Mining

are design for different degrees of education system [21].

As a result of the coronavirus that appeared in Wuhan of China in 2019, the pandemic was declared all over the World for several years [22]. This situation has had its negative impact on the educational system, like many areas. As a result, students could not go to schools, colleges, universities. According to the report of UNESCO shows which the number of out-of-school children and youth has increased by 6 million since 2021 and now totals 250 million. After coronavirus, economic problems decreased the economies of countries. This situation has had a significant impact on poor countries. Educational organizations began to use the online education. As mentioned above the alternative solution of the problems is AI. Functional performance of online educational platforms improved using AI [23].

The aim of the research is creating the architecture based on ML, creating a mathematical model for each ML algorithm. Futhermore, unveiling the benefits of an educational platform built on the architecture.

This paper will depict the architecture of educational platform based on ML and it's implementation for the education. The architecture consists of two parts, namely server side and user side. The server and user sides are connected via a computer network. The main part of the architecture is the server side. The server side also consists of two subparts. The first subpart consists of database. The database is composed of four tables, namely groups, subjects, modules and complexity degree of module. The second subpart is a system which created based on ML algorithms. The mathematical model of each machine learning algorithm is described, and in the next sections we will analyze the mathematical model of each machine learning algorithm. Furthermore, we will discuss the result of each algorithm by percent. Support vector machine (SVM), Naive Bayes, artificial neural network(ANN) and Decision tree techniques are applied for the architecture because the algorithms showed high results when student's performance classified into classes and predicted. The architecture is flexible, so it is easy to be applied for each degree of education, such as elementary school, high education and so on.

Students were educated for a semester at a private school in Tashkent city to implement the educational platform based on the architecture. A total of 280 students from the 6th

to the 11th grade participated in the experiment, e.i., 153 of the students are boys and 147 are girls. The results of the experiment show that ML algorithms are highly accurate in classifying students' psychological condition and academic performance.

2 Methods

We will overview ML methods and how to build the architecture of educational platform in this section. Actually, the architecture is composed of user side, computer network side, database side and the system based on ML. Furthermore, we will consider the system which is based on ML algorithms in detail. We will overview four machine learning algorithms corresponding to the architecture. Each algorithm was showen effective results, when each of them applied for education. Therefore, the algorithms are chosen. This subpart plays important role in the architecture. SVM machine learning technique is used in order to determine a student psychological condition who is going to access the platform. In this case, the algorithm can be used as a classification i.e., it determines a students psychological condition. According to the results, the system can allow to the the student to access. In this case, linear SVM [24] could use to determine the students psychological condition. Each

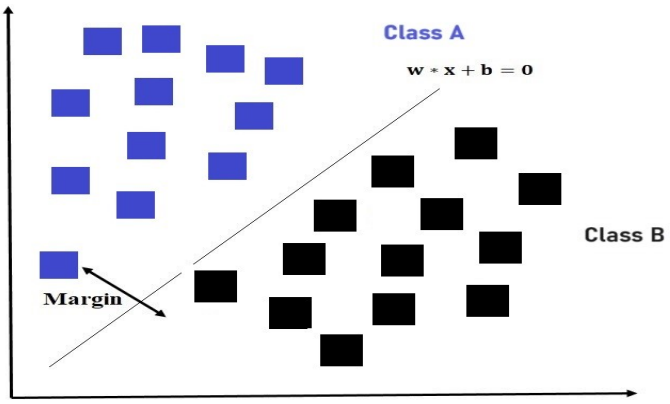

Figure 2: Classifying into classes the student's psychological condition using SVM

student is given psychological test questions in order to determine student's psychological condition. X set defines number of psychological tests. There are two answers in each test question, the first answer means positive, the second one means negative. Class A in Figure 2 depicts the positive answers, Class B depicts the negative answers. The equation in the Fig. 2. of a hyperplane is $w * x + b = 0$ where w is a vector normal to hyperplane and b is an offset. To classify a point as negative or positive we need to define a decision rule according to formula 1. We can define decision rule as:

$$\vec{X} * \vec{w} - c \geq 0 \text{ putting } -c \text{ as } b, \text{ we get } \vec{X} * \vec{w} - b \geq 0$$

Hence

$$y = \begin{cases} +1 & if \quad \vec{X} * \vec{w} - b \geq 0 \\ -1 & if \quad \vec{X} * \vec{w} - b \leq 0 \end{cases} \tag{1}$$

If the value of $w * x + b > 0$, it means a positive point, on the contrary, it means negative point. The second machine learning algorithm in the architecture is ANN [25]. ANN technique in the architecture illustrates in the Figure 3. After passing the psychological test, a student can choose a subject in the grade. After that, the student is given a test in the chosen subject [26]. In the Fig. 3. n is the number of questions in the different complexity for each group that is chosen by the student.

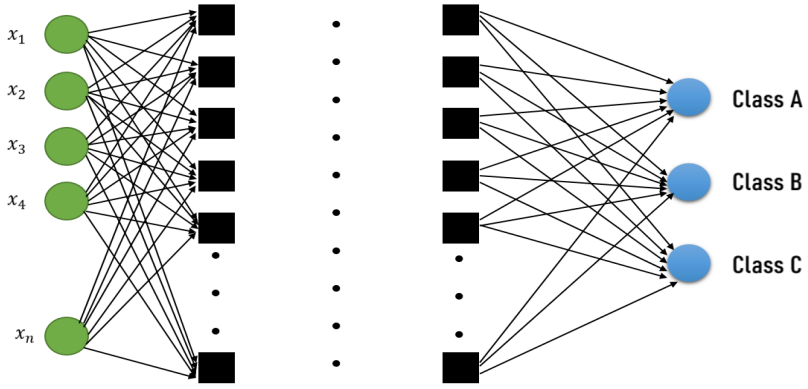

Figure 3: Classification of students knowledge into the classes using ANN

$$f(b + \sum_{i=1}^{n} * x_i * w_i) \tag{2}$$

Formula 2 illustrates activation functions for ANN.
Where,
b-bias
x-input values (in our case, student s results from each subject)
w-weights
n-the number of inputs from the incoming layer
i-a counter from 1 to n
Through the input layer, the students results from subjects are transmitted to the hidden layer. Each node in the hidden layer will calculate corresponding to the rule of ANN. As a result, ANN can classify following about a student:
Class A - the grade that corresponding to the level of the student s knowledge in the chosen subject;
Class B- the module in the selected subject that corresponding to the level of the student s knowledge;
Class C- a complexity level of the module;
This algorithm is used to determine the students level of knowledge in subjects.
The next machine learning technique of the architecture is naive Bayes classification algorithm. In the architecture, the algorithm classifies student s knowledge into classes (poor, average, good and excellent) from each subject. Naive Bayes [27] is a probabilistic

algorithm. Let a set of observations be given, each of which is denoted by a feature vector $x = (x_1, x_2, .., x_n)$ The algorithm assigns to each observation a probability $p(C_k|x_1, x_2, .., x_n)$ C_k- class. We write using Bayes theorem:

$$p(C_k|x) = \frac{p(C_k)p(x|C_k)}{p(x)} \tag{3}$$

In this formula, only the numerator is of interest from the point of view of classification, since the denominator does not depend on the class symbol and is constant. It can be illustrated that the characters are independent

$$p(C_k|x_1, x_2, ..., x_n) = (C_k)p(x_1|C_k)p(x_2|C_k)|p(x_n|C_k) \prod_{i=1}^{n} p(x_i|C_k) \tag{4}$$

Then a simple Bayesian classifier can be considered as a function that assigns a class label to each output value of the model, i.e., $y = C_k$ as follows

$$y = arg_k max_1 ...k \prod_{i=1}^{n} p(x_i|C_k) \tag{5}$$

Hence, class C_k is chosen, thus, class a is chosen, which maximizes the likelihood function, that is the product of the conditional probabilities of the values of the attribute x_i for each class C_k. The probabilistic classifier forecasts the class with the largest conditional probability for a given feature vector x. As for the application of the algorithm to the platform, the Platform has a set of subjects assigned to each group, and the set contains the scores of students in the group from each subject. Naive Bayes classifies a students knowledge into poor, average, good and excellent classes. Using the dataset about students grades from the subjects, each students grade is classified. First of all, we calculate the number of each score in the dataset. After that, the ratio of the total number of subjects to the number of each score is calculate [28] ($p(C_k)$ in formula (3)). After that, the probability of each score (poor, average, good and excellent) for each subject in the dataset is calculated ($(p(x_1|C_k)p(x_2|C_k)|p(x_n|C_k)$ in formula 4). We calculate y the probability of each estimate using the formula (3). With the usage of formula (4), with the highest probability score among the students scores will be calculated. The calculated score will be the students score.

The next ML algorithm in the architecture is Decision tree. The decision tree is a highly effective ML technique for data mining and predictive analytics. It is capable of addressing both classification and regression problems. In our case, we use this algorithm to classify student results into different categories [29]. Fig. 4. illustrates using Decision tree algorithm in the architecture. The algorithm helps to determine that whether a student could pass next level or not. Furthermore, we can use the algorithm that the student is able to determine to finish a module, to finish each subject in a group, to finish each group [30]. The best attribute in dataset of students grades is chosen by attribute selection measure for the root node and for sub-nodes.

$$InformationGain = Entropy(S) - [(WeightedAvg) * Entropy(eachfeature)]$$

$$Entropy(s) = -P(yes)log2P(yes) - P(no)log2P(no)$$

Where,

- S = Total number of samples (in the dataset of students grade).
- $P(yes)$ = Probability that a student can pass.
- $P(no)$ = Probability that a student cannot pass.

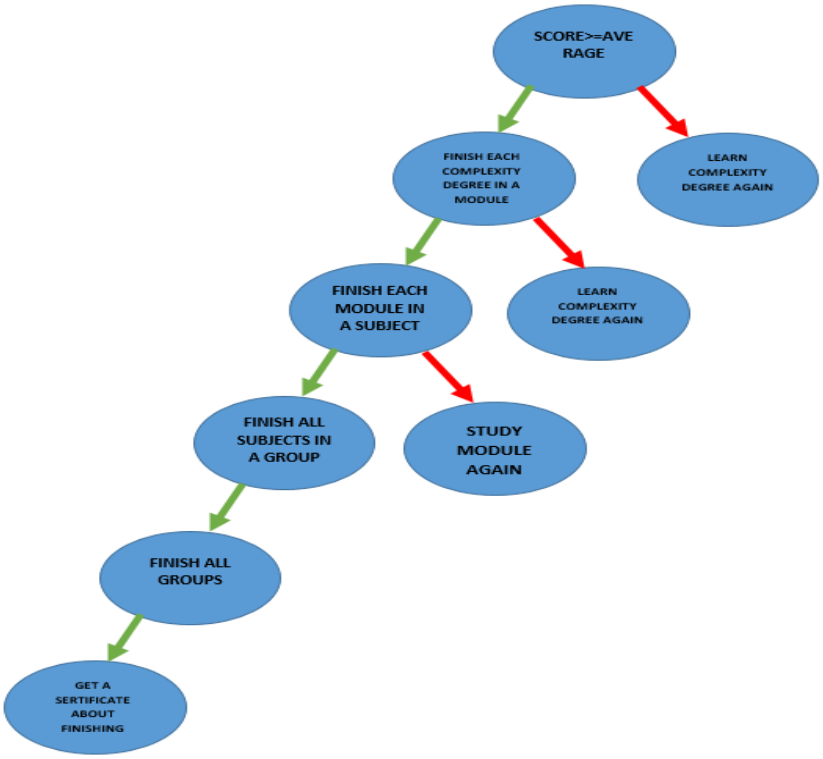

Figure 4: Predicting the passing a student to the next level using Decision tree

A a result, decision tree technique will identify the final result of each student. Fig. 5. depicts the architecture based on ML. The architecture is simple and flexible. The architecture consists of user side, computer network and server side. The server side has two subparts as well, namely the system is based on ML methods and database [31]. The database consists of four tables, namely list of groups, number of subjects in each group, number of modules in a subject and complexity degree of task in the module [32]. Courses are stored as followings, for example, group 8, group 9, group 10. The main part of the architecture is the system which is based on ML algorithms. The main pupose of the system is classifying psychologycal condition and the student s performance into classes [33]. Furthermore, to determine the level of knowledge of each student in each subject, to provide the student with appropriate educational materials, and finally to ensure that the student acquires a high level of mastery of all subjects in the courses.

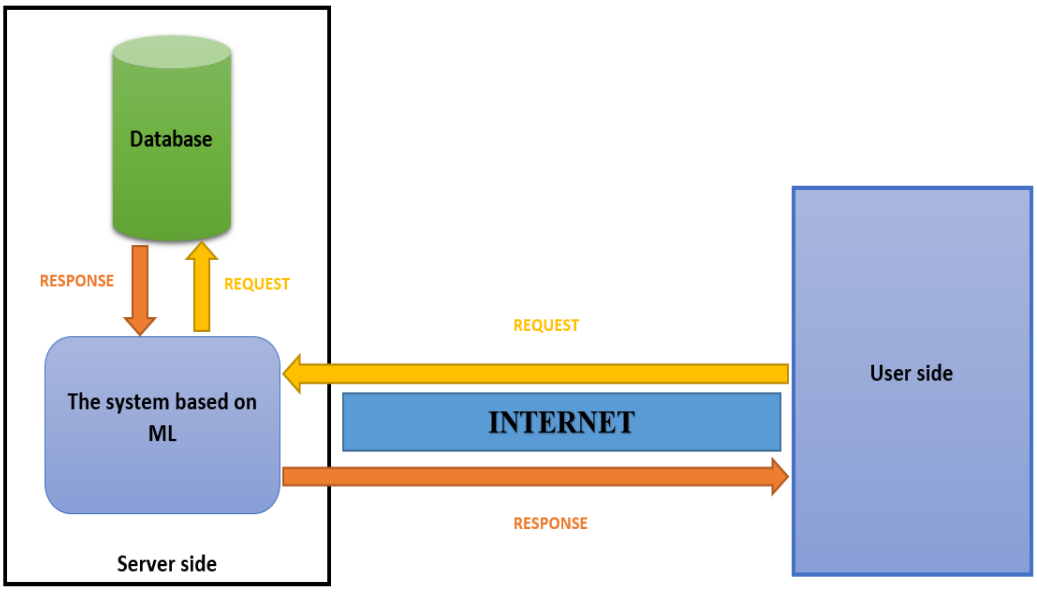

Figure 5: The architecture of the educational platform based on ML

3 Results

An educational platform was created based on the architecture and 280 students were taught. We will present the experimental results of each ML algorithm in the system. In the experiment, 50 students of 6th grade, 50 students of 7th grade, 40 students of 8th grade, 40 students of 9th grade, 40 students of 10th grade and 40 students of the 11th grade participated. The first algorithm is SVM. SVM classifies a student accessing the platform into two classes, namely psychologically healthy or psychologically unhealthy. Students will be asked a total of 24 psychological questions, 12 questions indicate psychological health, 12 questions indicate psychological unhealthy. Table 1 illustrates confusion matrix for SVM.

Table 1: Execution time of the created library on the Atmega 328 microcontroller

Psychological healthy	**Psychological unhealthy**
269	1
1	9

According to the results of the experiment, we can make the following confusion matrix: Accuracy is 99,3%, Precision is 99,6%, Recall is 99,6% and F1 score is 99.6%. 270 students could pass the psychological test.

The next ML algorithm is ANN. The aim of this algorithm on the platform is to classify the level of knowledge in the chosen subject of a student who successfully passed the psychological test. 270 students who successfully passed the first level participated in this level. The system classifies the students knowledge level into three classes, namely class A, class B and class C. First, we classify 270 students by grades (from 6th to 11th grade). Table 2 depicts confusion matrix of gardes.

Table 2: Confusion matrix of grades (grade 6 to garde 11)

Grade 6	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11
48	1	1	0	0	0
2	47	1	0	0	0
0	2	48	0	0	0
0	0	1	38	1	0
0	0	2	1	37	0
0	0	0	1	2	37

In this case, we calculated followings: Accuracy is 94.4%, Precision is 94.68%, Recall 95% and F1 is 94.8%.

Each grade has four modules. Table 3 illustrates confusion matrix of modeles in each grade.

Table 3: Confusion matrix of modules

Module 1	Module 2	Module 3	Module 4
56	2	2	0
1	67	1	1
1	4	56	1
0	1	3	74

The results of confusion matrix: Accuracy is 93.7%, Precision is 93.6%, Recall is 93.5% and F1 is 93.6%.

Class C represents the level of complexity of educational materials in each subject. Complexity levels are lower, medium and higher. Table 4 depicts confusion matrix of complexity educational materials in each module.

Table 4: Confusion matrix for complexity of educational materials in each module

Lower	Medium 2	Higher
101	4	0
0	113	5
0	2	45

The results of confusion matrix: Accuracy is 95.9 %, Precision is 95%, Recall is 95.6% and F1 is 95.2 %.

The third ML technique on the platform is naive Bayes. Naive Bayes classifiers student's mark into poor, average, good, excellent classes. Table 5 illustrates confusion matrix of students' marks.

Table 5: Confusion matrix of students marks

Poor	Average	Good	Excellent
39	1	0	0
1	56	3	0
0	2	96	2
0	0	4	66

The results of confusion matrix: Accuracy is 95.2%, Precision is 95.7%, Recall is 95.3% and F1 is 95.4%.

Last ML algorithm is Decision tree. Decision tree algorithm determines whether students can pass to the next level or students can not pass to the next level, i.e., it classifies students into two classes. Table 6 illustrates confusion matrix for Decision tree.

Table 6: Confusion matrix of Decision tree

Students who passed to the next level	Students who did not pass to the next level
227	3
1	39

The results of confusion matrix: Accuracy is 98.5%, Precision is 99.5%, Recall is 98.7% and F1 is 99.1%. We calculated confusion matrix for each technique. We will discuss the results of each machine learning algorithm in the next section.

First of all, we define the confusion matrix in detail. Accuracy measures the ratio of correct predictions to the total number of predictions. Precision, or Positive Predictive Value, evaluates the proportion of correctly identified positive cases among all predicted positives, making it crucial when false positives are costly. Recall, also known as Sensitivity or True Positive Rate, indicates how well the model identifies actual positive cases. The F1 Score, the harmonic mean of precision and recall, provides a balanced measure between the two.

4 Discussion

As we known, there are a lot of machine learning algorithms. In the architecture, we used the effective algorithms to develop student s academic performance. The result of each algorithm will be shown based on experiences. The experience results on student performance in academics were gathered from 280 school students. Furthermore, the students mental condition analyzed as well. The results of the students during one semester were analyzed [38]. SVM classified students psychological conditions into psychological healthy and psychological unhealthy classes [34]. The results were accuracy is 99,3%, precision is 99,6%, recall is 99,6% and F1 score is 99.6%. SVM determined that 10 students could not learn the subjects on the platform. 270 students who successfully passed the psychological test were given educational materials in appropriate subjects by ANN. ANN has excelled in providing materials appropriate to each students level of knowledge. ANN has achieved superior results in providing material that is appropriate for each students knowledge level. The results of classification on grades: Accuracy is 94.4%, Precision is 94.68%, Recall 95% and F1 is 94.8%, the results of classification on modules: Accuracy is 93.7%, Precision is 93.6%, Recall is 93.5% and F1 is 93.6%, the results of classification on complexity of educational materials in each subject: Accuracy is 95.9 %, Precision is 95%, Recall is 95.6% and F1 is 95.2 %. The next ML technique, naive Bayes classified the students results in each subject into four points, i.e., poor, medium, average and excellent. The results of the algoritm are Accuracy is 95.2%, Precision is 95.7%, Recall is 95.3% and F1 is 95.4%. Last ML algorithm in the architecture is decision tree. The decision tree classified the final results of students in each level, i.e. whether students could pass to the next level or students could not pass to

the next level. The algorithm carried out following results: Accuracy is 98.5%, Precision is 99.5%, Recall is 98.7% and F1 is 99.1%. As a result, 228 students were able to pass to next level [35].

5 Conclusion

Some countries spend millions on the education system every year. These money are a large percentage of the country budget. According to statistics, the countries in the world spend much money for school education system. The price of the educational platform to be built with the usage of the architecture will be several times cheaper than spending annual money to the offline education [36]. According to fact, the number of internet users in the World is expected to go up 47% from 5.35 billion users in 2024 to 7.9 billion users in 2029. Students who live in area supplied with the Internet can learn subjects in the educational platform [37]. The architecture is flexible so it can applied for each degree of education. A educational platform based on the architecture can detenmine student s performence accurecy as well as helps solve some educational problems [38]. Furthermore, using the educational platform in pandemic is effective [39]. Table 7 illustrates the comparation traditional offline education with educational platform based on the architecture.

Table 7: Comparison traditional offline education with educational platform based on the architecture

TRADITIONAL OFFLINE EDUCATION	EDUCATIONAL PLATFORM BASED ON THE ARCHITECTURE
Costly	Cheaper
Learning only in lesson time	Learning in 24 hours a day
A teacher is required	A teacher is not required
Possible to use in quarantine	Impossible to use in quarantine

In summary, educational platforms that utilize machine learning deliver a personalized, adaptive, and data-driven approach, setting them apart from traditional platforms. They enhance learning by offering a more engaging and efficient experience tailored to the unique needs of each student. Educational platform based on ML offers several benefits: personalized and adaptive content, tailored lessons, real-time assessments with instant feedback, self-paced learning, enhanced interaction through AI-driven tools, and engaging methods like gamified learning and simulations. Therefore, educational platforms based on ML are the new era of online education. Also using ML in education is able to solve some issues of education.

References

[1] Stone J. E. , Teacher training and pedagogical methods. *Teacher quality*, 2002. 33-54.

[2] Kabulov A., Saymanov I., Babadjanov A., Babadzhanov A., Algebraic Recognition Approach in IoT Ecosystem. *Mathematics*, vol. 12, no.7, 1086, 2024: 1-26. https://doi.org/10.3390/math12071086.

[3] F. A. Phang., K. M. Yusof., A. A. Aziz., N. D. Nawi. and A. N. Musa.,, Cooperative Problem-Based Learning to Develop 21st Century Skills among Secondary School Students through STEM Education. *2017 7th World Engineering Education Forum (WEEF)* ,Kuala Lumpur, Malaysia , (2017):405-409, doi: 10.1109/WEEF.2017.8467122.

[4] Kabulov A., Yarashov I., Otakhonov A., Algorithmic Analysis of the System Based on the Functioning Table and Information Security. *2022 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, (2022): 1-5, doi: 10.1109/IEMTRONICS55184.2022.9795746.

[5] D. T. Muhamediyeva and N. A. Egamberdiyev., Algorithm and the Program of Construction of the Fuzzy Logical Model. *2019 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan*, (2019):1-4, doi: 10.1109/ICISCT47635.2019.9011960.

[6] Okagbue E. F. et al., A comprehensive overview of artificial intelligence and machine learning in education pedagogy: 21 Years (2000-2021) of research indexed in the scopus database. *Social Sciences & Humanities Open.*, (2023): 8(1):100655, doi: 10.1016/j.ssaho.2023.100655.

[7] Deng J., Huang X., Ren X. , A multidimensional analysis of self-esteem and individualism: A deep learning-based model for predicting elementary school students' academic performance. *Measurement: Sensors.* , (2024): 33(4):101147, doi: 10.1016/j.measen.2024.101147.

[8] Rajendran S., Chamundeswari S., Sinha A. A. , Predicting the academic performance of middle-and high-school students using machine learning algorithms. *Social Sciences & Humanities Open*, (2022): 6(1):100357, doi: 10.1016/j.ssaho.2022.100357.

[9] Parkavi, R., & Karthikeyan, P., Predicting academic performance of learners with the three domains of learning data using neuro-fuzzy model and machine learning algorithms. *Journal of Engineering Research.*, (2023), doi: 10.1016/j.jer.2023.09.006.

[10] Bohme R. et al. , Machine learning for spelling acquisition: How accurate is the prediction of specific spelling errors in German primary school students? *Computers and Education: Artificial Intelligence.*, (2024): 6(3):100233, doi: 10.1016/j.caeai.2024.100233.

[11] Suhail, F., Adel, M., Al-Emran, M., & AlQudah, A. A., Are students ready for robots in higher education? Examining the adoption of robots by integrating UTAUT2 and TTF using a hybrid SEM-ANN approach. *Technology in Society.*, (2024): 77:102524, doi: 10.1016/j.techsoc.2024.102524.

[12] Maniyan, S., Ghousi, R., & Haeri, A. , Data mining-based decision support system for educational decision makers: Extracting rules to enhance academic

efficiency*Computers and Education: Artificial Intelligence.*, (2024): 6(2):100242, doi: 10.1016/j.caeai.2024.100242.

[13] Bahassi H., Azmi M., Khiat A, Cognitive Systems for Education: Architectures, Innovations, and Comparative Analyses *Procedia Computer Science.*, (2024):436-443 , doi: 10.1016/j.procs.2024.06.045.

[14] Saleh M. M., Abdelkader M., Hosny S. S., Architectural education challenges and opportunities in a post-pandemic digital age *Ain Shams Engineering Journal.*, (2023):14(8):102131, doi: 10.1016/j.asej.2023.102131.

[15] Lemay D. J., Baek C., Doleck T. , Comparison of learning analytics and educational data mining: A topic modeling approach *Computers and Education: Artificial Intelligence.*, (2021):2(1):100016, doi: 10.1016/j.caeai.2021.100016.

[16] S. M. Dol and P. M. Jawandhiya, Use of Data mining Tools in Educational Data Mining. *2022 Fifth International Conference on Computational Intelligence and Communication Technologies (CCICT), Sonepat, India*, (2022): 380-387, doi: 10.1109/CCiCT56684.2022.00075.

[17] F. Doringin and J. Sapoetra, Analysis of Informatics as a New Subject with the New Approach in Elementary and Secondary Education. *2020 International Symposium on Educational Technology (ISET), Bangkok, Thailand*, (2020): 214-218, doi: 10.1109/ISET49818.2020.00054.

[18] A. Verma and A. Singh, New Era Of Technology Empowered Education: Education 4.0 A Systematic Review. *2021 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO), Noida, India,*, (2021): 1-7, doi: 10.1109/ICRITO51393.2021.9596245.

[19] Kabulov, A. V., Normatov, I. H., Ashurov A.O., Computational methods of minimization of multiple functions. *Journal of Physics: Conference Series*, 1260(10), 10200, 2019. doi:10.1088/1742-6596/1260/10/102007.

[20] K. Joshi et al., Exploring the Connectivity Between Education 4.0 and Classroom 4.0: Technologies, Student Perspectives, and Engagement in the Digital Era. *in IEEE Access,*, (2024): 24179-24204, doi: 10.1109/ACCESS.2024.3357786.

[21] Kabulov Anvar, Babadzhanov Alimdzhan, Saymanov Islambek, Correct models of families of algorithms for calculating estimates. *AIP Conference Proceedings*, 2781 (1): 020010. 2023. https://doi.org/10.1063/5.0144830.

[22] W. Zhang and S. Qin, A brief analysis of the key technologies and applications of educational data mining on online learning platform. *2018 IEEE 3rd International Conference on Big Data Analysis (ICBDA), Shanghai, China*, (2018): 83-86, doi: 10.1109/ICBDA.2018.8367655.

[23] C. Kurniawan and F. Wahyuni, Sentiment Analysis of Online Learning Students Feedback for Facing New Semester: A Support Vector Machine Approach. *2021 7th International Conference on Education and Technology (ICET), Malang, Indonesia*, (2021): 1-6, doi: 10.1109/ICET53279.2021.9575116.

[24] W. Fan, Simulation System of College Physical Education Based on Support Vector Machine Algorithm. *2023 IEEE International Conference on Image Processing and Computer Applications (ICIPCA), Changchun, China,* , (2023): 1600-1604, doi: 10.1109/ICIPCA59209.2023.10257797.

[25] G. Jin, Y. Zhou and H. Quan, Application and practice of Artificial Neural Network in innovative experimental teaching of soil mechanics under the background of Emerging Engineering Education. *2021 International Conference on Education, Information Management and Service Science (EIMSS), Xi'an, China,* (2021): 309-313, doi: 10.1109/EIMSS53851.2021.00074.

[26] R. Qin, Interactive Effect Evaluation Model based on Neural Network in the Guiding of Online ideological Education. *2021 5th International Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India* , (2021): 836-839, doi: 10.1109/ICOEI51242.2021.9452852.

[27] A. Dangi and S. Srivastava, Educational data classification using selective NaΓÏve Bayes for quota categorization *2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE), Patiala, India* , (2014): 118-121, doi: 10.1109/MITE.2014.7020253.

[28] L. Fang et al., Application of Naive Bayesian Classifier for Teaching Reform Courses Examination Data Analysis in China Open University System *2015 8th International Symposium on Computational Intelligence and Design (ISCID), Hangzhou, China*, (2015): 25-29, doi: 10.1109/ISCID.2015.81.

[29] M. Abdar, M. Zomorodi-Moghadam and X. Zhou, An Ensemble-Based Decision Tree Approach for Educational Data Mining *2018 5th International Conference on Behavioral, Economic, and Socio-Cultural Computing (BESC), Kaohsiung, Taiwan*, (2018): 126-129, doi: 10.1109/BESC.2018.8697318.

[30] W. Yanxia, Student Information Management Decision System Based on Decision Tree Classification Algorithm *2022 IEEE 5th International Conference on Information Systems and Computer Aided Education (ICISCAE), Dalian, China,* (2022): 827-831, doi: 10.1109/ICISCAE55891.2022.9927597.

[31] S. Poudyal, M. Nagahi, M. Nagahisarchoghaei and G. Ghanbari, Machine Learning Techniques for Determining Students' Academic Performance: A Sustainable Development Case for Engineering Education. *2020 International Conference on Decision Aid Sciences and Application (DASA), Sakheer, Bahrain.* ,(2020): 920-924.doi: 10.1109/DASA51403.2020.9317178.

[32] Saymanov, I., Logical recognition method for solving the problem of identification in the Internet of Things. *ArXiv*, 2024, arXiv:2402.04338.

[33] Ofori F., Maina E., Gitonga R. , Using machine learning algorithms to predict students performance and improve learning outcome. *A literature based review //Journal of Information and Technology.*, (2020): 33-55.

[34] M. D.T,, Aproaches to the Construction of Fuzzy Models of Intellectual Analysis of the State of the Low-Formalized Processes. *2019 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan*, (2019): 1-5, doi: 10.1109/ICISCT47635.2019.9011909.

[35] Navruzov, E., Kabulov, A., Detection and analysis types of DDoS attack. *2022 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, (2022): 1-7, doi: 10.1109/IEMTRONICS55184.2022.9795729.

[36] Kabulov A., Saymanov I., Yarashov I., Karimov A., Using Algorithmic Modeling to Control User Access Based on Functioning Table. *2022 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, (2022): 1-5, doi: 10.1109/IEMTRONICS55184.2022.9795850.

[37] Ofori F., Maina E., Gitonga R., Using machine learning algorithms to predict students performance and improve learning outcome: A literature based review. *Journal of Information and Technology.*, (2020): 33-55.

[38] Saymanov, I., Logical automatic implementation of steganographic coding algorithms. *Journal of Mathematics, Mechanics and Computer Science*, Vol 121, no. 1, 2024. https://doi.org/10.26577/JMMCS2024121112.

[39] Muhamedieva Dilnoz, Erkaboy Samandarov, Overview of The Educational Platform for Predicting and Classifying of Pupils Knowledge Based on Artificial Intelligence *International Conference on Information Science and Communications Technologies-Applications, Trends and Opportunities ICISCT 2023*, 2023: 15-19.

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