A review on Data Mining Algorithms and Attributes for Decision Support Systems in Education Domain

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Abstract: Educational Decision Support System has become one of the fundamental needs for any learning centers. Data mining techniques have found to be capable of providing the Decision Support System (DSS) in education domain. Conventional Data mining algorithms needs to be adapted and modified for applying the educational data. The accuracy of any data mining algorithm is also considered to be affected by the attributes selected. This study focuses on different algorithms and attributes used in developing DSS. It is found that most of the studies aimed on improving the performance academic accomplishment of the students and less research has been conducted in providing a decision support system for organizing and maintaining educational infrastructure, areas of interest of students and courses demanded. It is also found that demographic features and students' past academic details are mainly used as attributes in this area of study. Student's psychology, its intelligence and the way student learn have not been found to be used as attributes while considering the DSS in education domain

Keywords: Educational Data Mining, Knowledge Discovery, Academic Analytics, Decision Support System

I. INTRODUCTION

Education sector has become more competitive in the last few decades. In order to have an edge over its competitors most educational institute is applying innovative ways in the form of Information and Communication Technology (ICT). ICT eventually leads to storage of data. The storage of these data is growing with higher velocity, volume and variety. Like any other business organizations, data is an asset for educational institutes.

Undoubtedly, educational institutes get the benefits of ICT in terms of automation of the work flow, better delivery of lectures, easy access and efficient storage of student data however it leads to information explosion and creates difficulty to make important decision for the decision makers of the educational institutes. This arises the need for the development of efficient decision support tools providing better suggestions and solutions than that can be provided manually.

The techniques involved in Data Mining are found to be suitable in creating decision support systems in the education environment[1]. However, it needs to be modified and cannot be applied directly like it is possible in other fields.

The use of data mining to harness the educational data gives birth to a separate research area in the recent years.

It began to be apparent in 2008 with the inauguration of the annual International Conference on Educational Data Mining and the Journal of Educational Data Mining.

In this paper, a review on various applications of data mining algorithms and attributes used for the development of decision support systems (DSS) for educational institute is presented. This paper is organized into four different sections. Section II describes educational data mining (EDM) definition and DSS; Section III reviews on different algorithms and attributes that have been used in providing decision support system on educational data mining. Finally, the conclusion of this work is described in Section IV.

II. EDUCATIONAL DATA MINING AND DECISION SUPPORT SYSTEM

EDM may be defined as an amalgamation of statistics and artificial intelligence disciplines to develop methods and techniques for extracting new and worthwhile information from educational data. It is an evolving discipline and aims at providing tools that enhanced understanding the students and their learning environment. Data from education sector is unique and is at large scale [2]. To provide a DSS for the academic institute, can be considered as the prime goal of EDM.

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Any Educational Institute has the following entities
    a) Student
    b) Faculty
    c) Program/Course
    d) Administrator

All these entities have their own constraints to achieve their goals and the role that DSS has to play is different from one entity to another entity. So the objectives to be met by EDM and eventually by DSS can be broadly considered as
    a) Academic
    b) Administration
    c) Business

Academic objectives – To design educational content that aims in improving the academic achievement of the students

Administration objective- To optimize the organization and maintenance of educational infrastructure, areas of interest, and courses demanded

Business objective- To perform market segmentation that allows and facilitates the capture of pupils

III. DATA MINING ALGORITHMS AND ATTRIBUTES FOR DSS

Various areas of Education Domain have been explored in an effort to provide support to it. Some of the areas and the algorithms and the attributes used to provide Decision Support System using Data Mining are broadly discussed as below:

A. Student's Performance
Mishra, Kumar and Gupta [3] developed prediction model for student's performance by using J48 and Random Tree classification techniques. They gathered the records of Master of Computer Applications students of the affiliated college of Guru Gobind Singh Indraprastha University, Delhi, India. They predicted the third semester performance by considering the students' social and academic integration and various emotional skills as features. They found that Random Tree provided better accuracy than J48 algorithm.

Verma,Thakur and Jaloree [4] used Apriori algorithm to develop a model that determines weak students. They considered marks obtained at graduate level, previous semester's mark obtained, current semester attendance and current semester mid semester marks. They used 50 data sets obtained from Samrat Ashok Technological Institute, Vidisha, Madhya Pradesh of the course Master of Computer Applications (MCA) from session 2007 to 2010. They observed that in order to get the good performance, students have to be good in their attendance and unit test. Also graduation performance has an impact on the student's unit test performance.

Lakshmikanth and Sangareddy [5] used Bayesian classification method to analyze the student performance. They considered 25 attributes which include personal, social and academic details. Prediction, results and recommendation were provided by this information and helped the user to take further decision.

[6] conducted a study on the prediction of students' final grade using the ID3 decision tree algorithm. Data from the Academic Department of Redeemer's University, Ede, Nigeria were analysed. The data comprised of student's gender, entry grades in secondary school (O' level result), entrance examination scores and graduation grade for all graduates between the academic year 2008 to 2009 and 2011 to 2012. The data and the attributes that influenced their results were selected and analyzed. The model achieved an accuracy of 79.556 %.

Al-barrak and Al-razgan [7] presented a case study in EDM . They developed a model to predict final Grade Point Average of student. They utilized the decision tree classification technique. The study was based on the grades of their previous courses. They used the secondary data of the transcripts of graduated female students in th year 2012. The total size of the data was 236 and was of female students from Computer Sciences College at King Saud University. Other than predicting the final grade, in their study, they also evaluate the most important courses in the study plan that has a big impact on the students' final GPA.

Kabakchieva [8] developed a data mining model for forecasting the performance of students. It was based on the personal characteristics, pre-university and university-performance of the students. It involved 10067 instances and 14 attributes collected from the students of University of National and World Economy (UNWE). One Rule, Neural Network, Decision Tree and K-Nearest Neighbor classification algorithms were applied. Neural Network Model with 73.59% showed the highest accuracy. The study also found that classification process is mostly affected by the score obtained at the University admission

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test and the pass percentage of the first year university exam.

Ruby and David [9] focused on identifying various indicators that affected the academic performance of the students; They collected data from 165 Post Graduate Computer Application students of an Arts and Science College studied between 2007 and 2012 and considered 13 attributes. Out of the 13 attributes, 7 attribute namely Medium of the Study, Percentage at UG, Marks obtained for theory papers, Stay, Extra Curricular Activities, and Family Income. In their study, they found that performance of the Previous Course studied was found to be the most influencing attributes in the academic performance.

In [10], the researchers used 182 students' records collected from Coimbatore Institute of Technology (CIT), college from the year 2008 to 2010 and identified 7 factors viz. SSLC percentage, HSC percentage, Subject Difficulty, Family Income, Stay, Medium and Staff Approach that influence the performance of students in a 'C' Programming course from an initial set of 20 attributes. They derived the factors that influenced the result of students. For the purpose, they used correlation analysis and various feature selection methods. The prediction model built using Bayes classifier showed highest accuracy of 82.4% and can predict unseen data.

[11] studied the impact of family background on students' academic performance. The factors considered are mother's educational qualification, father's educational qualification, sponsor, family size, mother's occupation, father's occupation, parent's marital status and average family income. They collected 7500 students' data randomly from Babcock University for the period 2001-2010. They used Random forest, J48, random tree, Decision table, Decision stump, JRip, ZeroR, OneR, PART and REPTree classification tree. They also used a multilayer perceptron learning algorithms in generating models from Waikato Environment for Knowledge Analysis (WEKA). Of all the algorithms, random tree provided the maximum accuracy with 99.908%.

B. Slow Learners
Kaur, Singh and Singh [12] used data of 152 high school students in order to predict and analyze slow learners. They selected 14 variables viz. Gender, Institution at high level, Board type, Instruction Medium, Private tuition, Location at school level, Type of school, student having mobile, own computer at home, Student having net access, Student's roll no, Internal grade of student, Attendance count, Whether qualified or not. The dataset is analysed by using five different classification algorithms. They are Multilayer Perception, REPTree, Sequential Minimal Optimization, Naive Bayes and J48. They observed that Multi Layer Perception (MLP) performs effective and efficiently with 75% accuracy.

Kumar, Shambhu and Aggarwal [13] considered 13 attributes viz 'Types of High School', 'Class' , 'Medium of Instruction',' Type of School', 'Internal Grade of student', 'Gender of student', 'Private Tuition taken', 'Location of the school area', 'Types of Education board ', ,'Mobile Phone','Computer at Home',' Internet access to student',' Attendance in the school'. They analysed the data in the classifiers - Naive Bayes, J48, RepTree, ZeroR, OneR, SMO and Multi Layer Perceptron. From these classifiers, Multi Layer Perceptron gave an accuracy of 87.44 and proved to be very effective for the prediction of slow learners.

C. Student's Placement Chance
Tiwari and Sharma [14] developed a predictive model for the student placement using random forest technique. They collected 2013 batch B. Tech students data and considered the attributes gender, category, student's scores in the first, second and third year, student's confidence level, native place, family background, leadership ability, extracurricular activities, social interaction. They applied ID3, Bayesian Network, Radial Basis Function network, J48, Random tree algorithms on the student information data set using WEKA tool. They found that Random Tree algorithm with 73% is the most accurate algorithm for the prediction process.

[15] used data mining techniques to analyze students' entrance exam result and predicted students' placement chance. In their work, three classification methods were applied on students' data i.e. J48, Naive Bayes, and Random Forest classification methods. From the analysis result of the experiments J48 performs with the accuracy of 91.304%, Naive Bayes 74.581% and Random Forest 95.652%. They found that Random Forest Classifier is most suitable method for this type of student dataset.

[16] developed a predictive model for placement of student after completing Master of Computer Applications course by the three selected classification algorithm. For the purpose, a dataset of size 65 were obtained from VBS Purvanchal University, Jaunpur(Uttar Pradesh) for session 2008-2012. They used Naive Bayes,

Multilayer Perceptron (MLP) and J48 classification algorithm and found that Naive Bayes Classification algorithm gave the best accuracy, 86.15%.

[17] used J48 algorithm on 101 records with 14 attributes collected from Nallamuthu Gounder Mahalingam College of Arts and Science, Pollachi, Tamil Nadu. To predict the students' placement chance, registration number, gender, department, name, admission type, SSLC board, SSLC marks, HSc board and their mark, locality, back paper, Percentage obtained at UG, Jobs obtained after UG were processed into attribute selection process. They selected Best Fit with Correlation based Feature Selection algorithm based on the placement class. However, the attributes gender, SSLC mark, UG percentage and HSc marks were selected after evaluating the training data. On evaluating the data set by J48 classifier the result generated correctly classified instance of 94.05 %, F-Measure value of 0.938 and Recall value of 0.941.

[18] used Roll no, Higher secondary board marks , under graduate marks, Board, Communication skills as attributes to predict the placement of the UG students. A total of 1342 records were taken from the placement cell of Dr.N.G.P arts and Science College. C4.5, ID3 and CHAID data mining techniques were implemented on these data and found that ID3 algorithm is appropriate for predicting student placement. ID3 gives 95.33% prediction while C4.5 provides 95.05 and CHAID algorithm 94.18

In [19] a sample of 300 UG student's record was taken from a computer science department of a private Educational Institution. They used marks obtained in the subjects of English, Maths, Programming language, Practical marks of the UG course as attributes for the predicting the placement chance. They tested the data set with five different classification algorithms namely Naïve Bayes Simple, J48, SMO, REPTree and Multilayer Perception. Multi Layer Perception algorithm with an accuracy of 87% is found to be the most appropriate algorithm for predicting the chance of placement of the students.

[20] collected 325 MCA students records from various institutes in Mumbai. They considered the attributes like student's gender, percentage of mark obtained at SSCE (Secondary School Certificate Examination), HSCE (Higher Secondary Certificate Examination) percentage, percentage of mark obtained at their Graduation, , Graduation stream, MCA final result and the details of

organization where student had been placed. Using XLminer tool, decision rules were developed according to a classification tree. They obtained an overall error of 38.46%.

D. Student Dropout

Kajaree and Behera [21] obtained student data from G.H. Raisoni College of Engineering, Nagpur, Maharashtra for classification and prediction of likely to dropout students. They considered the attributes of TAE (Teacher Assessment Exam) and CAE (Class Assessment Exam) for five subjects studied in First year of Engineering, Semester Grade Point Average (SGPA), Gender, Category, Marital Status, HSSC_PCM marks as total SSC marks, HSSC marks, board of SSC and HSSC, Working Status of Parents, Father's income, the student's residing Place, throughout his engineering education considered. The data has been analyzed using three classifiers namely J48, Decision Stump and Naive Bayes in WEKA 3.7.4. Decision stump classifier gives 97.91% accuracy whereas J48 and Naive Bayes provides 90.62% and 86.45% accuracy respectively.

Pal [22] used data mining methodologies with the aim to potential drop out students at their first year of engineering. The author used 1650 students' information from the Institute of Engineering and Technology of Veer Bahadur Singh Purvanchal University, Jaunpur, India. The time period considered were 2006-07 to 2010-11. The attributes used are students' branch, sex, category, high school grade, senior secondary grade, admission type, teaching medium, living location of the student, family annual income, Fathers qualification, Mothers occupation. Four classification techniques viz. ID3, ADT, CART and C4.5 had been applied on the dataset and found that ID3 algorithm provides better accuracy with 90.9091 %.

[23] applied ID3 algorithm with an effort to predict drop out students. They collected 220 records of data on student randomly through survey at University. Out of 33 attributes selected, 12 attributes were found to be influencing in the prediction of dropout. The 12 attributes are Participate in extra curriculum activity, family experiences stress, Stream in Senior secondary(12th), Satisfaction with course, Enrolled in other institute, Change of goal, Campus Environment, Family Type, Family problem Infrastructure of university, Adjustment Problem, Residence. They achieved 98% accuracy and considered ID3 classifier to be the best classifier.

Thomas [24] applied rule induction and decision tree algorithms to predict college students dropout. They collected 150 students' data from the students that had been enrolled in B. Tech Degree courses in the academic year 2014-18 in one of the reputed colleges affiliated to M.G University, Kerala, India. Out of 67 attributes, 13 attributes were found to be most influential and were used. The attributes are Score in BME, Score in BEE&IT, Score in EG, Total, Score in BLE, Score in EC, Difficulty level in EM1, Score in EM1, Score in EM, Score obtained in Mathematics in 12th grade, level of boredom during classes, level of attentiveness during classes, taking notes from class. Among the rule induction algorithms, the best accuracy is provided by Nnge algorithm with 88% accuracy while ADTree algorithm yields maximum accuracy of 92% among the Decision Tree Algorithms

[25] observed that two subjects Algorithms Analysis and Digital Design played a major role in deciding the drop out of Computer Science students at the AL-AQSA University, Palestine. In their study, they used the daily study record, average score at High School, information if student took Computer as major at their previous studies, transcript for first and second years of the course as the attributes. They used Decision Tree and Naive Bayes and got 98.14% and 96.86 % accuracy respectively.

Marquez-Vera et al. [26] used Interpretable Classification Rule Mining (ICRM) algorithm version 2 (ICRM2) to predict student drop at the early stage. This evolutionary programming algorithm was implemented using the data set collected from 419 students of the Academic Unit high school, Autonomous University of Zacatecas, Mexico. They used class statistics, students' attendance, and social information, physical conditions of students, student behavior in class, information about the scores obtained in the various exams etc as attributes at various stages and found the efficient and accuracy. They observed that ICRM2 outperformed the entire traditional classification algorithms.

E. Faculty Performance
[27] considered the attributes viz. name of the teacher, the way content has been arranged, speed at which the lecture were delivered, presentation skill, subject knowledge, content delivery, communication skill, explanation capacity, doubts clearing, overall course completion and regularity, discussion of problems, student's attendance, result, performance of teacher to develop a model that would forecast the quality and the productivity of faculty. They used Naive Bayes, CART, LAD and ID3

classification algorithms. It was found that Naive Bayes algorithm provided the highest accuracy with 80.35% among the others algorithm considered.

Kumar [28] developed a model to conduct faculty performance assessment. The author used the teaching assistant evaluation data set of UCI Machine Learning Repository. Six attributes namely English Speaker, Course instructor, Course, Summer or regular, class size, performance were analyzed using classification algorithms IBK, J48 and Meta Bagging in WEKA 3.6.9 data mining software tool.IBK algorithm with 62.2517% showed the highest accuracy.

[29] used course evaluation questionnaire to evaluate faculty's performance. Data from 2850 students were randomly selected from various departments of Marmara University, Turkey. 26 variables were analyzed in seven classification models: 2 using decision tree algorithms (C5.0, and CART), 1 using Support Vector Machine, 3 using Artificial Neural Networks, and 1 using Discriminate Analysis. It was found that C5.0 algorithm provided the highest accuracy with 92.3%.

[30] implemented multilayer perceptron, ID3, C4.5 algorithms in WEKA 3.6.13 to forecast the academic performance of teachers. They collected data from Academic Department of a University in Ondo State, South West of Nigeria. They divided the data into two categories of variable as teachers' data variables and students' learning outcome (results) variables. Teacher's data variables consist of Appointment status, Rank, University working experience, Highest Qualification, Year of last Qualification, Professional Qualification and Result. The students' learning outcome variables include Course ID, Course Name , Course Lecturer , Course Performance. C4.5 decision tree outperformed the ID3 and MLP algorithms with an accuracy level of 83.5% and acceptable kappa value 0.743.

Bhatnagar S. and Saxena P. S. [31] analysed the faculty performance using classification algorithm. They used Discriminant Analysis, Artificial Neural Networks, Support Vector Machines and Decision Tree for the purpose. With the attributes of the subject command, helping attitude, Interaction at laboratory, Control over student in the class, teaching methods used, Sense of Time, decision tree was developed and found to have the least over fitting accuracy (0.0073) and sensitivity (0.0084).

IV. CONCLUSION

In this paper, a review on various algorithms of data mining that are commonly used to develop decision support system in education domain is presented. As the accuracy of data mining algorithm heavily depend on the attribute selected for the problem to be studied, the attributes used in the application of the algorithms is therefore presented. Through this paper, it is found that many of the research in EDM focuses on providing a decision support system for the student academic performance. It is also found that less research has been conducted in providing a decision support system for organizing and maintaining educational infrastructure, areas of interest of students and courses demanded. Student Demographic features; socio-economic characteristics and prior educational background are found to be commonly used as attributes. Student's psychology, learning styles and its intelligence may also be explored to find any hidden pattern in future.

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