Predicting Academic Performance with Applying Data Mining Techniques (Generalizing the results of two Different Case Studies)

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ABSTRACT

Several research works are attempted to predict students' academic performance and assess the evaluating students' knowledge or detecting students' weakness and probability of failure in final semester examinations. However, several factors affect the performance of students in different countries or even in different states of one country. Therefore, understanding these factors and analyzing the effects of each one of those factors in each country, is necessary for improving instructors' decisions in selecting the best teaching method for helping weak students or increasing performance of other students. This study is motivated to study the students' academic performance in high school and bachelor degree studies in Iran and comparing these analysis results with the similar study's results in India. In this article, we used several classification and prediction algorithms for improving the accuracy of predicting students' academic results before examination. Our experimental results show that, factors such as gender, family background, parents' educational level, life style have important effects on students' academic performance in both countries. We collected students' academic performance results from their high schools and dean academic of universities. Data for this research work is collected through the interview with students and asking questions regarding their number of family members, parents' job and their education level, family welfare. Further, with applying simple Random sampling (without replacement) method, 300 students including 100 high school and 200 college students are selected and the mental condition of these students is checked by our Psychologist for identifying their stress level or any other mentality problems.

Keywords: Academic Performance, CPI (Cumulative Performance Index), Classification, Prediction, Simple Random Sampling, Decision Making.

1. INTRODUCTION

Data mining and its techniques can be help for solving these problems. Since it is contains several process for discovering valuable knowledge from huge amount of data [1, 2]. Collecting the correct data is the main point during data mining processes. Therefore, data collection and pre-processing are the starting steps of data mining processes and any mistake in these steps can be create critical situations during analysis and in most of cases can be make fault analysis results. Several research efforts have attempted to discover the students' behavioral patterns and use these patterns for predicting their academic performances. Some of researchers have been studied the impact of various factors on academic performance of students such as gender [3 ~ 7], technology [8], Internet and Social network websites usages [9 and 10] and etc.

This study is extension for our before studies [4 ~ 6, 9, 11 ~ 15] regarding detection of important factors that have effects on students' academic performance. In before studies, we had been collected the academic performance of students from dean academic office of one Indian National Institute of Technology and also we had been collected the proxy server access log files during 36 months continually. The results of those studies has been shown that, the frequency of Internet connections per a day, the average time spending in Internet per a day, gender, number of different visited Websites per a day, the number of visited

papers per a day (we named as number of hits per a day) are important factors in predicting students' academic performance after 1 month of starting date of semester.

In this investigation, we could not collect access log files of any proxy server because of two reasons: the main reason was regarding inaccessibility of user-name or password for student users in Iran universities. The other reason was regarding life style of Iranian students. Unlike Indian students, in Iran most of the students (especially male students) prefer to live out of campus or college's hostels. Therefore, collecting their access files through college's proxy server during 24 hours of a day practically is impossible. The data which is used in this study is, students' results of final semester examination, that is used as academic performance and the interview results which we made with those students and their instructors and parents.

Some of our study's attributes are: students' virtual Registration number (we made for each individual student one unique virtual registration number for protecting privacy of that user), age, gender, last 2 examination results and GPI (Grade Point Index), their number of family members, parents' job and their education level, family welfare. Further, with applying simple Random sampling (without replacement) method, 300 students including 100 high school and 200 college students are selected and the mental condition of these students is checked by our Psychologist for identifying their stress level or any other mentality problems. Some objectives of this study are:

- Extracting different factors that are having important role on students' academic performance.
- Analyzing these factors and exploring positive or negative effects of each factor on students' academic performance.
- Study the feasibility of predicting students' academic performance by the help of those extracted results.
- Applying various classification algorithms for enhancing the accuracy of our predictions.
- Comparing these results with our before experimental results that was belong to other country (India).
- Generalizing or specializing the results of our analysis.

This paper is organized in five sections. The second section included some basic concepts related to this study. The third section has mentioned the related works and literature. The fourth section presents the accuracy of applying different classification algorithm for exploring predicting results. The fifth section compares the results of this study which is belong to Iranian students, with our before studies' results that was belong to Indian students. Finally section sixth concludes our paper with summarizing the results.

2.   BASIC CONCEPTS

2.1.   DATA MINING

Data mining is the process of extracting knowledge from data. This data can be customers' transaction records in market, users' access log files or student's academic records in schools as well as universities or education departments. Data mining has different steps which are mentioned in shortly in Figure 1.
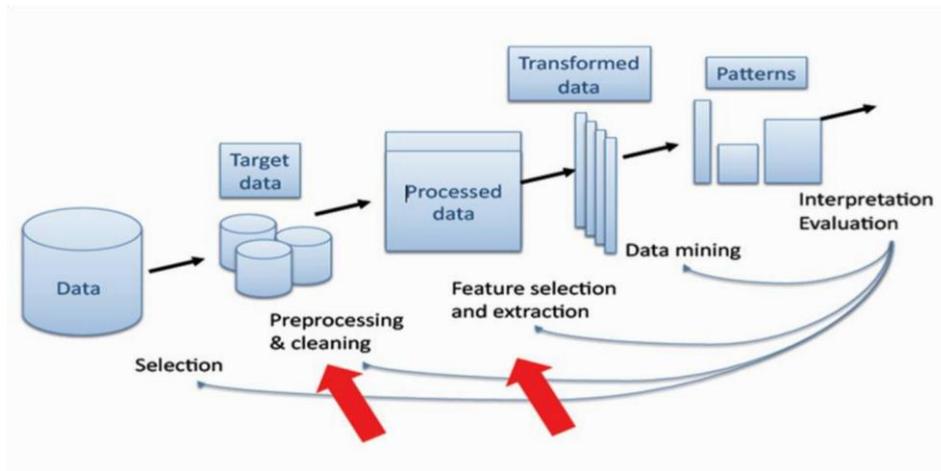
FIGURE 1. Data Mining Processes [16]

From figure 1, it is evident that, data mining has the following steps [16]:

- Data Collecting and Processing: in this step data collection is executed. Based on our goals, data can be collect from different environments or offices, such as markets, banks, educational environments, schools and etc. After collecting data, one data warehouse may be providing for keeping this date for further processing steps. The collected data further will be processed and all mistakes, duplicate data and etc., will be removed.
- Data Transformation: in this step based on usage or tools which we will use for analyzing data, we need to transform data. For example for using with Weka we need to make .csv files and etc.
- Pattern Discovery: in this step with applying data mining techniques such as classification, clustering and etc., we will be try to discover pattern from that data.
- Knowledge discovery: in this step we will be try to use the extracted patterns for more analysis or extracting association rules or further analyzes.
- Evaluation: in this step, with testing our extracted knowledge, the percentage of efficiency of that knowledge will be declared.
- Action: finally with discovering all weakness or efficiency of these extracted knowledge we can use these knowledge for various usages or applications.

2.2.   SOME OF DATA MINING TECHNIQUES
2.2.1. CLASSIFICATION

Classification is the most commonly used techniques of data mining. It is create a model with classifying a set of data. It can be classify the population of data. Different algorithms for classification are available. The most popular methods for classification are [17 and 18]: Decision Trees, Nearest Neighbor Method, Naive Bayes, and C4.5. Or regression methods such as: Random-Forest, Bagging and etc.

2.2.2. CLUSTERING

Clustering is referred as a unsupervised classification of extracted patterns [19] because in this type of grouping data based on their similarity we do not have any pre-defined models such as classification which we had some pre-defined groups and we just looked for replacing the new data in those groups.
Two types of clustering are available: Hierarchical clustering and Partitioning clustering [20] and different clustering techniques are available such as: k-means, DBSCAN and etc.

2.3. DATA MINING TOOLS

Several data mining tools are available. Some of these tools are commercial (such as: Statistica [21], SAS Enterprise Miner [22 and 23], IBM Intelligent Miner [24 and 25], Clementine[25] and etc.] , and some of them are free [Weka[26], R-Miner [27], Rapid-Miner [27]]. Each one of these tools has some special and some common performances. Weka, Clementine and Rapid-Miner are used in this research work.

3. RELAT ED WORKS

Data mining techniques are useful for modeling individual and group behavior of users and to evaluate their differential behaviors for providing different services. Several studies have been made to evaluate impact of technology in general on users and students in particular [28 ~ 31]. Bidgoli [28] predicted the students final grades based on their Web-usage features. They designed, implemented and evaluated a series of pattern classifiers with various parameters in order to compare performance on a dataset. Machado [29] analyzed the students' navigation behavior based on course activities enabled to evaluate students learning models with regard to site structure. Merceron [30] discovered pedagogical relevant knowledge contained in databases and proposed a model based on number of exercises undertaken and mistakes committed by students in their completion to classify them under different categories which might be used by instructors to take corrective actions. The research study by Leiba [31] found significant positive correlations between the amount of messages posted in internet by students and the students' final grade.

Liccardi [32] studied the role of social networks in students learning experiences. This study had been concluded that social networking place a positive role in students' learning experiences. Figl [33] found that by identifying students' communication habits, universities and instructors can promote social networks and can consider them in learning context, is the basis for successful learning.

Several researchers studied gender based effects of information technology in particular on education [34 ~ 41]. Welty [34] found that women opted for communication and medical technologies more frequently than men. Jo Sander [35] has presented an excellent survey of relationships between technology in education and gender. She mentioned that many parents do not advocate usage of new technology by girls due to their culture and religious disposition.

Kim and Chang [36] has concluded that computer usage have differential effects on academic performance of users from the immigrant and gender groups.

Some of the researchers [37~ 41] studied the impacts of Internet usages on students' academic performances. Radaideh and Awais[37 and 38] proposed a model to predict the performance of students in the final examination. Alaa El-Halees [39] grouped all students' grades into five groups excellent, very good, good, and poor and failure. They discovered that attendance, students' GPAs, lab grades had a positive relationship with the final grade. Wang [40] proposed an data mining algorithm for evaluating quality of mathematics teaching. Zhu [41] Provided valuable suggestions for improving education efficiency. The results of study [42] in India, declared that SN Websites usage behavior of female users can be varying depend on those students undertaken programs even semesters. Further our analysis results shows that during examination days, time spent on SN Websites was increased these seems for cope of examination stress female students more using social network websites. Finally, this seems that SN usage is necessary for female users because most of SN users were excellent users.

In [43] we proposed a prediction method for predicting students' future academic performance by analyzing their Internet and SN Websites usage patterns.

4. APPLYING VARIOUS CLASSIFICATION METHODS

This study is based on analyzing the mark sheets of 500 students from 5 high schools in Iran and 300 students from one government university and 250 students from one Islamic Azad University in Iran. Therefore we have totally 500 samples of students belong to high school level and 600 students belong to Bachelor degree level. Further, we made an interview with all of these samples and create a database based on their answers to our questions regarding their family background, parent's age, parent's education level, their level of welfare in life and etc. Pre-processing of collected data has done by Excel and a Matrix Table is created for saving all date. Since we used Weka, clementine and Rapid-miner, therefore we saved data in two formats including .xls and .csv respectively for working with Clementine and Weka.

After selecting the useful fields, with the help of data mining techniques we attempted to discover the possible models in this dataset. And after evaluating these models, un-used models are removed and the process of predicting students' future performance with the help of these extracted models is finalized. It is interesting to note that, all analysis has done without any predefined idea or classification.

Various algorithms are checked for obtaining proper models and evaluating the performance of these models. Classifier methods such as Naive Bayes, C4.5, Random Forest, Neural Networks. Meta Classifier techniques such as: Bagging, Boosting, Adaboost. Prediction techniques such as: Linear Regression, SMO, RBF-   Regressor,   RBF-Network, GaussianProcess,RegressionByDiscretization+J48,AdditiveRegression+RBFRegressor are used for enhancing the accuracy of our predictions. Further, for statistical analysis and summarizing the results and extracting valuable knowledge from data, a Confusion Matrix is created which is allows visualization and evaluating the performance of supervised learning algorithms. Each column of this Matrix includes one instance from predicted class and each row of this Matrix shows one instance from an actual class. For extracting the differences between the actual amount on an instance and its predicted amount in models, we used Root Mean Square Error. Further, Mean Absolute Error is used as a quantity to measure how close predictions are to the eventual outcomes.

In this section the results of applying classification and meta-classification methods in data are mentioned in two tables named as *Summary table* and *Confusion Matrix* and the comparison of all of the obtained results are mentioned in a table named as *Final Table*, this table shows the comparison results of applying all algorithms with different parameters. In the following sub-sections the effects of various factors on students' academic performance are mentioned.

4.1. ANALYZING THE EFFECT OF VARIOUS FACTORS ON ACADEMIC PERFORMANCE OF STUDENTS

4.1.1. ANALYZING THE EFFECT OF GENDER

Our first study concerned on, analyzing the effects of gender on predicting students' academic performance. Our results show that, there is a relationship between students' gender, education level of their parents and their academic performance. For predicting students' academic performance based on their before examination results and gender with/without applying the education level of their parents, we used different classifiers and meta-classifiers. Based on the results, the best algorithm was C4.5 with having prediction accuracy equal to 94%. Based on these results, applying Naïve Bayes and RBF algorithms occurs weakest prediction accuracy. In the other words, the best algorithm in this analysis for predicting academic performance with highest accuracy is C4.5.

TABLE 1.
Predicting Academic Performance with/without Concerning Parent's Education Level

Prediction Accuracy	C4.5	MLP	Naive Bayes	RBF Network	Bagging Classifier 69.5%	Adaboost Classifier 78 %
CLASSIFIERS				**META CLASSIFIERS**		
Without Parent's Education Level	71%	84%	79%	70%	94%	94 %
With Parent's Education Level	96%	95%	84%	79%		

For Table 1, it is evident that, parents' education level has positive effects on predicting students' academic performance. Further, within different classifiers and meta-classifiers, C4.5 had highest percentage of accuracy for predicting students' academic performance with applying their parents' education level, their past examination results and gender. Moreover, our results indicated that, male students are more sensitive regarding their parents' education level. In the other words, the high percentage of female (approximately 71%) with low education level of parents' had high academic performance. Whereas, this percentage for male students was only 47%.

The other interesting results show that, the number of male students with/without high education level of their parents, who suffered from stress or depression, was much more than female students with similar conditions.

All of these results were almost similar for students in Bachelor degree and high school levels.

4.1.2. ANALYZING THE EFFECT OF LIFE WELFARE

Based on our analysis, the life style and welfare was important issue on academic performance of students both in college and high school. Further, students in bachelor degree 61% belonged to family with medium level of life welfare specially in government university. It is interesting to note that, the academic performance of this group of students was much better than students with life welfare condition. Even number of family member also was important factor on students' academic performance especially in high school level.

Gender issue also had positive effect of this performance. In the other hand, female students even with high number of family members (with having more number of sisters and brothers) had better academic performance in compare with male students with similar condition.

We can conclude these results as: gender, number of family members and life welfare are important factors that effects on students' academic performance. With the help of these factors we can predict students' academic performance before examination.

4.1.3. ANALYZING THE EFFECT OF BRANCH OF STUDY

There is a relationship between gender and undertaken branch by students. Based on the experimental results, female had better academic performance in some courses or branches such medical, Literature and mnemonic science. Whereas, male students had better performance in Mathematics and formal science.

More interesting results was shown that, the percentage of female students in engineering branches (such as Information Technology [IT], Software Engineering) in an average was 65% in most of the Iranian universities.

4.2. EVALUATING THE RESULTS

For evaluating the results, we used various Evaluation Factors such as: Correlation Coefficient (CC), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), Relative Absolute Error (RAE), in Total Number of Instances (TNI). Ignored Class Unknown Instances (ICUI) and Time Taken to Build Model (TTBM) in minutes also are important factors in our evaluations. Further, various algorithms such as RBF Regressor ،Gaussian Processes , SMOreg, RBF network are used for evaluation purpose. The results are shown in Table 2.

TABLE 2.
Evaluating the Results of Our Analysis with Applying Various Algorithms

Evaluation Factors	CC	MAE	RMSE	RAE %	ICUI)	(TNI)	(TTBM)
RBF Regressor	0.7	2.5	3	69	50	1050	0.1
RBF Network	0.2	3.2	4	90	50	1050	0.04
Linear Regression	0.4	4.7	11	132	50	1050	0.1
Gaussian Processes	0.7	2.5	3	70	50	1050	0.01
SMOreg	0.6	2.8	3	77	50	1050	1.7
MLP	0.4	0.03	0.1	15	50	1050	0.9
RBF Network	0.3	0.1	0.3	51	50	1050	0.9
C4.5	0.7	0.1	0.3	46	50	1050	0.1
Naive Bayes	0.5	0.1	0.3	45	50	1050	0.1
Bagging Classifier	0.4	0.2	0.3	88	50	1050	0.4
AdaBoost Classifier	0.4	0.2	0.3	86	50	1050	0.02

It is evident from Table 2 that, the minimum and maximum time taken for building a model belongs to RBF network and SMOreg respectively. Whereas, minimum and maximum MAE belong to MLP and Linear Regression respectively. In the other hand, C4.5 seems having almost better results in compare with other algorithms.

5. COMPARISON OF PREDICTION RESULTS BETWEEN IRANIAN AND INDIAN STUDENTS

We compared our results of this study with before studies which have done in India. The comparison results show:

- In an average maximum percentage of students in Indian Engineering colleges belongs to male students whereas, this is completely reverse in Iran and in Iranian engineering colleges specially some branches such as Software Engineering and Information Technology Engineering maximum number of students are female.
- In both of the countries, female students had better academic performance in Literature and mnemonic science. Whereas, male students had better academic performance in Mathematics and formal science.
- Life style or welfare and parents' level of education had various effects on students' academic performance in both countries. In the other words, female students with low education level of their parent's had lower academic performance compare with male students with similar situation in India, whereas, it was completely reverse in Iran.
- In both countries, male students were more sensitive than female students when they faced with some unwanted situations and they suffered stress and depression during semester or examination dates more than female students.

6. CONCLUSION

In this investigation, we attempted to discover the effects of some factors such as: the education level of parents, life style or welfare, the number of family members in home, gender and the undertaken branch on students' academic performance in Iranian high

schools and universities. And we compared these results with the results of our analysis in India. The results of these comparison show that, some of these factors are having similar effects on students' performance in both countries. But some of these factors act differently in both countries. Analyzing results can be helping us for predicting students' performance before examination with high accuracy rate.

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