Applications of Data Mining Techniques in Faculty Performance Analysis: A Survey

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Abstract— Educational Data Mining (EDM) is one of the applications of data mining. In EDM, there are two key areas, one is related with students and the other is with faculty. A detailed research work has already been carried out in both domains. The purpose of this survey is to review the academic literature of the past three years in the area of data mining applied to the educational domain in a traditional classroom-based environment at Higher Education Institutions (HEIs). We described Educational Data Mining (EDM) and its main methods and techniques as they are applied to Faculty Performance Evaluation, and we proceed then to review 16 primary-research papers on the subject. The data mining methodology used for extracting useful patterns from the higher educational institutions database for extracting certain unidentified trends in faculty performance when assessed across different parameters. We determine that classification is by far the most popular method used by the primary-research studies, followed by clustering and association rule mining.

Index Terms— Faculty performance, Classification, EDM, Clustering, K-nearest neighbor, WEKA, Regression

1. INTRODUCTION

DATA Mining can be used in educational field to judge performance of faculty and students by identifying, extracting and evaluating helpful patterns. Data Mining in Education is referred as Educational Data Mining (EDM). Now-a-days, EDM is very popular for identifying interesting patterns through its various techniques / tools. EDM derives its properties from various areas like Learning Analytics, Psychometrics, Statistics, Artificial Intelligence, IT, Machine learning, Database Management System, Computing and Data Mining. It can be considered as an interdisciplinary research field which provides intrinsic knowledge of teaching and learning process for effective education [1].

Data mining techniques can be classified consistent with the knowledge to be mined. The set includes association rules, characteristic rules, classification rules, discriminant rules, clustering, neural network, decision trees, regression, nearest neighborhood methods and deviation analysis [2].

Basically two types of predictive data mining tasks are performed; Classification and Prediction. To predict the unknown class label of discrete target variable, it is recommended to use Classification. The aim of Classification is. Regression, time series analysis are some other examples of prediction techniques. Decision trees, neural networks and support vector machines are used for both classification and prediction tasks. Han and Kamber (2006) defined decision tree as a flowchart-like tree structure. The widespread use of decision trees are accounted for their explanation capability, easy trainability and free of statistical assumptions. The rules extracted from decision trees can simply be understood by even non specialists. They can also (even) be incorporated into decision support systems [3].

As the educational data is additionally growing at the exponential rate, there is an imperative need for research in EDM in order to meet the varied objectives and goals within the education field. As the students and faculty, both play an important role in education so, there is a great urge to explore such factors that directly have an effect on their performance. A majority of the analysis) work done up to now emphasized on students' performance.

The objective of this paper is to highlight the research trends, tools, techniques and educational outcomes during 2013-2016 in Performance Analysis of Faculty.

2 COMPONENTS FOR FACULTY PEROR-MANCE EVALUATION

Since the number of colleges have considerably grown over the amount of years, it becomes prudent to look appear at how teaching and learning have modified. The institutions are creating substantial investments for their computing infrastructure to satisfy their goals. In this regard the tools, which may be adopted widely by institutions today to align their growth methods and HR strategies are 360 degree feedback, competency mapping and assessment centers. Two types of performance analysis techniques are used viz formative and summative evaluations. Formative Evaluation refers to a quantitative analysis of the instructors aimed at identifying strengths, weakness and providing adequate skilled development opportunities. It involves the use of classroom observations, student evaluation report etc, to measure the performance and effectiveness of a faculty member. The general intention of this is to supply informative feedback to help faculty in improving their teaching performance.

In order to measure aptitude and knowledge and to ensure

that required standards are met Summative evaluation is represented as an indispensable source of documentation and recognizable way to evaluate instructors' quality. It is used to determine the worth and career advancement of a faculty.

3. COMREHENSIVE REVIEW OF LITERATURE

This paper presents a detailed comprehensive literature review of major important researches in the area of Educational Data Mining for faculty performance evaluation from Year 2013 to 2016. The referred work is presented below in a categorized tabular form (Table 1).This survey will be useful in determining how to make use of the proposed assessment for the betterment of the faculty, students and institutes.

Table 1. Shows the comprehensive survey based on application of different data mining techniques for faculty performance evaluation in prior research studies from different perspectives.

This survey performed on the basis of the following categories:

1 Objective of the research.
2 Parameters used for finding the faculty performance evaluation.
3 Methodology used in the research papers for evaluation of faculty performance.
4 Techniques and tools applied for evaluation.
5 Data Mining tools used for analysis and visualization.
6 Finding or conclusions of the research.

TABLE-1: A SURVEY OF RESEARCH PAPERS

S. No.	(1) Year & Author	(2) Paper Name	(3) Objectives	(4) Parameters Used	(5) Methodology	(6) Technique(s) and Tool Used	(7) Findings
1.	2013 Fateh Ahmadi, M.E Shiri Ahmad abadi[9]	Data Mining in Teacher Evaluation System using WEKA	Analyze the performance of final Teacher Evaluation of a semester of a college using WEKA tool. education according to teacher evaluation.	Dataset have teachers' information such as Evaluation's score, Teacher's degree, Degree's type, Teaching experience, Acceptation.	In this research study, has followed a popular data mining methodology called Cross Industry Standard Process for Data Mining (CRISP-DM), which is a six-step process.	Classification, clustering & Association Algorithm. Weka was used to carry out this research.	New rules by using data mining and J48 tree as a decision tree are useful for education managers in future decisions to select new teachers and continue with elected old teachers. .
2.	2013 Ajay kumar pal , Saurabh pal[10]	Evaluation of Teacher's Performance: A Data Mining Approach	This model considers the various aspects of performance measures of University teachers that have deep influence on the teachers' performance.	Fourteen parameters such as teachers Name ,speed of delivery ,content arrangement, presentation, communication , knowledge , content delivery , explanation power Doubts clearing, etc.	To evaluate the exactness of the resulting predictive model and to visualize erroneous predictions, Classification and Regression algorithms were applied on the dataset.	Naive bayes, ID3, CART and LAD tree. Weka Tool was used.	1. The best algorithm was Naïve Bayes classification with lowest average error as compared to others. 2. Content arrangement was the strongest attribute, and then the result plays an important role in the performance of teachers.
3.	2013 Aranuwa Felix Ola, Sellapan Pallaniappan[6]	A data mining model for evaluation of instructors'performance in higher institutions of learning using machine	To improve reliability and efficiency of faculty performance evaluation system that will optimize students' academic	instructors' information	Formative and Summative models are used. First component is data acquisition and storage, second is model building through classification models spe-	networks and decision tree algorithms	The proposed system, will help stakeholders in decision Making and provide basis for instructors' performance improvement that will optimize students' academic outcomes

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		learning algorithms	outcomes for ensuring quality education.		cifically neural network, third component is for mapping the patterns and the fourth component is the recommendationsystem.		
4.	2014 Nirmala G, P. B. Mallkarjuna[11]	Faculty performance Evaluation Using Data Mining	Developing algorithmic models for Faculty Performance Evaluation System.	Parameters of faculty such as student's performance, student feedback and other activities like papers presented, workshops, seminars and conferences attended and conducted etc.	Exploring different - Data Selection methods such as in record form, - clustering techniques such as K means for different parameters of faculty, -frequent itemset generation for Apriori algorithm for Association rule.	K means Clustering algorithm Apriori Association rule algorithm	1. K means Clustering, to make groups of faculty members with different parameters for future use by administration. 2. Apriori Association rule, to decide faculty members with different parameters are supporting with minimum value for a particular activity.
5.	2014 Archana Bhardwaj], Mamta Bhusry [12]	Two Approach Comparisons for Relative Evaluation of Faculty Performance Using Data Mining Techniques	In this paper multiple classifier system was developed and compared single classifier approach for relative evaluation of faculty performance using data mining techniques.	The authors have collected data of 2 consecutive years (i.e. 2010-11 and 2011-12) .This data comprises the feedback taken from 360 students of 2nd, 3rd and 4th year of both batches for all 25 faculties who taught them, and the result obtained in the respective courses taught by these 25 faculty.	In multiple classifier approach K-nearest neighbor (KNN) is used in first step and Rule based classification is used in the second step of classification while in single classifier approach only KNN is used in both steps of classification.Then both are compared. .	KNN ,Rulebased classification	The overall performance of multiple classifier approach is better than the single classifier approach. In the second step of multiple classifier approach we Rule-based classification have been used where the authors define their own rules for classification, which make the difference from single classifier approach. In single classifier approach we sum up the both parameters scores which may restrict the performance of this approach.
6.	2014 G.Jyothi*, Ch. Parvathi,P.	Fuzzy Expert Model for Evaluation of	Proposed a Fuzzy Expert System for evaluat-	Four parameters student feedback,teachers self ap-	Performance Evaluation of faculty with Fuzzy Expert	Fuzzy Logic. Mat-lab fuzzy toolbox on Windows XP	The overall performance of a faculty determined by fuzzy model is

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	Srinivas, and,Sk. Althaf Rahaman [13]	Faculty Performance in Technical Educational Institutions	ing teachers overall performance based on fuzzy logic techniques under uncertain facts in the decision making process.	praisal,assessment by peers, result of the student. The proposed Fuzzy Export model was studied and tested with 50 faculties data obtained in the year 2013 from repudiated engineering college	System comprised with three steps: 1.Identification of crisp value. 2. Fuzzification of input value. 3.Determination of application rules and inference method. 4. Fuzzy output overall performance value and Defuzzification of performance value.	platform.	more realistic than the direct values.
7.	2015 Thuy-Van t.Duong, Thuc-Doan do, Ngoc-Phien Nguyen [14]	Exploiting Faculty Evaluation Forms to Improve Teaching Quality: An Analytical Review	A literature review was carried out on the exploitation of knowledge from faculty evaluation forms to improve the quality of teaching and support stakeholders and analysed decisions. based on the previous studies.	Collected empirical data from the online faculty evaluation system of Ton Duc Thang University in the second semester 2013-2014. The total number of evaluation forms is 116,576 consists of 17 questions Ready to answer students' questions like. Inspire students , Monitor the attendance of students , regularity, etc.	The factors are divided into five groups: course content, teaching method, study guide, the responsibility of the instructor ,the behaviours of the instructor and one section to record the additional comments of Students and an overall rating. This analysis was conducted for each of 15 departments.	Classification methods consisting of four algorithms: The methods consist of classification, regression analysis, statistical tests, association rules mining, decision tree, and stepwise regression tree	1. The factors friendly to students, the group behaviours and Content arrangement have the most important impact on the overall rating. 2. Regression analysis and statistical tests are most suitable. 3. Decision tree can only identify the most important factor which is the factor at the root of the tree. 4. Naïve Bayes algorithm had the highest classification accuracy.
8.	2015 Randa Kh. Hemaid , Alaa M. El-Halees [5]	Improving Teacher Performance using Data Mining	To improve teacher performance through the study of their specialization and expertise and the time of the period in the service of the educational process, evaluate and determine courses for needy teachers under improving their per-	Teacher data set consists of 813 records and 46 attribute. It combines s the training, administrative and questionnaire information about the courses received by teachers in the training. It contains the questionnaire on three main pivots (Goals courses, trainees, trainers) and includes 29 questions which are answered through.	The methodology starts from the data collection, then preprocessing. Data mining methods applied were association and classification followed by the evaluation of results and finally the knowledge representation process	Association, classification rules -Decision Tree, Rule Induction, K-NN, Naïve Bayesian	1. Association rules that improves session of professional competence. 2. Rule induction the session of professional competence with accuracy of 76.23% if: Implemented trainee's experience they have gained in their classrooms, By applying the K-NN classifier, the model has an accuracy of 79.92% which is acceptable accuracy; 3.But By applying the Naïve Bayesian Kernel classifier, the

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			formance.				model has an accuracy of 77.46% which is acceptable accuracy.
9.	2015 Priyanka r Shah, Dinesh b Vaghela ,Priyanka Sharma [15]	Predicting and analyzing faculty performance using distributed data mining	To develop a model for predicting faculty performance and design a framework of distributed data mining with the use of classification via clustering approach.	Parameters related to faculty performance such as educational qualification, experience, student support etc. were used.	Distributed data mining was proposed in order to fetch data from different sources the clustering and Classification - ion algorithm was applied on it. For this (i) Local Site that includes Web page through which user interacts with the system and a middleware which is located at the local site which was the main part of the proposed work. and (ii) Remote Site includes different web servers and database/datasets located at different locations. .	Clustering and Association Rule. Weka Tool was use for this research.	EDM provides an efficient and effective way to find out trends and patterns from the educational data. These patterns are helpful for providing quality education system for betterment of society.

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10.	2016 Mustafa Agaoglu [16]	Predicting Instructor Performance Using Data Mining Techniques in Higher Education	Building a classifier Model to evaluate instructors' performance based on students' perception.	Students feedback, assessment by peers, teachers self appraisal, result of the student.	Four different classification techniques are used to build classifier models. The dataset consisted of students' responses to a real course evaluation questionnaire using accuracy, precision, recall, and specificity performance metrics	Decision tree algorithms, support vector machines, artificial neural networks, and discriminant analysis	1. In this study, following classification models are generated: • Two using decision tree algorithms (C5.0, and CART), • one using SVM, • three using ANNs, and • one using DA. 2. Data mining techniques, specifically decision tree algorithms, boosting, SVM, ANN, and DA in higher educational mining are presented over a dataset from the daily life in a more effective manner.
11.	2016 Asanbe M.O., Osofisan A.O., William W.F. [17]	Teachers' Performance Evaluation in Higher Educational Institution using Data Mining Technique	To design a framework based on academic background factors and socioeconomic factors among other factors which can be used to predict teacher's performance and suggest remedial measures for improvement.	The data included two basic categories of variables, the first group comprised 350 teachers records. The second group of variables includes the students' learning outcome (results) from 2010 to 2015 academics sessions. The fields selected for the model include: Appointment status, Rank, University working experience, Highest Qualification, Year of last Qualification, Professional Qualification and Result.	The prediction model was developed using the Classification-ion methods of the Data mining technique. The Neural Network data mining technique (the multilayer perceptron algorithm) and Decision Trees methods specifically the ID3 (Iterative Dichotomiser 3) and C4.5 algorithms (the C4.5 is implemented in WEKA by the classifier class: weka.classifiers.trees.J48) were used and their performances were compared to each other. A (CRISP-DM) was followed.	C4.5 Decision Tree Classification Algorithm, ID3 Decision Tree Classification Algorithm and MLP Neural Network. Weka	1. Both C4.5 and MLP algorithms results show great superiority over ID3 algorithm. 2. Neural Network performed well in classification as well as in prediction but suffered from lack of speed. 3. The ID3 Decision Tree was the fastest, but did not perform well at the classification. 4. Working Experience and Rank were the variables that contributed mostly to the performance of the teachers 5. Another important factor that positively influences teachers' performance is Highest Qualification and Appointment Status and Professional Qualification have little influence.

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12.	2016 Priti Ughade , S.W.Mohod [18]	A Survey on "Analysis of Faculty Performance Using Data and Opinion Mining"	The proposed model analyse the faculty performance using 4 parameters i.e., student complaint about faculty, Student review feedback for faculty, student's feedback, and students result etc.	faculty performance using 4 parameters i.e., student complaint about faculty, Student review feedback for faculty, students feedback, and students result etc.	System defines two approaches and compares them. One is multiple classifier approach where K-nearest neighbor (KNN) is used in first step and Rule based classification is used in the second step and the other is a single classifier approach where only KNN is used in both steps.	Here KNN is used for mapping purpose. And rule based algorithm is used for deciding the rules on the data.	1. The performance of multiple classifier approach is superior than the single classifier approach which uses only KNN in both steps. 2. KNN is used as the first step. Rule-based classification used
13.	2016 R K Banu and R Ravanan [19]	A Competency Framework Model to Assess Success Pattern for Indian Faculties A NLP Based Data Mining Approach	For analyzing the success pattern of college teachers based on Neuro- Linguistic Programming (NLP in various contexts for their professional growth.	Competency of 20 faculties was evaluated using 8 parameters. These are Continuous learning, Curriculum planning and Scheduling, Research Skill, Creativity, Positive Feedback, Work Coordination, Democratic Decision making, etc.	Heuristic Algorithm was used; database constructed based on the assessment from the different educational institutions.The association rules are formed for finding the success rate of the given competency. 3. The database was scanned projected data was taken by using prefixspan algorithm.	Association Rules and prefixspan Algorithm. Neuro-Linguisti'C' Programming (NLP) Tool	1. Analyzed the top competencies of a faculty who can fit for their job role as a teacher with Modified Prefixspan Algorithm with minimum cost and time. Analysis will help the management to decide whether they had a right choice in their recruitment process.
14.	2016 Renuka Agrawal, Jyoti Singh, A.S. Zadgoankar[20]	Formative Assessment For Performance Evaluation of Faculty Using Data Mining	Modelling an improved instructors' performance evaluation technique by using formative evaluation methods, propose an optimal algorithm	Academic behaviour of students used in the questionnaire is Attendance, Assignment work, performance in Internal exams. Sessional marks and previous year results. Questionnaires for Per-	Data collection from Students Database followed by preprocessing. Association, clustering and classification were applied and results were evaluated. The main	Association Rules, Decision tree. Weka is used in this research.	Association rule result interpreted as, - 1. 17 %(support) students are Good in their class attendance, assignment, having performed average in internal exams. 2. 73% probability or confidence that student will get the

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			and design a framework of instructors' evaluation system and aid administrators in decision making.	formance Evaluation includes 21 questions like explanation power, content delivery, doubt clearing, friendly attitude etc.	motive is to categorize students in two categories whether they will be able to give a realistic feedback or not.		grade Good and so on. 3. 19 %(support) students are poor in their class attendance, poor grades in assignment, and poor in sessional marks. 4. 75% probability or confidence that student will get the grade Poor and so on.
15.	2016 Vrunda Suryaji Warke [21]	Data Mining Approach for the Analysis of Performance Based Appraisal System of Selected Teachers in Kolhapur City	To analyse performance based apprais -al system of selected Teaching Staff. To develop a data mining model with classification, clustering and association techniques from PBAS dataset.	Collected 200 selected teachers PBAS data using UGC Proformas for PABS.	First Preprocessing is applied to the data. After pre-processing the data, research applies data mining techniques - association, classification, clustering etc, for the analysis of educational data.	Classification, Clustering and Association rule. R Data Mining Tool was used to carry out this research.	1. Appraisal evaluation based on realistic data. 2. Developed a model with classification, clustering and association techniques 3. For performance assessment and adequate support in decision making this research can produce significant bases.
16.	2016 Francis F. Balahadia and Benilda Eleonor V. Comendador [22]	Adoption of Opinion Mining in the Faculty Performance Evaluation System by the Students Using Naïve Bayes Algorithm	Promotes adoption of Opinion Mining for faculty performance evaluation and helps the university administrators to identify the strengths and weakness -sees of the faculty members	The polarity word dictionary was constructed to filter and analyze some polarity words from the University Information System and OTE comments server. The sentiment words are categorized into Tagalog words and English words like He's really good in teaching his students-positive comment. I can't understand his diction-negative.	The authors identified 2000 positive words and 1000 negative words; The authors applied a machine learning method which is Naïve Bayes. For evaluating it's effectiveness, a pilot test was done on August 2014 to October 2014.	For Classification, Naïve Bayes techniques is used.	Stakeholders accepted the challenges of analyzing narrative responses of the students in the teacher's evaluation. The online performance evaluation of the teacher is very important because it is a tool for assessing their performance and addressing students' concerns.

4. CONCLUSION

A comparative analysis of various research papers during 2013-2016 shows how useful data mining techniques are in higher education, particularly to predict the faculty performance and also to facilitate the faculty for enhancement of their skills and in turn also improve the quality of teaching.

Multiple factors are associated with the assessment of teaching performance of faculty members and it has been observed that good prediction will pave the way for faculty members to reach the highest level of quality in her/his performance. These researches reveal some significant areas in the evaluation of faculty performance. This study revealed some major trends:

1. Classification and Regression are the most commonly used predictive data mining techniques. In classification, decision tree, statistical algorithm and rule based algorithm are the most prominent one.
2. In case of descriptive data mining techniques, clustering and association rules are popular in evaluating faculty performance. KNN is the most widely used clustering technique.
3. It has also been found that Naïve Bayes gives best result with lowest average errors and has highest classification accuracy. Statistical tests and Neural Network also performed well in classification as well as in prediction.
4. The overall performance of multiple classifier approach which uses KNN in first step and rule based classification in second step is better than the single classifier approach which uses only KNN in both steps.
5. The performance was evaluated on the basis of faculty qualification, experience, research, content arrangement, presentation and communication skills, doubt clearing, results etc. The study reveals that working experience and rank were the variables that contributed mostly to the performance of the faculty.
6. Content arrangement and results of the students also have the most important impact on overall rating of the faculty.
7. From above survey, it is concluded that a less amount of work done in the area techniques such as Artificial Neural Network and fuzzy logic. So, there is a scope for the applications of ANN and fuzzy logic in this area in the future.
8. In majority of the papers Weka tool is used for applying data mining techniques.
9. In future, applications of data mining techniques in Higher Education will be increased extensively particularly in performance monitoring and evaluation of students and faculty members.

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