

## STUDENT'S PERFORMANCE ANALYSIS USING DECISION TREE ALGORITHMS

Abdulsalam Sulaiman Olaniyi <sup>1</sup>, Saheed Yakub Kayode <sup>2</sup>, Hambali Moshood Abiola <sup>3</sup>,  
Salau-Ibrahim Taofeekat Tosin <sup>2</sup>, Akinbowale Nathaniel Babatunde <sup>1</sup>

<sup>1</sup>Department of Computer Science, Kwara State University Malete, Nigeria

<sup>2</sup>Department of Physical Sciences, Al-Hikmah University, Ilorin

<sup>3</sup>Department of Computer Science, Federal University, Wukari, Nigeria

Corresponding Author: Abdulsalam Sulaiman Olaniyi, [sulaiman.abdulsalam@kwasu.edu.ng](mailto:sulaiman.abdulsalam@kwasu.edu.ng)

**ABSTRACT:** Educational Data Mining (EDM) is concerns with developing and modeling methods that discover knowledge from data originating from educational environments. This paper presents the use of data mining approach to study students' performance in CSC207 (Internet Technology and Programming I) a 200 level course in the department of Computer, Library and Information Science. Data mining provides many approaches that could be used to study the students' performance, classification task is used in this work to evaluate the student's performance and as there are numbers of approaches that can be used for data classification, including decision tree method. In this work, decision trees were used which include BFTree, J48 and CART. Students' attribute such as Attendance, Class test, Lab work, Assignment, Previous Semester Marks and End Semester Marks were collected from the students' management system, to predict the performance at the end of semester examination. This paper also investigates the accuracy of different Decision tree algorithms used. The experimental results show that BFTree is the best algorithm for classification with correctly classified instance of 67.07% and incorrectly classified instance of 32.93%.

**KEYWORDS:** Classification, Decision tree, Students' Performance, Educational Data Mining.

### 1.0 INTRODUCTION

The main assets of Universities/ Institutions are students. The performance of students plays vital role in producing the best graduate students who will be a future viable leader and manpower in charge of the country's economic and social development. The performance of students in Universities should be a concern not only to the administrators and educators, but also to other stakeholders. Academic achievement is one of the main factors considered by the employer in recruiting workers especially the fresh graduates. Thus, students have to place the greatest effort in their study to obtain a good grade in order to fulfill the employer's demand. Students' academic achievement is measured by the Cumulative Grade Point Average (CGPA). CGPA shows the overall students' academic

performance where it considers the average of all examinations' grade for all semesters during the tenure in the University. Many factors could act as barrier and catalyst to students achieving a high CGPA that reflects their overall academic performance ([KBP11]).

The main functions of data mining are to apply various methods and algorithms in order to discover and extract hidden patterns of stored data ([FPS96, A+14]). Data mining (DM) tools predict patterns, future trends and behaviors, allowing businesses to effect proactive, knowledge-driven decisions.

Galit et al. ([G+07]) gave a case study that use students data to analyze their learning behavior to predict the results and to warn students at risk before their final exams. Ayesha, Mustafa, Sattar and Khan ([A+10]) presented the use of k-means clustering algorithm to predict student's learning activities. The information generated after the implementation of data mining technique may be helpful for instructor as well as for students.

Bharadwaj and Pal ([BP11]) applied the classification as DM technique to evaluate students' performance, they used decision tree method for classification. The goal of their study is to extract knowledge that describes students' performance in end semester examination. They used students' data from the students' previous database including Attendance, Class test, Seminar and Assignment marks. This study helps earlier in identifying the dropouts and students who needs special attention and allow the teacher to provide appropriate advising.

### 2.0 MATERIALS AND METHODS

#### 2.1 Methodology

The proposed methodology used in this work for predicting students' performance in Internet Technology and Programming I course using decision tree algorithms belongs to the process of

Knowledge Discovery and Data Mining. The stages in the process include the following:

### 2.2 Data Mining Process

In present day’s educational system, a student’s performance is determined by the internal assessment and end semester examination. The internal assessment is carried out by the teacher based upon student’s performance in educational activities such as class test, seminar, assignments, attendance and lab work. The end semester examination is the mark obtained by the student at the end of semester examination. Each student has to get minimum marks to pass a semester course from both internal and end semester examination.

### 2.3 Data Preparation and Summarization

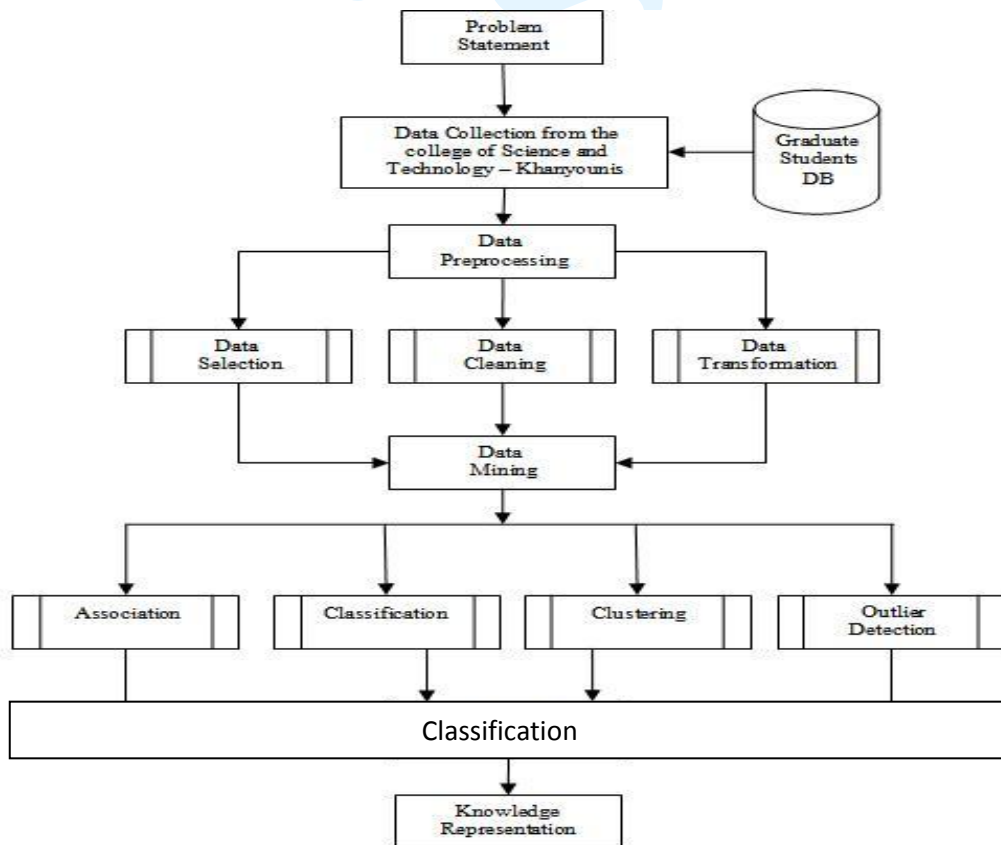
The data set used in this research was obtained from Kwara State University, on the sampling method of Computer Science department course CSC 208 (Internet Technology and Programming I) from session 2009 to 2011. Initially size of the data is 285. In this step data stored in different tables was joined in a single table, after the joining process, errors were removed.

**Table 1: Students Related Variables**

Variable	Description	Possible Values
PSM	Previous semester marks	{First $\geq$ 60% Second $\geq$ 45 & <60% Third $\geq$ 36 & <45%, Fail < 36% }
CTG	Class test grade	{Poor , Average, Good }
ASS	Assignment	{Yes, No }
ATT	Attendance	{Poor , Average, Good }
LW	Lab work	{Yes, No }
ESM	End Semester Marks	{First $\geq$ 60% Second $\geq$ 45 & <60% Third $\geq$ 36 & <45% Fail < 36% }

### 2.4 Data Selection and Transformation

This stage involves dataset preparation before applying DM techniques. At this stage, traditional pre-processing methods such as data cleaning, transformation of variables and data partitioning were applied. Also, other techniques such as attributes selection and re-balancing of data were employed in order to solve the problems of high dimensionality and imbalanced data that may be present in the dataset. Table 1 shows the selected attributes.



**Fig. 1: Proposed Methodology of Classification Model**

## 2.5 The Data mining Tools

The experimental tool used was WEKA. WEKA (Waikato Environment for Knowledge Analysis) is used for classifying data in this work. Weka is one of the popular suites of machine learning software developed at the University of Waikato. It is open source software available under the GNU General Public License. The weka work bench contains a collection of visualization tools and algorithms for data analysis and predictive modeling, together with graphical user interfaces for easy access to this functionality.

## 2.6 Decision Tree Algorithms

A decision tree is a flow-chart tree structure, where each internal node is denoted by rectangles, and leaf nodes are denoted by ovals. All internal nodes have two or more children node and the internal nodes contain splits, which test the value of an expression of the attributes.

### 2.6.1 C4.5

C4.5 known as J48 in WEKA is a successor of ID3 developed by Quinlan (1992). It is also based on Hunt's algorithm. J48 handles both categorical and continuous attributes to build a decision tree.

$$Gain(S, A) = Entropy(S) - \sum_{v \in value(A)} \frac{|S_v|}{|S|} Entropy|S_v| \quad (1)$$

Where  $Values(A)$  is the set of all possible values for attribute  $A$ , and  $S_v$  is the subset of  $S$  for which attribute  $A$  has value  $v$  (i.e.,  $S_v = \{s \in S / A(s) = v\}$ ). The first term in the equation for  $Gain$  is just the entropy of the original collection  $S$  and the second term is the expected value of the entropy after  $S$  is partitioned using attribute  $A$ . The expected entropy described by this second term is simply the sum of the entropies of each subset, weighted by the fraction of examples that belong to  $Gain(S, A)$  is therefore the expected reduction in entropy caused by knowing the value of attribute  $A$ .

$$Gain\ Ratio(S, A) = \frac{Gain(S, A)}{Split\ Information(S, A)} \quad (2)$$

### 2.6.2 Classification and Regression Tree (CART)

CART was introduced by Breiman et al. (1984). It is also based on Hunt's algorithm. CART handles both categorical and continuous attributes to build a decision tree. It handles missing values. CART uses Gini Index as an attribute selection measure to build a decision tree. Unlike ID3 and J48 (C4.5)

algorithms, CART produces binary splits. Hence, it produces binary trees. Gini Index measure does not use probabilistic assumptions like ID3, C4.5. CART uses cost complexity pruning to remove the unreliable branches from the decision tree to improve the accuracy.

$$Gini\ Index: \quad 1 - \sum_j p^2_j \quad (3)$$

Gini index of a pure table which consist of single class is zero because the probability is 1 and  $1-1^2 = 0$ . Similar to Entropy, Gini index also reaches maximum value when all classes in the table have equal probability.

## 3.0 RESULTS AND DISCUSSION

The study main objective is to find out if it is possible to predict the class (output) variable using the explanatory (input) variables which are retained in the model. Several different algorithms are applied for building the classification model, each of them using different classification techniques. The WEKA Explorer application is used at this stage. The classify panel enable us to apply classification and regression algorithms to the resulting dataset, to estimate the accuracy of the resulting predictive model, and to visualize erroneous predictions, or the model itself. The classification algorithms used for this work are BFTree, C4.5 and CART. Under the "Test options", the 10-fold cross-validation is selected as our evaluation approach. Since there is no separate evaluation data set, this is necessary to get a reasonable idea of accuracy of the generated model. The model is generated in the form of decision tree.

### 3.1 Development of Data Mining Models

The training dataset used in this study for predicting unknown outcomes for new dataset were records of 284 students obtained from Computer Science department, Kwara State University, that wrote CSC 208 course examination in 2010/2011 and 2011/2012 academic sessions.

### 3.2 Machine Learning Algorithm 1: C4.5

Cross-validation: The classifier is evaluated by cross-validation, using the number of folds that are entered in the Folds text field.

#### 3.2.1 Evaluating performance of C4.5 using Cross-validation

Cross-validation is based on improvement upon repeated holdout using holdout method. Below show 10% for testing, repeated 10 times. The classifier is

evaluated by cross-validation, using the number of folds that are entered in the Folds text field output model. The classification model on the full training set is output so that it can be visualized.

**Table 2: Cross validation Result 1**

Cross validation 10-Fold	Correctly classified instances
1	67.6
2	66.5
3	66.9
4	66.5
5	64.4
6	65.1
7	66.5
8	65.1
9	63.3
10	65.8
Total	657.7

Using the below formula to calculate our sample mean:

$$\bar{x} = \frac{\sum x}{N}$$

Therefore, the average fold is:  $657.7/10 = 65.77$

### 3.2.2 Machine Learning Algorithm 2: CART

Cross-validation: The classifier is evaluated by cross-validation, using the number of folds that are entered in the Folds text field.

### 3.2.3 Evaluating performance of CART using Cross-validation

Cross-validation is based on improvement upon repeated holdout using holdout method. Below show 10% for testing, repeated 10 times. The classifier is evaluated by cross-validation, using the number of folds that are entered in the Folds text field.

**Table 3: Cross Validation Result 2**

Cross validation 10-Fold	Correctly classified instances
1	67.3
2	66.5
3	65.5
4	67.3
5	67.3
6	67.9
7	69.0
8	65.1
9	65.5
10	66.9
Total	668.3

Using the below formula to calculate our sample mean:

$$\bar{x} = \frac{\sum x}{N}$$

Therefore, the average fold is:  $668.3/10 = 66.83$

### 3.2.4 Machine Learning Algorithm 3: BFTree

Cross-validation: The classifier is evaluated by cross-validation, using the number of folds that are entered in the Folds text field.

### 3.2.5 Evaluating performance of BFTree using Cross-validation

Cross-validation is based on improvement upon repeated holdout using holdout method. Below show 10% for testing, repeat 10 times.

**Table 4: Cross validation Result 3**

Folds	Correctly classified instances
1	67.6
2	67.6
3	67.6
4	66.2
5	67.6
6	67.9
7	68.6
8	65.8
9	66.9
10	65.8
Total	670.7

Using the below formula to calculate our sample mean:

$$\bar{x} = \frac{\sum x}{N}$$

Therefore, the average 10 fold is:  $670.7/10 = 67.07$

### 3.2.6 Result Obtained

Table 5 shows the accuracy of BFTREE, C4.5 and CART algorithms for classification applied on the data sets in Table 1 using 10-fold cross validation is observed as follows:

**Table 5: Classifiers Accuracy**

Algorithm	Correctly classified instances	Incorrectly classified instances
BFTree	67.07%	32.93%
C4.5	65.77%	34.23%
CART	66.83%	33.17%



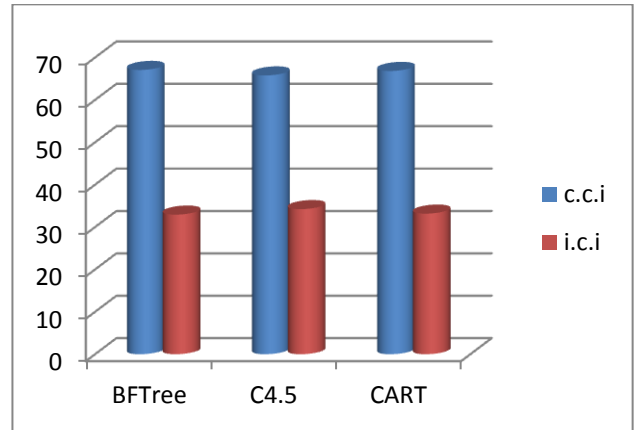
Table 5 shows that a BFTree technique has highest accuracy of 67.07% compared to other methods. CART algorithm also showed an acceptable level of accuracy.

The Table 6 shows the time complexity in seconds of various classifiers to build the model for training data.

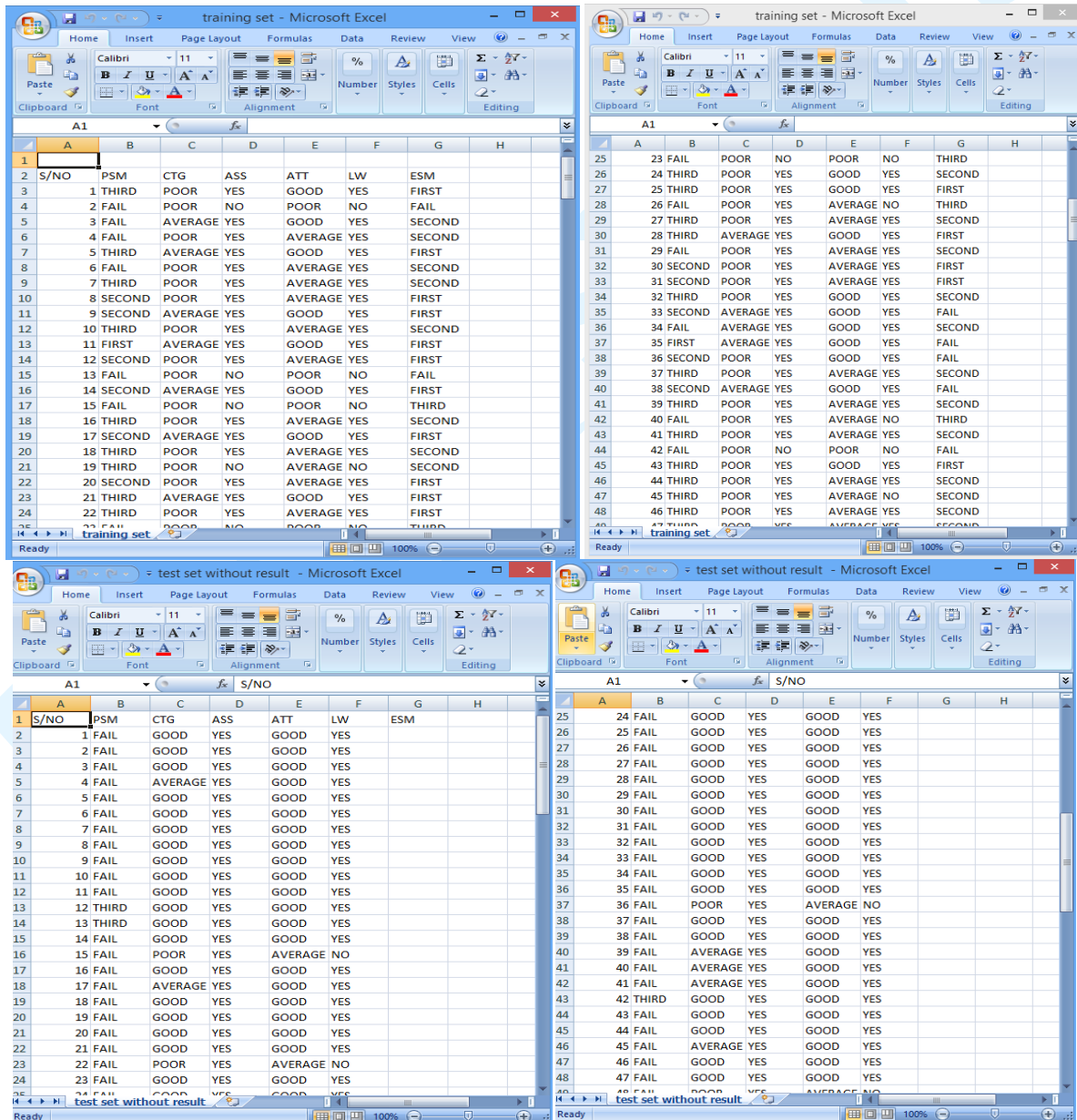
**Table 6: Execution Time to Build the Model**

Algorithm	Execution Time(sec)
BFTree	0.07
C4.5	0.06
CART	0.07

The classifier accuracy on various data sets is represented in the form of a graph below (Fig. 2).



**Fig. 2: Comparison of classifiers (where C.C.I.=correctly classified instances; I.C.I.=incorrectly classified instances)**



**Fig. 3: Screen Shot of Training and Testing Dataset**

### 3.3 Training and Testing set

The result of applying the chosen classifier will be tested according to the options that are set by clicking in the training and test option box: The Figure 3 shows the captured dataset for the training and testing.

1. **Use Training Set.** The classifier is evaluated on how well it predicts the class of the instances it was trained on.

- **Step 1**

- Open Weka GUI, click on the preprocess panel and load the full dataset

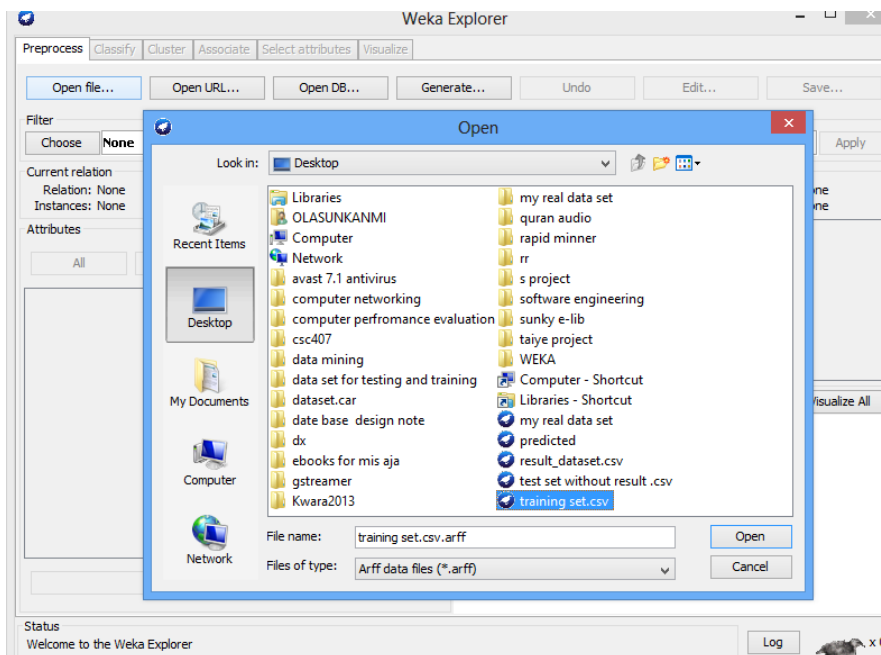


Fig. 4: Preprocess Panel and Load Dataset

- **Step 2**

- Click on the classify panel and choose the BFTree algorithm for better classification
- Select the use training set and our focus must be on the result only
- Start the classification

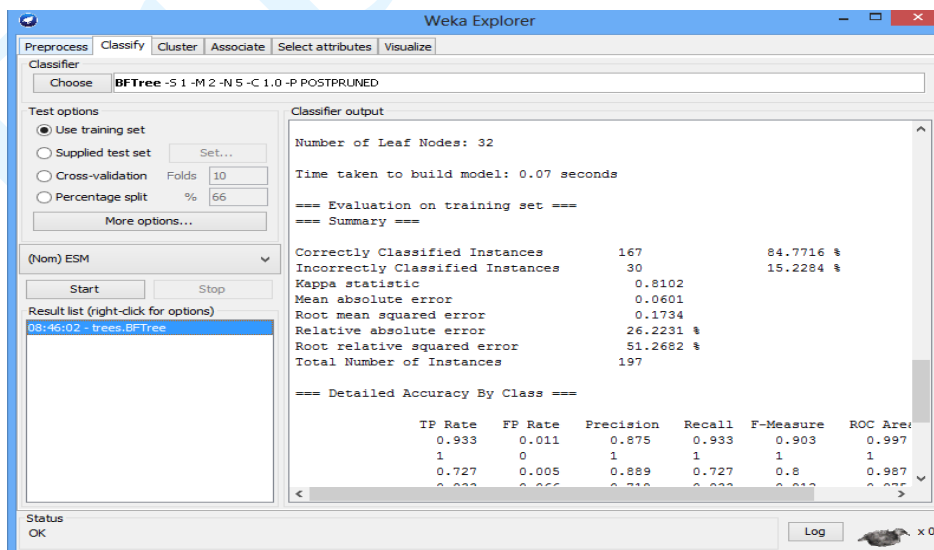


Fig. 5: BFTree Classification Panel

- **Step 3**

- Save the generated data as a new file

2. **Supplied Test Set.** The classifier is evaluated on how well it predicts the class of a set of instances loaded from a file. Clicking the Set... button brings up a dialog allowing you to choose the file to test on.

- **Step 1**

- Load the dataset into the set option

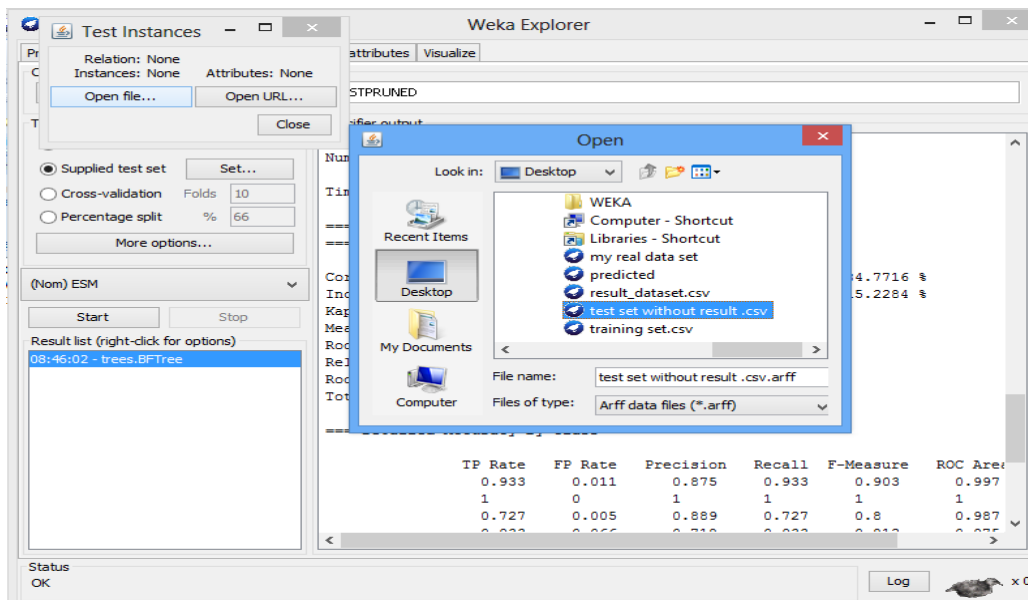


Fig. 6: Loading Test Dataset

- **Step 2**

- Start the classification
- Visualize classification and save the model to see the predicted result

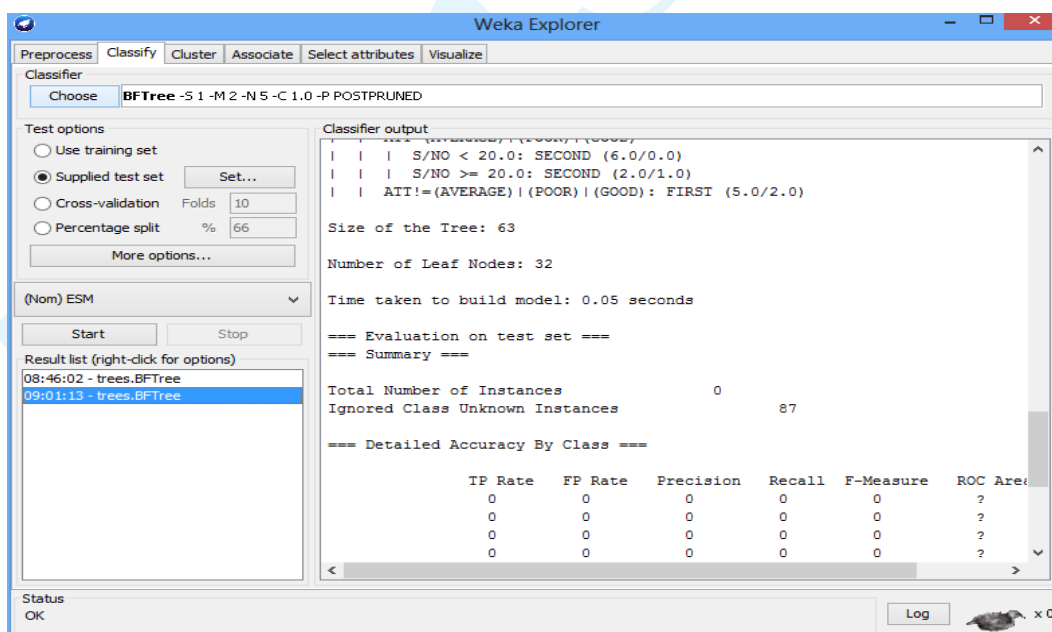


Fig. 7: BFTree Classification Panel

## CONCLUSION

Data Mining is used in educational field to enhance better understanding of learning process to focus on identifying, extracting and evaluating variables related to the learning process of students. The fact that many Universities and even Colleges demand

that a prospective Computer Science candidate should have a sound science background calls for inquiry on the effect of the science subjects on their performance in their course of study. In this research, the classification task is used to evaluate student's performance and as there are many approaches that are used for data classification, the

decision tree method is used here. Student's information like Attendance, Class test, lab work and Assignment marks were collected from the student's management system, to predict the performance at the end of the semester examination. This paper investigates the accuracy of different Decision tree. Data Mining is gaining its popularity in almost all applications of real world. One of the data mining techniques that is, classification is an interesting topic to the researchers as it is accurately and efficiently classifies the data for knowledge discovery. Decision trees are so popular because they produce classification rules that are easy to interpret than other classification methods. Frequently used decision tree classifiers are studied and the experiments are conducted to find the best classifier for Student data to predict the student's performance in the end semester examination. The experimental results show that BFTree is the best algorithm for classification based on the dataset used in this study.

#### REFERENCES

- [A+10] **Ayesha S., Mustafa T., Raza Sattar A., Khan M. I.** - *Data Mining Model for Higher Education Systems*. European Journal of Scientific Research, Vol.43, No.1, pp.24-29, 2010.
- [A+14] **Abdulsalam S. O., Adewole K. S., Akintola A. G., Hambali M. A.** - *Data Mining in Market Basket Transaction: An Association Rule Mining Approach*, International Journal of Applied Information Systems, Vol. 7, No. 10, pp. 15-20, 2014.
- [A+15] **Abdulsalam S. O., Babatunde A. N., Hambali M. A., Babatunde R. S.** - *Comparative Analysis of Decision Tree Algorithms for Predicting Undergraduate Students' Performance in Computer Programming*. Journal of Advances in Scientific Research & Its Application (JASRA), 2, Pg. 79 – 92, 2015.
- [BP11] **Bharadwaj B.K., Pal S.** - *Data Mining A Prediction for Performance Improvement Using Classification*. International Journal of Computer Science and Information Security (IJCSIS), Vol. 9, No. 4, pp. 136-140, 2011.
- [FPS96] **Fayadd U., Piatetsky-Shapiro G, Smyth P.** - *From Data Mining to Knowledge Discovery in Databases*. AAAI Press / The MIT Press, Massachusetts Institute of Technology. ISBN 0-26256097-6, 1996.
- [G+07] **Galit B. Z., Hershkovitz A., Mintz R., Nachmias R.** - *Examining Online Learning Processes Based on Log Files Analysis: A Case Study*. Research, Reflection and Innovations in Integrating ICT in Education, 2007.
- [KBP11] **Kumar S., Bharadwaj B., Pal S.** - *Data Mining Applications: A Comparative Study for Predicting Students Performance*. International Journal of Innovative Technology and Creative Engineering (ISSN:2045-711)VOL. 1 No. 12, December, 2011.
- [RSN06] **Al-Radaideh Q. A., Al-Shawakfa E. W., Al-Najjar M. I.** - *Mining Student Data Using Decision Trees*. International Arab Conference on Information Technology (ACIT'2006), Yarmouk University, Jordan, 2006.