Predicting Students Performance Using Classification Techniques

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Abstract
This research paper aims to use data mining methodologies to predict student's performance to figure out factors influenced students' success to help the university to success more effectively in an efficient way. In this paper, we will go through the literature to review the most recent contributions to this topic. Then, we propose a model that focuses on predicting students' performance using classification techniques by applying different algorithms and compare them to find which one is more suitable in our case. In the end, the reader becomes aware of the importance of studying students' academic performance through understanding the previous studies that have helped educational institutions to improve and enhance their professionalism in education and increase their students' performance success rate in an efficient way.

Keywords:
Data Mining, Classification, Educational Mining, Student Academic Performance, Predictive Model, Descriptive Model.

1. Introduction

Data mining recognized as part of the knowledge discovery in databases by the early 1990s [1]. There are three important technologies that data mining is built on which are statistics, artificial intelligence, and machine learning [2, 3]. These important technologies are helpful to study and analyse data, and to determine relationships between different data sets. The statistical method could be used in data mining classification algorithms to create rules and decision trees, while artificial intelligence is used based on heuristics to apply human thought processing [4, 5]. Machine learning is mixed with statistical analysis and artificial intelligence heuristic [6].

Data mining is a procedure which be used to identify unknown pattern and to find relationships among data sets from a large data sets by turning raw data into useful information [7]. Data mining is knowledge discovery in databases (KDD), which is used for exploring and discovering data in search of unknown patterns or knowledge [8]. Data mining is a process that consists of understanding the requirements, selecting a target data set, integrating the data set, cleaning and processing the data, building model, selecting data mining algorithms, evaluating the results, testing the results, and using the result to discover knowledge.

Nowadays students become the main valuable asset in any educational institution and learning about their performance will help both the educators and learners to improve the learning and teaching process [9]. Understanding the attributes and factors that affect students' academic success is a critical way to improve the educational landscape [9]. Moreover, the using of web technologies such as learning and educational systems in universities increased the actual amount of data about students [10]. This will lead the analysis of educational data, educational data mining and predictive analytics to become an important and innovative area of research [10].

Data mining is playing a critical and essential role in the educational sector. Students are the main stakeholders of universities and recognizing their academic performance will be very helpful in the development of a society that will support the educational institutions to improve the quality and to increase the success rate more efficiently [10]. Besides, students' performance is an important criterion for a high-quality university but predicting the results from the massive amount of data in the educational database becomes more demanding [11]. Because of big data in education, new data mining methods and techniques become more and more necessary to handle them [12]. Data mining in education can discover hidden information by applying different classification algorithms for machine learning to analyse the data [13]. There are various classification algorithms for predicting students' performance such as Neural Network, Decision tree, Naive Bayes, K-Nearest Neighbour and support vector machine [11].

Our aim in this paper is to use the classification technique to early identify students at risk with a low future academic performance and support them to choose the right university majors or advise them to change their major that they have chosen before they starting their academic study to enhance success rate. Our model will be able to predict students' performance depending on the meaningful information. Our research paper will focus on predicting students' performance by classification techniques using different algorithms and then comparing them to choose the best algorithm that provides the highest accuracy rate. We will focus on the students' data to build this model and test it using the WEKA tool.

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The subsequent of the paper is organized as follows: Section 2 gives the literature review. The anticipated model is introduced in section 3. Section 4 presents the results and discussions. Finally, section 4 shows the conclusion and future work.

2. Literature Review

2.1. Data mining in the education field

Sree and Rupa [14] defined knowledge discovery in databases or data mining as a process that used to identify and discover the existing relationships or pattern, and extract the valuable knowledge. Data mining used today in different fields, but in their research, they focused on data mining in the education field to take advantage of student's learning behavior and performance by enhancing the learning process, identifying, extracting and discovering variables and attributes [14]. For universities, data mining techniques could help increase student's retention rate, increase educational improvement ratio, increase student's learning outcome, provide more personalized education, maximize educational system efficiency and decrease the cost of education process [9].

Mining in the educational field called Educational Data Mining, which provides a new way to look into education from the perspective that was hidden from humankind [15]. Romero and Ventura discovered data mining in education since 1995. In their research paper, they explained in detail several traditional educational data mining techniques such as statistics, clustering, classification, association rule mining, text mining, and prediction. Each of these data mining techniques has a specific purpose to resolve different educational activities such as applications dealing with assessment of the student's academic performance, application that provide learning recommendation in reliance on the student's behaviors, application that provide feedback to both teacher and students in e-learning courses, and application that discover atypical students that have some type of problem or unusual patterns of behavior such as: cheating, dropping out, academic failure, etc. [15]. Their work gives us an impulse to search more for this topic and to know the evolution in this field since data mining had to use an advanced technique such as machine learning and artificial intelligence for estimating large datasets. Researchers of educational data mining studied student's performance by discovering different areas such as finding factors or attributes that affect student performance or analyzing several data mining algorithms that can take advantage for predicting student's academic performance and discovering what is appropriate tools that can be applied in mining the data and finding the results [16].

2.2. Attributes or Factors affecting Student Academic Performance

According to the study [17], the authors discovered that the attribute CGPA is using in the most universities to assessing the performance of the students. CGPA refers to the average grade points obtained for all courses throughout the entire student's academic performance. In their research paper, they explored and examined the factors that can affect student performance at The Islamic University of Bahawalpur. They gathered the information through the questionnaire by distributed them randomly among each department in the university and from each department four classes were selected randomly. The study found the eight factors that affect student performance at The Islamic University of Bahawalpur which are family income, father education, mother education, size of family, the motivation of parents, the regularity of teacher, and involvement in co-curricular activities and interest in the subject. Furthermore, a systematic literature review [16] on students' behavioral by employing data mining was prepared to find the important factors and the most data mining approaches that can take advantage for predicting the students' performance. In this paper, researchers summarized common attributes used in predicting which include: internal assessment, CGPA, Extracurricular activities, Student demographics, high school background, scholarship, psychometric factor, and soft skills. Moreover, they found the frequent attributes that have been utilized to predict the performance that is cumulative grade point average (CGPA) and internal assessment such as assignment mark, quizzes, lab work, class test, and attendance. By finding the coefficient correlation analysis, they found that CGPA is the most significant input variable compared to other variables followed by internal assessment.

In addition, the most often attributes used for prediction are demographics such as gender, age, family background and disability, and external assessments that is the mark of the final exam for specific subjects [18]. Moreover, the other two main important attributes that influencing student's performance that is extra-curricular activities and high school background [19]. Student demographic attribute such as gender, age, family background, and disability according to the study [20], is the next most important attribute can be used for prediction. Researchers rarely depend on psychometric factors such as student interest, study behavior, engage time and family support to predict the student performance because this factor focuses mainly on qualitative data and it is hard to get valid data from respondents [21]. According to the study [22], researchers identified the drivers that have an impact on the performance of the student in the final exam and explored the suitable data mining algorithms used to predict the grade of students. Researchers have collected their data from higher secondary students by selecting randomly nine schools from

Kanchipuram district and they applied several data mining algorithms on the selected date. They found that the type of school does not influence student performance but the factor that plays a major role in predicting the student grades was the parent's occupation [22]. Bhardwaj and Pal [23] performed a study at Awadhi University, India and they selected 300 students. They used the Bayesian algorithm and found 17 attributes that affect student's performance and the most highly influenced factors were student's grade in the senior secondary exam, the location where they live, mother's qualification degree, amount of family income, and the status of their families. Following with another study that was conducted by Hijazi and Naqvi [24] by picking a sample of three hundred students both female and male at Punjab University of Pakistan. They used simple linear regression algorithm and they found the highly correlated factors with the student's performance were mother's certification degree and family income of the students.

2.3 Data mining models for predicting students' performance

There are two models for exploring the data and knowing the students' performance, which are a descriptive model and predictive model.

2.3.1 Predictive Model

This model has been defined by Delen and Demirkan [25] as a model that uses known results from different data to predict subsequent data values and tries to find the best predictions about future forecasting. This model relies on to use the existing and previous state of the attributes to predict what will happen in the future and why will it happen. Nawal Ali Yassein et al. [26] found that Predictive modeling is the most useful model that has been used in predicting student's performance. The researchers figured out some of the tasks or methods that can be employed in this field that are classification, regression, time series analysis, and prediction. According to them, classification is a technique used to categorize each item in a set of data into predefined groups or classes that could be used and processed in the future work to classify the data. This could be achieved by using mathematical techniques such as decision trees, statistics, neural networks or neighbor nearest method. Tree structure algorithms such as nearest neighbor method and decision trees produce a set of decisions that generate rules for a set of disaggregated data. Moreover, regression is a data analysis technique that has been used to describe the relationship between variables and to estimate the value of one variable if the other one is known. Time series analysis is a part of predictive analysis to view the behavior of the data over time to produce a fundamental analysis and it can be used in stock market analysis, economic and sales forecasting, budgetary analysis, utility studies, inventory studies, science and engineering experiments and medical treatment. In addition, they mentioned in their paper that prediction is the most widely used predictive analysis model to estimate and forecast the data based on learning from historical data.

2.3.2 Descriptive Model

This model is mainly used to explore the characteristic of data that being studied but is not for predicting the characteristic of the data like the predictive model. Nawal Ali Yassein et al. [26] defined a descriptive model as a model that defines patterns and relationships in data by mining and recognizing data in depth to recap information from data. Clustering, association rules, sequence discovery, and visualization are the main techniques that can be used in a descriptive model to learn more about student performance in an educational institution. Moreover, clustering as they described is a data mining technique that group objects which they have similar characteristics into different classes or groups. Clustering is a data mining technique that makes a useful cluster of objects that are similar to one another in the same cluster and dissimilar to objects in another cluster. It is unsupervised learning because it does not use a predefined class. This technique first divides a set of data into classes based on data similarity and then identifies labels for those classes. By applying the clustering technique in the university, we can keep students that have similarities in one cluster.

Association pattern as they have defined is one of the best data mining techniques for knowledge discovery that can be used to discover a pattern based on a relationship between items. This technique has the ability to process vast amounts of data and deduce all possible laws that explain some of the existing attributes depending on the presence of other attributes. Moreover, it is a popular method for a discovered interesting relationship between a large set of data item, it defines a strong association between items that appear frequently in a given data set. Sequence discovery is called a time series analysis method that uses to discover similar patterns, regular events or trends in transaction data over the business period. It consists of a sequence of events that occurred over repeated time that measured at an equal time interval. Sequence discovery could be used in educational data mining to identify the association and sequential patterns in data over time to cover unknown facts while visualization technique is helpful in understanding and observation of the data output from the data-mining algorithm.

2.4 Data mining classification technique for predicting student performance

In the field of educational data, mining classification technique is a main and most useful technique and can be used for prediction. There are several classification

techniques that can be used in educational data mining and selecting the appropriate technique depends on the nature of the data as well as the size of the data. Classification technique is a classic data mining technique based on machine learning which is used to classify each item in a set of data into one of predefined classes or groups. In the classification algorithm, we learn from the training set and then create a model that is used to classify the object [26]. The classification technique is performed by two steps that are first building the model from a training set made up of database rows and their associated class label, then used that model to classify the data into appropriate class and use test data to estimate the accuracy of a classification rule. Algorithms used various classification for prediction such as Naive Bayes Algorithm, Random Forest Algorithm, Neural Network Algorithm, K-Nearest Algorithm, J48 Algorithm, ID3 Algorithm, and C4.5 Algorithm. According to research papers [26, 27, 28, 29], each of the data mining algorithms has advantages and disadvantages.

- Naive Bayes Algorithm: it is a simple probabilistic and efficient algorithm that can be used to predict student performance and it shows a higher accuracy rate with independent attributes [28].
- Random Forest Algorithm: An ensemble algorithm combines more than one of the classification algorithms and used to improve predictive accuracy. It creates a set of decision trees that are selected randomly from the training set and then the decision about the final class will be based on the voting from randomly selected decision trees [29].
- Neural Network Algorithm: it is used to identify and find hidden and complex relationships in the data set through the different processes but it is not the perfect algorithm to deal with missing data or to support mixed variables. It used in educational data mining because it has the ability to learn from the data and to generalize [29].
- K-Nearest Algorithm: it is a simple algorithm that can work with noisy and incomplete data but it is not the perfect algorithm to deal with missing because it is required many data [29].
- J48 Algorithm: it is similar to ID3 but it counts the missing data, deals with decision tree pruning and handles continues variables [29].
- ID3 Algorithm: Iterative Dichotomiser 3 is a decision tree algorithm that consists of the root node that contains the most relevant attribute in the dataset and has the other two types of nodes called internal nodes and leaf nodes. This algorithm has many advantages some of them are: it is simple to understand and visualize a useful approach for the practical problems, can handle both numeric and categorical data, gives accurate results, and detection rate is high. In addition, has some disadvantages, which are: it may contain empty branches, it is unstable because small variation in the data might result in a completely different tree being created, searching time is very high, and it needs very large memory to store the tree structure [29].
- C4.5 Algorithm: it is an improvement of the ID3 algorithm and it is very easy to implement and interpret. In addition, it is accepted both continuous variable and discrete ones but it is not a suitable algorithm to deal with a small dataset [28].

3. Anticipated Model

The proposed solution is to create and build a model using data mining techniques that will be helpful in achieving accurate results and measuring academic performance to help the students to take better decisions and improve their performance. The proposed model consists of specific steps that deal with students' data and their secondary school certificate. The main steps are selecting data, selecting the appropriate technique, preparing data, selecting the proper algorithms, selecting the most suitable application tool, and evaluate the results.

3.1 Dataset and attribute selection

We have selected a public dataset contains the performance results of several students [30]. The dataset contains 649 records and 32 attributes, that display: information of the students which include (school; sex; age; address; famsize; Pstatus; Medu; Fedu; Mjob; Fjob; reason; guardian; traveltime; studytime; failures; schoolsup; famsup; paid; activities; nursery; higher; internet; romantic; famrel; freetime; goout; Dalc; Walc; health; absences; G1; G2; G3).

3.2 Data Preprocessing and Cleaning

We have selected the WEKA interface tool to prepare our data. WEKA that refers to Waikato Environment for Knowledge Analysis tool allows us to do data cleaning which is means selecting or removing attributes based on our needs. Then, we either pre-processed our dataset to remove missing values or duplicated rows. This is a very important step because machine-learning algorithms do not accept any missing values. Filtering is a very helpful step because it helps to prepare the dataset by converting the numeric attributes to nominal.

3.3 Classification Process Cleaning

In this step, we applied different classification algorithms into our dataset after finishing the preparation process. We decided to use the Weka tool to apply the algorithms and we compared the performance of algorithms

in the aspect of accuracy, sensitivity, and specificity of classifying. We trained the model to predict the final student grade using first-period grade, second-period grade, demographic, social and other student-related data. The proposed machine-learning algorithm is One Rule classifier. Moreover, other algorithms used as baseline classifiers are Decision Trees (DT), Random Forest (RF), REPTree, Sequential Minimal Optimization (SMO) and Naive Bayes.

The One Rule, OneR, is one of the learning classification algorithms that depend on the frequency table. The OneR Algorithm proves to be accurate since it is a trained model and most trained models prove to be good and accurate overall. It handles missing values either by omitting them or by treating them as not available. Since it only handles categorical data, the OneR has several methods to handle numerical data if it existed in the set of data [31].

4. Results and Discussions

One rule classifier is the proposed method in our study. In this section, we will show the results of applying OneR classifiers for the dataset using two supervised approaches which are binary classification and 5-level classification with two methods of testing one with 10-fold cross-validation method and other one is holdout (70% training and 30% testing) evaluation methods as shown in Tables 1, 2, 3, and 4.

Table 1: 5-Level Classification Accuracy result using holdout (70% training and 30% testing)

Classifier	***Accuracy***	***Training Time***	***Sensitivity (Recall)***	***Precision***
OneR	73.0769%	0.02	73.1	74.3

Table 2: 5-Level classification accuracy result using 10-fold cross-validation

Classifier	***Accuracy***	***Training Time***	***Sensitivity (Recall)***	***Precision***
OneR	68.7211%	0.04	68.7	68.9

Table 3: Binary classification accuracy result using holdout (70% training and 30% testing)

Classifier	**Accuracy**	***Training Time***	***Sensitivity (Recall)***	**Precision**
OneR	96.9231%	0.07	96.9	96.2

Table 4: Binary Classification Accuracy result using 10-fold cross-validation

Classifier	***Accuracy***	***Training Time***	***Sensitivity (Recall)***	***Precision***
OneR	97.6889%	0.08	97.7	97.2

We did an experiment to compare between proposed classifier and other tested classifiers which are Decision Trees DT, Tables 1 and 2 show the result of applying OneR for five-level classification and the accuracy for applying OneR using tenfold cross-validation was 68.72% and 73.08% using hold out method. Tables 3 and 4 show the result of applying OneR for binary classification and the accuracy for applying OneR using tenfold cross-validation was 97.69% and 96.92% using hold out method. Random Forest (RF), REPTree, Sequential Minimal Optimization (SMO) and naive Bayes. For each classifier, we tested our dataset using two supervised approaches that are binary classification and 5-level classification with two methods of testing one with tenfold cross-validation method and the other one is holding out method. Tables 5 and 6 present the comparison accuracy results of classifiers for 5-level classification and binary classification approaches.

Table 5: Comparison accuracy results of classifiers for 5-level classification

Classifier	***Classifier Accuracy by using 10-Fold Cross Validation Method***	***Classifier Accuracy by using Holdout Method***
OneR	68.7211 %	73.0769 %
J48	59.168 %	57.6923 %
Random Forest	60.2465 %	62.3077 %
REPTree	65.9476 %	69.2308 %
SMO	59.9384 %	62.3077 %
Naïve Bayes	59.322 %	63.0769 %

Table 6: Comparison accuracy results of classifiers for binary classification

Classifier	***Classifier Accuracy by using 10-Fold Cross Validation Method***	***Classifier Accuracy by using Holdout Method***
OneR	97.6888 %	96.9231 %
J48	96.6102 %	96.9231 %
Random Forest	97.3806 %	96.9231 %
REPTree	97.0724 %	96.9231 %
SMO	97.3806 %	96.9231 %
Naïve Bayes	93.6826 %	93.0769 %

From Tables 5 and 6, we observe that the OneR classifier has the highest accuracy rate than other classifiers. Moreover, the OneR classifier produces a higher rate of accuracy, which is 97.69 % when dealing with binary data by 10-fold cross-validation rather than five-level classification. From this result, we concluded that OneR has a higher accuracy rate when dealing with binary classification approach. OneR classifier works best when dealing with the student records dataset, and it has several methods to handle numerical data to give better results.

5. Conclusion and Future Work

Data mining is widely used in the educational field especially in prediction the performance of the students in the educational institutes for several purposes and objectives. The main objective is to increase the educational quality by finding the factors that may affect the academic performance of the students. We aim to conduct this study to find out the most important factors that affect students' performance. This will help the students to make better decisions in order to continue their studies in the major they have chosen or advise them to change their major study to prevent future failure. Future academic success in Saudi universities depends on the academic performance for a preparatory year program. Knowing or predicting their performance at the beginning stage will be helpful and will result in a reduction of student dropouts. In this present study, we will focus on predicting student performance by applying classification technique using one of the suitable data-mining tool.

Throughout this study, we started with analyzing the concept of educational data mining, especially in prediction students' performance. Moreover, we differentiated between data mining models that include (Predictive and descriptive models). Moreover, we discussed all the important factors that may affect academic performance by summarizing several research papers in this field. After that, we presented a comprehensive identification of the main works related to the field of the prediction of the students' performance using classification techniques. Finally, we summarized the implications of the literature and includes a summarized table for all the discussed contributions that closely related to our topic.

Next, we have conducted a critical overview of the main challenges faced by the previous for better developing an approach to overcome these challenges. After we summarized the previous works, we concluded that there are some research challenges in predicting students' performance. One of the most challenges is that the analytical tools used to analyze the data in the educational field are inaccurate and did not produce the required results. Difficulties in assessing students' performance may be due to poor access to a comprehensive assessment. In addition, there is huge data for students and their results for a long period but it has not been effectively exploited to find out the success factors and failure factors and assess the students' academic performance in a comprehensive manner to improve the performance of educational institutions. Then, we proposed some recommendations that helped us in identifying a road map for the proposed model.

After acquiring sufficient knowledge in this area, our future work will apply the latest deep learning architecture to build a model that is capable to predict students' performance and classify students into classes. Moreover, we aim to expand our work by expanding our data set and applying this model in all universities in the Saudi Kingdom. We would like to build an automatic system to discover and find all the effected students automatically.

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References

[1] U. Fayyad, G. Piatetsky-Shapiro, and P. Smyth. "From data mining to knowledge discovery in databases." *AI magazine* 17, no. 3 (1996): 37-37.

[2] J. Gama, T. Li, Y. Yu, E. Chen, Y. Zheng, and F. Teng. *Advances In Knowledge Discovery And Data Mining: 26th Pacific-asia Conference*. Vol. 13281. Springer Nature, 2022.

[3] M. Sharma. "Data mining: A literature survey." *International Journal of Emerging Research in Management & Technology* 3, no. 2, 2014.

[4] C. Romero, S.n Ventura, P. G. Espejo, and C. Hervás. "Data mining algorithms to classify students." In *Educational data mining 2008*. 2008.

[5] A. A. Hasan, and H. Fang. "Data Mining in Education: Discussing Knowledge Discovery in Database (KDD) with Cluster Associative Study." In *2021 2nd International Conference on Artificial Intelligence and Information Systems*, pp. 1-6, 2021.

[6] M. L. Kolling, L. B. Furstenau, M. K. Sott, B. Rabaioli, P. H. Ulmi, N. L. Bragazzi, and L. P. C. Tedesco. "Data mining in healthcare: Applying strategic intelligence techniques to depict 25 years of research development." *International journal of environmental research and public health* 18, no. 6 (2021): 3099.

[7] A. U. Khasanah. "A comparative study to predict student's performance using educational data mining techniques." In *IOP Conference Series: Materials Science and Engineering*, vol. 215, no. 1, p. 012036. IOP Publishing, 2017.

[8] A. S. Olaniyi, H. M. Abiola, S.-I. TaofeekatTosin, S. Y. Kayode, and A. N. Babatunde. "Knowledge Discovery from Educational Database Using Apriori Algorithm." *Computer Science & Telecommunications* 51, no. 1, 2017.

[9] A. Yusuf, and A. Lawan. "Prediction of students' academic performance using educational data mining technique: Literature review.", 2018.

[10] G. Eason, B. Noble, and I. N. Sneddon. "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions." *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* 247, no. 935 (1955): 529-551.

[11] A. Daud, N. R. Aljohani, R. A. Abbasi, M. D. Lytras, F. Abbas, and J. S. Alowibdi. "Predicting student performance using advanced learning analytics." In *Proceedings of the 26th international conference on World Wide Web companion*, pp. 415-421. 2017.

[12] K. Sin, and L. Muthu. "Application of Big Data in Education Data Mining and Learning Analytics--A Literature Review." *ICTACT journal on soft computing* 5, no. 4, 2015.

[13] E. Y. Obsie, and S. A. Adem. "Prediction of student academic performance using neural network, linear regression and support vector regression: a case study." *International Journal of Computer Applications* 180, no. 40 (2018): 39-47.

[14] G. S. Sree, and C. Rupa. "Data Mining: Performance Improvement In Education Sector Using Classification And Clustering Algorithm." *International Journal of Innovative Research and Development (ISSN 2278–0211)* 2, no. 7, 2013.

[15] C. Romero, and S. Ventura. "Educational data mining: A survey from 1995 to 2005." *Expert systems with applications* 33, no. 1 (2007): 135-146.

[16] A. M. Shahiri, and W. Husain. "A review on predicting student's performance using data mining techniques." *Procedia Computer Science* 72 (2015): 414-422.

[17] M. Daniyal, T. Nawaz, M. Aleem, and A. Hassan. "The factors affecting the students' performance: A case study of Islamia University of Bahawalpur, Pakistan." *African journal of education and technology* 1, no. 2 (2011): 45-51.

[18] U. Bin Mat, N. Buniyamin, P. M. Arsad, and R. Kassim. "An overview of using academic analytics to predict and improve students' achievement: A proposed proactive intelligent intervention." In *2013 IEEE 5th conference on engineering education (ICEED)*, pp. 126-130. IEEE, 2013.

[19] D. M. D. Angeline. "Association rule generation for student performance analysis using apriori algorithm." *The SIJ Transactions on Computer Science Engineering & its Applications (CSEA)* 1, no. 1 (2013): 12-16.

[20] M. Kumar, A. J. Singh, and D. Handa. "Literature survey on student's performance prediction in education using data mining techniques." *International Journal of Education and Management Engineering* 7, no. 6 (2017): 40-49.

[21] G. Gray, C. McGuinness, and P. Owende. "An application of classification models to predict learner progression in tertiary education." In *2014 IEEE International Advance Computing Conference (IACC)*, pp. 549-554. IEEE, 2014.

[22] V. A. M. A. N. A. N. Ramesh, P. Parkavi, and K. Ramar. "Predicting student performance: a statistical and data mining approach." *International journal of computer applications* 63, no. 8, 2013.

[23] B. K. Bhardwaj, , and S. Pal. "Data Mining: A prediction for performance improvement using classification." *arXiv preprint arXiv:1201.3418*, 2012.

[24] S. T. Hijazi, and R. S.M. Naqvi. "Factors affecting student's performance: A Case of Private Colleges." *Bangladesh e-Journal of Sociology*, vol. 3, no. 1, 2006.

[25] D. Delen, and H. Demirkan. "Data, information and analytics as services." *Decision Support Systems* 55, no. 1 (2013): 359-363.

[26] N. A. Yassein, R. G. M. Helali, and S. B. Mohomad. "Predicting student academic performance in KSA using data mining techniques." *Journal of Information Technology & Software Engineering* 7, no. 5 (2017): 1-5.

[27] M. Agaoglu. "Predicting instructor performance using data mining techniques in higher education." *IEEE Access* 4 (2016): 2379-2387.

[28] P. Shruthi, and B. P. Chaitra. "Student performance prediction in education sector using data mining.", 2016.

[29] J. M. Braxton. "Leaving college: Rethinking the causes and cures of student attrition by Vincent Tinto." *Journal of College Student Development* 60, no. 1 (2019): 129-134.

[30] P. Cortez and A. Silva. Using Data Mining to Predict Secondary School Student Performance. In A. Brito and J. Teixeira Eds., *Proceedings of 5th FUture BUsiness TEChnology Conference (FUBUTEC 2008)*, pp. 5-12, Porto, Portugal, April, 2008, EUROSIS, ISBN 978-9077381-39-7.

[31] C. G. Nevill-Manning, G. Holmes, and I. H. Witten. "The development of Holte's 1R classifier." In *Proceedings 1995 Second New Zealand International Two-Stream Conference on Artificial Neural Networks and Expert Systems*, pp. 239-242. IEEE, 1995.

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