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Studying of Educational Data Mining Techniques

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ABSTRACT: The Electronic (E) - Learning attracts the attention of researchers in the recent years. This for different reasons, such as easing the board studying and guarantee the education for busy people. Different methods and algorithm have been adopted in e-learning systems to offer more flexible services for students. In addition, the recent smart systems consider the prediction strategies for expecting the logical results of different categories in e-learning. The researcher goes further with decision making for students, presented as a recommendation for each type of classification. Moreover, the e-learning systems use the classification and clustering methods for classifying the investigated dataset. In this paper, a comprehensive study of the recent e-learning decision making and prediction is presented. It offers a wide information regarding the subject of decision making and prediction in e-learning that can improve them efficiently. Discussion and recommendations have been included in this paper.

KEYWORDS: Educational Data Mining; Student Performance Prediction; Hybrid Technique.

1. INTRODUCTION

Data mining (DM) is defined as Knowledge Discovery in Databases (KDD), used for discovering hidden information from different data sources, multiple data mining techniques can be applied in various fields including marketing, business, medical, etc [1].

In recent years there was an intense attention in the field of educational data mining (EDM) as a result of the development of e-learning systems, the massive volume of educational data, and even evolving traditional education. Educational data mining is a subdomain from data mining which has been developed to extract and analyze new information from educational data sources [2].

Early Student academic performance (SAP) prediction can support educational institutes, universities and schools in improving their education quality by forecasting student level activities, student' subject interests, factors (economic, educational, behavioral, social, etc.) that affect student performance and identifying dropout points [3].

For the purpose of early notifying student activity level, machine learning utilized along with EDM. This can improve the acquisition of knowledge or skills on how to treat weak points at student's achievement. In the future, machine learning techniques can be considered as an integrated part of any educational institution instead of manual investigation in related data which has great effort and time-consuming [4,5].

There are numerous machine learning and DM techniques that can be categorized into two types; either traditional DM methods and compare accuracy among them or a combination of two or more methods (hybrid) to improve accuracy and overcome drawbacks of a single approach. This paper aims to illustrate and study the main prediction techniques, in addition, to discuss their findings, (pros& cons) in case of presenting, state on which features classification is performed and suggest some recommended beneficial to the learning process.

II. LITERATURE REVIEW

Several research studies have dealt with the prediction of students' performance in different levels. In the present literature, a number of complementary approaches are offered with taking into consideration distinct sizes and sources of datasets, as well as factors affecting student performance assessment.



In [6], the authors utilized Apriori algorithm to extract similar patterns come from a different set of records. Additionally, they employed the k-means cluster analysis to generate a group of students based on their personal and academic fields. This study gave greater priority to psychological attributes than an academic one. Students were grouped into two clusters good and poor. Dataset consisted of 100 students using 45 parameters of Government Higher Secondary School and prediction was satisfactory.

The authors of [7] performed the preprocessing to the data that was collected from three different colleges of 300 students with 24 attributes. After employing the data cleaning by removing incomplete data, 22 features were selected. Four types of classifier J48, PART, BayesNet and Random Forest were applied. Based on accuracy and classification errors, a confusion matrix was found to show that Random Forest was more suitable than other classification methods, Apriori algorithm also executed to extract association rule among all attributes and find the best-suited rules.

Another study of predicting the performance of students in [8] introduced two new features family expenditures and student personal information. The authors analyzed these feature with other feature to determine the impact of the selected attribute. Two generative (Bayes Network (BN), Naive Bayes (NB)) and three discriminative (SVM, C4.5, CART), SVM was the most effective for finding the new feature among other methods.

In addition, soft computing methods played a major role in EDM. They were applied as a single or hybrid with other methods. The authors of [9,10,11,12] analyzed student's academic level using the Neural Network (NN) trained by decision tree learning or applied various types of NN to classify the students into the predicted success and failure categories.

III. TRADITIONAL DM TECHNIQUES

The Prediction can be applied using DM that consider the following techniques:

- classification.
- clustering.
- association rule mining.
- Sequential and Pattern prediction.

Classification is the most popular methods used for SAP prediction in EDM [13][14]. This paper preview the most frequently used methods applied for forecasting SAP, including classification and clustering.

a. CLASSIFICATION

Classification is a process of describing a model (or function) that distinguishes data classes. The model is built based on data objects for which the class labels are known. After that, the model is used to predict the class label of unknown label objects [13]. Classification is supervised learning method. It consists of two steps [15]:

- Model construction by analyzing the training data.
- Test data used for model evaluation.

The most popular method for data classification is the decision tree that includes many types.

Decision Tree

A decision tree is a tree-like structure, which starts from root attributes, each branch of the internal node being a possible value of the attribute and ends with leaf nodes (class's names). Decision tree classifiers produce simple way used to interpret the classification rules [9].

Many forms of decision tree search related student personal and social factors assumed to influence students' academic performance. Four kinds of decision tree classifiers: ID3, C4.5, CART, and CHAID have been used on a dataset of 270 records collected through classes and Google forms. This research found that the performance of students does not depend entirely on academic factors, although there are other factors that have the same or greater impact on the level of performance students [16].

Next research of [17] was used the same DT types on a different dataset. Predicted student performance can be found by comparing between different decision trees classifiers. These classifiers are built based on various attributes belong

to 466 students from an engineering college. The accuracy of each classifier was computed and it was shown that CHAID has the highest accuracy of 76.11%, C4.5 with 73.13%. Table 1. shows accuracy results for four decision tree types, dataset sizes, and attributes used for prediction in each research.

TABLE 1: DECISION TREE TYPE'S ACCURACY

RESEARCH	Attributes	Datasets size(record)	ID3	C4.5	CART	CHAID
[16]	Academic and social features	270	33.33%.	35.19%.	40%.	34.07%.
[17]	Previous Semester Marks Internal Tests Grades Project Marks Attendance Final Semester Marks (Semester 8)	466	70.15%	73.13%	71.64%	76.11%

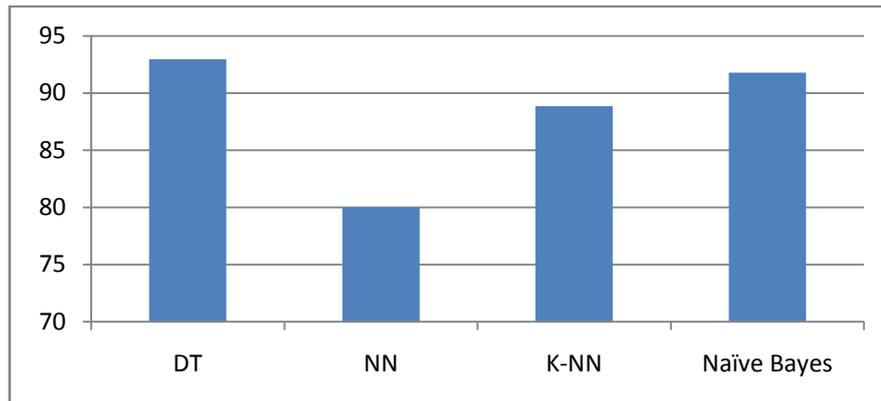
Addition to that, the numerous forms of the decision tree can be compared with a different classifier (Neural Network, Naïve Bayes, and KNN) in term of their accuracy. Table 2 shows the decision tree accuracy as compared to another classifier. It can be said that decision tree has higher accuracy than other methods in investigated papers based on the various attribute.

Table 2: Comparison accuracy of Decision Tree with other classification methods

Research	Methods	accuracy	Attribute
[20]	J48 Neural Network	82.2% 80.0%	Gender, Nationality, Place of Birth, Stages,
[21]	J48 Random Forest Naive Bayes Naive Bayes Multinomial	75.8333 % 76.6667 % 67.7083 % 43.9583 %	Gender, Nationality, Place of birth...
[22]	DT Naïve Bayes KNN	92.96% 91.79 88.86%	Level, Orphan, SHC, BirthYear, Camp,FatherWork, FailYears, PrevYear, first term, FinalResult

Performance accuracy for each classification method for researches explained in Table 2 in recent two years (2017-2018) can be visualized in Figure 1.

Figure 1: DM Classification Technique's highest accuracy in 2017-2018



B. Clustering

Clustering is an unsupervised method that divides data into distinct categories, in which the data in the same set have similar properties and differ from other data in other aggregates. Clustering has an important role in data mining applications, for example, marketing, text mining, medical diagnostics, and many others [21].

There are various clustering techniques can be utilized in data mining. In [22], the authors provided a comprehensive review of different clustering techniques in data mining. Figure II states the main categorization of clustering approach in DM.

K-mean

Several research studies were reviewed EDM with various clustering methods. The authors of [23] presented EDM clustering methods in an overall review by stating objective of presented paper, algorithm, and datasets. Most of the goals are focused on analysis and definition of educational data so that universities can know who can be failed in advance. In [24], authors showed that the K-mean clustering algorithm was the major type in the analysis of student data due to finding common characteristics that enable educational institutions group to help their students for faster performance prediction.

Figure 2: Major Clustering Methods [22]

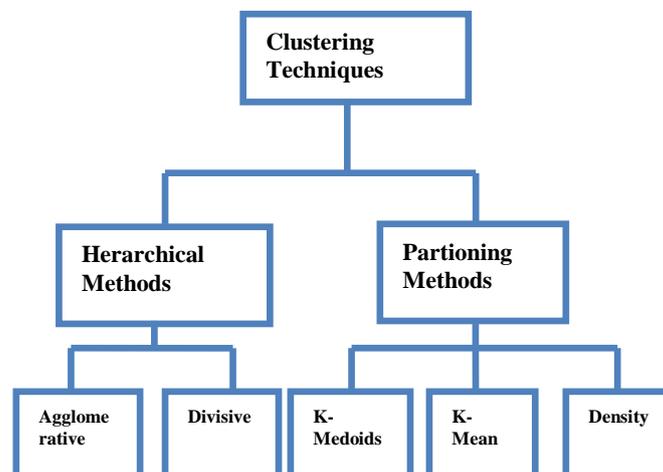


Table 3 summarizes some researches that predict students performance based on clustering techniques which use k-mean method along with other clustering and classification technique.

Table 3: EDM Clustering/Classification Techniques

research	#instance	Attribute	Methods	#cluster	Findings
[10]	58	Total marks Grade attendance Major / minor1/minor2	Kmean/ Hierarchical Clustering Algorithm(single linkage)	3	<ul style="list-style-type: none"> • Influential clustering for instances using k mean. • The model was built with less time using k-mean(0.12 sec) while taking (0.49 sec) using the hierarchical method
[11]	118	Grades from semester III to semester VII	k-mean	4	<ul style="list-style-type: none"> • Present performance evaluation for semesters based on deterministic model.
[12]		10 th percentage, 12 th percentage, semester marks	Kmean Decision tree	3	Decision tree obtain more accuracy than k-mean, therefore ,Preferred classification on the clustering
[13]	79	Student's scores of 9 courses	k-mean	3,4,5	Evaluate clustering performance for each cluster number
[14]	200	Grade (Quiz, Internal, Lab, Attendance	K-mean/ decision tree	3	using K-Means in clustering algorithms and decision tree technique to analyze and improve the quality of engineering education
[15]	270	No. of students, Placements	k-mean	4	<ul style="list-style-type: none"> • . faster k-mean implementat-ion • produce tighter clusters



[19]	94	Gender, Category, Grade division in X class, Grade division in XII class,.....	PCA K-MEAN	2,3,4,5	• uses extraction method PCA to analyze variables and perform ANOVA test to contrast the group's means
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IV. HYBRID TECHNIQUES

The major traditional/classic approaches may have certain drawbacks, to overcome weak points in elementary methods. This section highlights the outcomes of the researches that used a combination of two or more soft computing/DM methods. This section can be explained in different categories as follows:

A. Fuzzy Decision Tree

DT is built by splitting the nodes depending on the best features, as it influences DT accuracy, and finally interpreting its rule. Intuitionist fuzzy decision tree classifier (FDT) uses intuitionist fuzzy entropy to compute information gain, which is based on a soft decision tree that is an extension of ID3. In [36] authors presented a comparison between the FDT classifier and other well-known methods (J48, Logistic Model Tree, NBTree, RandomForest, MultilayerPerceptron, Logistic) using two criteria ROC curve and identification of instances. The obtained results showed that the standard deviation of the accuracy of FDT method is lower than other methods. Additionally, classification accuracy is slightly better than other methods of 0.39.

B. Genetic Decision Tree

In e-learning, the numbers of dropout students are absolutely greater than those in traditional educational institutions. Furthermore, dropout rates depend on the e-learning system provided by the educational institution, and on the chosen topic. Authors of [37] predicted student failure by improving decision trees (populations) size vs. accuracy using a fitness function. Genetic algorithms generated a number of DT population sorted according to fitness value. Genetic operators have performed on DT population result in a new population. The accuracy of the proposed method (GATREE) performed well as compared with other methods, such as J48, MLP, Logistic regression, Naïve Bayes, 3-NN.

C. Fuzzy Genetic

Fuzzy logic represents real world due to uncertainty. Authors of [38] exploited this concept through the use of fuzzy with genetic algorithm (FGA) made classification more flexible for a student, classified as at a low level (fail). This student could be in safe (success) by combining the attribute that has high efficiency with other attributes with low effect to obtain more successful students. In contrast to DT that follows hard classification rules, the truth is they were on the edge of success, this affected the degree attention of the lecturers to those students due to categorizing more students at risk.

D. Fuzzy Probabilistic Neural Network

The probabilistic neural network is a neural network with deterministic classification and has fast building/training time, while the fuzzy neural network has the ability to solve nonlinear and uncertain equations. In [39], the authors used Fuzzy probabilistic Neural Network (FNN) to fix misclassification problem when input can belong to more than one class at the same time with a certain degree of the membership. Some methods were used for predicting SAP without considering the most relevant factors due to their ambiguity. In order to improve the obtained results, FNN can be used. The proposed method was applied to two datasets 300, 570 students into three classes (good, average, and poor). The correct prediction percentage for average class of the first dataset is 100%, and the processing time is about 47 mins as compared with a typical back propagation network which takes about 120 mins.



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E. Adaptive Neuro-Fuzzy Inference (ANFIS)

The combination of more than one methods can deal with cons of two approaches when they are used separately. Neuro-fuzzy inference system (NFIS) is a soft computing tool which merges the FL with the NN. In [40] three kinds of ANFS models have been used: Gaussian, Triangular, and Generalized Bell membership functions. The preprocessing step (normalization) was done first to the degrees of the previous exam to enhance the accuracy of SAP prediction due to minimizing error during the learning process. The normalization was achieved by using the mean and standard deviation of the data samples. The second step applied ANFIS to the forecasted future outcome. The result showed that ANFIS-GbellMF had the lowest Root Mean Square Error as compared with two other models.

V. DISCUSSION

From Table 1, we conclude that the two types of research used different characteristics to predict the level of students. Research work of [17] was based on the evaluation of students' grades with the consideration of grades in the previous semester marks, tests, project scores, and attendance. In contrast to the research work of [16], the authors considered the academic and social factors of the student without adopting the previous and current grades of the students. Therefore, the accuracy obtained from the classification was higher in [17], even though the above research worked on two different datasets.

Research work of [35] considered single UCI dataset that consisted of attributes of two courses (Portugal Language course and Math Course). The making of prediction was performed using three decision trees algorithms: J48, RepTree, Hoeffding Tree. In each algorithm, different student variables were considered. The first algorithm selected all attributes except G1Grade, G2Grade, G3Grade used as end class, Absence attribute deleted and replaced by Absence Rate. The second algorithm was run based on all attributes except G1 and G3 with the goal student want higher education or not. The third algorithm used all attributes. From all tests can be inferred that the accuracy affected by two factors: the number of input attributes and the goal class attributes and the goal class attributes.

Clustering analysis is affected by some properties, such as high dimensionality, attributes, shape, size, etc. Cluster analysis can be used when data label is not known well, thus relevant data can be grouped together and noisy data can be excluded. Among many DM methods, prediction and clustering provide accurate results in forecasting student performance as conducted by the work, presented in [31]. For example, the decision tree can be used for predicting student's performance by categorizing critical courses based on social/demographic feature and marks at early stages. Then clustering can be used for identifying attributes of outgoing students [32]. But the decision tree does not take all the variables for the students into consideration when building the model and k-mean that has a divergence problem in computing cluster, led to infinite iterations. Thus, the research work of [33] overrides limitation of two algorithms using enhanced K-strange point clustering algorithm, Naïve Bayes, and multiple linear regressions.

The most important issue in predicting student's early failure or success is to determine and identify the most influencing factors that affect student during their study. This is done by analyzing the relationship between students behavioral and their scores. From Table III, the authors of [34] conducted that feature of parent's occupation has a vital effect on prediction and 'type of school' does not influence student performance.

The research works, considered hybrid techniques, demonstrated that reasonable accuracy could be achieved when some or all drawbacks at ingredients of hybrid methods are addressed. For example, using fuzzy logic with DT or with neural networks can ride of crisp classification results (either success or failure).

It is important to note that the use of hybrid methods cannot gain the highest accuracy as explained in [41] showed that the combination of the neural network multilayer perception, DT (C4.5), NB classifier has a lower accuracy (94.47) than NB classifier that obtains greater accuracy (95.09) on the selected case study.



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VI. RECOMMENDATIONS

The existences of some issues are implicitly / explicitly stated in the processes of predicting the future achievements of students. Making the motivation for some recommendations that can be taken when considering different EDM techniques to have better results:

1. The algorithm can deal with the certain type of features, utilize influencing factors that affect classification accuracy, therefore, the preprocessing steps are time-consuming and effort-intensive.
2. Feeding algorithm with students' a priori knowledge (i.e, previous semester grades, daily exams, and tests) can improve accuracy.
3. Using an algorithm that has the ability to handle outliers.
4. Taking into consideration dataset scalability.
5. The result of the algorithm must be interpreted to understandable rules.
6. Using of methods that can deal with misclassification problem resulted from using an ambiguous feature, for example, fuzzy reasonable.
7. Data collected manually through questionnaire is time-consuming thus student admission data in learning system is recommended.

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