

Towards Prediction of Students Educational Accomplishments Using Data Mining



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Abstract Prediction outcomes help students and faculty learn new ideas for gaining the desired goals of institutes. The goal of this research is to study all the data mining techniques, algorithms, and factors that help in the prediction of the student's performance between the years 2010 and 2021. In this paper, we have reviewed and analysed more than 35 research papers based on seven aspects, i.e. (1) prediction of the student's performance outcomes related to the student grade, result, and knowledge, (2) models and software developed in performance prediction, (3) factors that helped in prediction, (4) algorithm that gave the most accurate result, (5) student posture in the classroom while taking the class, (6) subjective paper evaluation, and (7) feedback related to students and faculty.

Keywords Recognition · Educational data mining · Prediction · Machine learning · Review · Outcome

1 Introduction

Everything becomes online, i.e. shopping, playing, examination, education, banking, and business in this pandemic era. New technologies and ways have been developed using educational data mining and machine learning for making online education interesting and powerful. Cheating prevention is very less in online examinations, many students lack knowledge related to the subject and practical, but they get the full marks, due to this students do not get a placement and faculty cannot be able to measure the right performance of the students. In this technology era, more institutes, colleges, and universities are opened and all of them have high-level competition. Predicting the performance of the students becomes more challenging for a good

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result database. The best ranking, institutes, and universities students have excellent performance because they provide the best teachers, methodology, and excellent learning system. These universities have excellent results and records of student performance. Students are big source of advertising and feedback of the institution all over the world therefore, students' satisfaction about the teaching process and course selection is very important. The country has different types of boards (like NAAC accreditation under UGC and NBA accreditation under AICTE), and they work on the quality enhancement of the institution like technical programmes, teaching methodology, laboratory equipment, placements, and years wise progress of the students. A lot of students aspire to become an engineer but only some students become successful engineers, some drop out the college in the middle of the course because they cannot bear the pressure of the various internal and external exams. Data mining techniques and machine learning play a vital role in prediction of student performance.

Data mining techniques light on important aspects from a database and expose important data that is not in limelight. Clustering in data mining analyses the data and clusters the same type of data that are similar in specific manner [1]. Academic mining discovers student understanding and chooses how teacher deliver the right lecture in changing academic standards [2].

Data mining is a procedure to draw out important data from data sets without error using machine learning algorithms or artificial intelligence. The process cycle of data mining is shown in Fig. 1. This combination of predicting the student performance and the outcome helps the faculty for improving and making interesting teaching methodology. In this paper, our objective is to review various techniques and algorithms, i.e.

- Analyse existing prediction models.
- Identify key findings of existing model.
- Analyse gaps in previous research.



Fig. 1 Data mining process cycle [3]

- To study subjective paper evaluation, student gesture in classroom.
- Analyse student and teacher feedback.

2 Research Methodology

The methodology is being used for finding the gaps, study research algorithms, study and analyse factors of existing or previous research, and develop a new research in the same field with different or same algorithm and factors. Through the research methodology getting the all answers related to the research questions that are helpful in outcome.

2.1 Research Questions

Research questions are very important part of overall literature review. Through thus researcher develops some questions related to research and finding out the answers that are being helpful in researcher research. Various frameworks have been developed for developing research questions. We are using PICO, finer, and QA. Tables 1, 2, and 3 show the research strategies.

Many questions had been developed using above research framework, and some questions are given below:-

- How many prediction algorithms have been used?
- What are the common factors?
- What are the results of different algorithms on common factor?
- What type of degree involve in research?

Table 1 PICO research strategy

| PICO factors | Description |
|---------------------------|--|
| P: Population of interest | What type of population has been used for experiment/what type of population has do research on this/student performance |
| I: Intervention | How many and which type of factors and algorithms have been used |
| C: Comparison | Comparison among various algorithms and factors for finding best, study of case studies |
| O: Outcome | Deeply study of past research, find out best prediction algorithms and methods |

Table 2 QA research strategy

| QA factors | Description |
|---------------|--|
| Q:Quality | Quality of the past researches |
| A: Assessment | Assessment of various research results |

Table 3 Finer research strategy

| Finer factors | Description |
|----------------|---|
| F: Feasibility | Tools, time, algorithms, sample size, funding, methods, researchers, study design in previous research had been sufficient or not |
| I: Interesting | How research can be made interesting. Finding out the most interesting factors and algorithms |
| N: Novel | Finding the new research from the previous research |
| E: Ethical | Research should be ethical. All researchers should follow the rules and regulations |
| R: Relevant | Past research had been relevant. Do a new relevant research |

- How prediction algorithm outcome worked on student performance?
- Which algorithm is best for prediction?
- What are the factors and attributes used in comparison with algorithm?
- What is the quality of previous research?
- How previous research helpful for finding new one?
- What is the sample size used in previous research?

3 Common Factors/Attributes Used in Prediction

Attributes are the most important part of predicting performance. Some research papers had the same attributes along with additional attributes. The most common attributes that have been used are parents and family background details (like parents occupation, parents education, family size, parents salary, language, etc.) because family and parents are ideal to everyone. Family and parents are the first teacher and motivators of their children [4–9]. Next, a most used attribute is gender (female/male) because female students are serious, hardworking, self-motivated, focused, and disciplined in comparison with boy's students [4, 8–11]. Most used attributes for internal assessment are attendance, internal marks, assignment, and presentation, i.e. shows how student serious to their studies [5, 6, 8, 9, 12–15]. Grade or external assessment is also most important attribute of student performance prediction in this 10th, 12th, and external marks are included [4–10, 12, 15]. Some important attributes that help in prediction, i.e. nationality, language, Internet access, entrance result, scholarship, community, and distance and these attributes are the least important, and some researchers used in their research because, i.e. not give the valid result [4, 5, 8, 10, 11]. In the above some attributes, researchers predict the student performance based on student school background, some researchers use family background, and some researchers used grade, internal assessment, and external assessment based on 10th, 12th, b.tech internal and external marks, and some researchers used assignment, language, extracurricular activities in prediction. Some attributes are work on the qualitative data and some on the quantitative data.

4 Key Findings and Gap Analysis in Previous Research

This paper contains the various sections, and each section has different information of research done in previous years in tabular form.

| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|-----------------------------------|--|--|---|--|
| 1 | Prediction of student performance | S. Anupam Kumar & Dr. Vijayalakshmi M. N., 2011 | Decision tree | Predicted the MCA students' final results using C4.5 algorithm and compare with ID3 algorithm | Build the system for predicting the placement, faculty feedback, student feedback, etc. |
| 2 | | Osmanbegovic E., Suljic M., 2012 | Naïve Bayes, MLP, and J48 | Predicted the passed and failed result of students in which course they were involved | Extend the research with more attributes, algorithm and will finding the accurate result |
| 3 | | Vamanan Ramesh et al., 2013 | Naive Bayes, multilayer perception, SMO, J48, and REPTree algorithms | Identified the different higher predictive variables and construct algorithm for grading the higher secondary students | Modify the system for providing the online learning material and also find out the various factors that affected the student's performance |
| 4 | | Elakia et al., 2014 | Decision tree algorithms (C4.5 and CART) | Classification technique had been used for predicting carrier of high school students and also predicts the violation behaviour of students | Would examine different types of techniques and attributes for predicting more accurate result |
| 5 | | A. M. Shahiria, W. Husaina, N. A L Rashida, 2015 | Data mining algorithms | Studied the various predicting algorithms and find out best attributes that given the best result in prediction | Develop the model that predicts the students' performance using meta-analysis |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|------|---|--|---|--|
| 6 | | P. Thakar, A. Mehta, Manisha, 2015 | Data mining techniques | Analysed various types of educational tools and applications that help in performance prediction | Identify and apply various data mining techniques for predicting the more accurate result |
| 7 | | Amjad Abu Saa, 2016 | Decision tree algorithms and Naive Bayes model | Constructed the prediction model on the base of various attributes that depends on the personal, family, and social factors | Finding out the more patterns for improving the students' performance by applying the more data mining techniques on the students record |
| 8 | | Annisa Uswatun Khasanah, Harwati, 2017 | Feature selection method, Bayesian network, and decision tree algorithm | Analysed the different attributes that gave the accurate prediction. The study showed that first year attendance and GPA had the important attribute in accurate performance prediction | Using the more two attributes gender and origin in predicting the students' performance |
| 9 | | Aysha Ashrafa, Sajid Anwerb, M. G. Khan, 2018 | Various data mining algorithms, classifiers, classification algorithms, and use of neural network in data mining | Identified the best prediction method and algorithm that gave the accurate result on the basis of comparison and study | Finding out more efficient techniques for accuracy in result |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|------|---|--|---|---|
| 10 | | Atta-Ur-Rahman, Kiran Sultan, Nahier Aldhaffer, Abdullah Alqahtani, 2018 | Clustering, C-mean, and Apriori algorithm | Constructed the model on the basis of student interest and feasibility | Including the some attributes in the research like student is working or not, what could the time table and timing of class? How teachers will evaluate the marks |
| 11 | | S. Urkude, K. Gupta, 2019 | Decision tree, Naïve Bayes, and support vector machine | Calculate how many students complete their graduation and how much course rate achieved in which student enrolled | Same technology will applied on the large data set and develops more attributes related to first year progress |
| 12 | | K. K. Lay, A. Cho, 2019 | Naive Bayesian classifier | Classification model was used on previous result of IT students for predicting division | Applying the more classification algorithms and add the more attributes that will give the optimal result |
| 13 | | Vairachilai S, Vamshidharreddy, Avvari Sai Saketh, Gnanajeyaraman R, 2020 | Decision tree, support vector machine (SVM), and Naive Bayes | Identified the different dependent and independent factors and apply the various data mining algorithm in which Naive Bayes algorithm predicted the best grades | Applying and analyse the data set to identify the students' performance in systematic manner |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|------|---|---|--|---|
| 14 | | R. Hasan, S. Palaniappan, S. Mahmood, A. Abbas, K. U. Sarker and M. U. Sattar, 2020 | Classification tree, random forest, KNN, SVM, regression, Naïve Bayes, NN, and CN2 rule induction | Analysed various e-learning applications and apply various algorithms. Apply the genetic algorithm and various components to the result to reduce the features | Develop the dashboard would helpful for teachers to predict the student performance and find out the poor performers on the weekly basis. Students could also calculate their own performance |
| 15 | | F. Afrin, M. S. Rahaman, M. Hamilton, 2020 | SVM, multilayer perceptron, decision tree, random forest, decision table, and KNN | Predicted the satisfaction of the students in aspects of course outcome, professional outcome, course objective, and how to all learning things connect to the real world | Will add the more aspects for predicting the satisfaction of the students like teaching method, teacher knowledge related to subject, text books, syllabus, etc. |
| 16 | | Ahajjam Tarika, Haidar Aissab, F. Yousef, 2021 | Regression algorithm, decision tree, and random forest algorithm | Advised the students to take the preference of the subject by performance of first year and aptitude test and how will future grow with subject preference after bachelors and predicted the grades after deciding the subject | This model made for Moroccan students so after doing the some changes in the existing model and will work for Indian students |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|----------|---|--|---|---|
| 17 | | J. Dhillan, N. Vijayalakshmi, S. Suriya, Arockiya Christopher, 2021 | Binomial logical regression, decision tree, and entropy and KNN classifier | Students recognize the final grade and improve their academic performance | More attributes will add to the database for improving the accuracy of the result |
| 18 | Feedback | D. Shrivastava, S. Kesarwani, A. K. Kadam, A. Chhibber, N. kumar J. kumar, 2017 | General sentiment analysis algorithm, multi-use sentiment analysis algorithm | This system calculates the overall feedback example course, subject teacher related and reduce the time and paper work | After modify the system. It will use in the hotels, hospitals, etc. |
| 19 | | Rajvee Patel, Omkar Agrawal, Yash Gangani, Ashish Vishwakarma, 2018 | HTML, CSS, j Query, My SQL, | Evaluated the feedback online to reduce the manpower and paperwork | Adding the module of student feedback in existing system |
| 20 | | R. R. Kamble, V. V. Patil, P. R. Bhujange, P. M. Kolawale, N. A. Kamble, 2019 | HTML, CSS, j Query, My SQL, Ajax with Xampp server, php | Through this module student easily modify the feedback anytime and faculty see his/her past feedbacks easily | Develop more modules for making feedback process easy |
| 21 | | B. T. Agricola, F. J. Prins, and D. M. A. Sluijsmans, 2020 | ANOVA F-ratios, MSLQ, FAPQ | In this research, researcher studied that verbal feedback is more accurate than the written feedback because it does not create misunderstandings | Will trained the students how to fill the properly feedback form |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|------------------------------|---|---|--|---|
| 22 | Subjective answer evaluation | S. M. Patil, S. Patil, 2017 | NLP | Developer identify the important keyword, sentences in the answer and gave the weight according to the presence and then compare to the users answer and give the score according to the weight | Rebuild system will give the report to the students that how their answer will evaluate |
| 23 | | P. Patil, S. Patil, V. Miniyar, A. Bandal, 2018 | Nave Bayes, cosine similarity, machine learning | In this model, scanned sheet of answer has been taking and then tokenize the answer in to words and sentences and the match to already given answer on the basis of grammar, keywords, cosine similarity, etc., and gave the appropriate grade | Some add-ons done on the system that will give the more accurate result |
| 24 | | Sakshi Berad, Pratiksha Jaybhaye, Sakshi Jawale, 2019 | Natural language processing | In this admin insert a question and related answer and machine compared the user answer to the machine answer word by word and gave the marks according the answer | Develop the system for giving the marks to new words and sentences |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|---------------------|---|--|--|--|
| 25 | | R. S. Victoria D, V. G. Vinitha P, Sathya R, 2020 | Optical character recognition, natural language processing, machine learning | In this model, handwritten answer extracted by OCR and then comparison done by the given answer that give the result on basis of sentence length, keyword match, and usage of words | Upgrade the software for evaluating the digits, broken characters, and images in the subjective answer |
| 26 | | Vineet Sanjeev Khalkho, Shoyab Malik. S. K, S. Rama, 2021 | NLP, regular expression, cosine factor, TF-IDF | In this system, developer converts the question and related answer in to regular expression and then generate the cosine factor and then same method done in user answer and then both results measure by the TF-IDF for accurate result | A system in which electronic invigilator and student help module will construct |
| 27 | | A. Girkar, M. khambayat, A. Waghmare, S. Chaudhary, 2021 | Natural language processing, Naive Bayes, decision tree classification | Evaluate the subjective answer by comparing the all these like keyword matching, cosine similarity, number of words and line in answer, cosine similarity, etc., to the faculty answer, i.e. given in the starting | Modify the system for giving the more accurate result |
| 28 | Posture recognition | J. Redmon, A. Farhadi | YOLOv3 | In this user add the more attributes in YOLOv3 to clearing the computer vision more clearly | Doing the more research for clear computer vision |

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| S. No. | Type | Author name and published year | Methodology | Key findings | Gap analysis |
|--------|------|---|--|---|---|
| 29 | | Quang Trung, Nguyen, Hoang Tieu Binh, The Duy, Bui, Phuong Dung, N. T, 2019 | VGG16 AND VGG 19, adaptive learning | Through the postures and gestures of the student, the students were taking interest in class material and methodology or not. It helped the teacher to give a lecture more attractive to the learners | Developing the more modules of adaptive training system |
| 30 | | Y. Zhang, T. Zhu, H. Ning, Z. Liu, 2021 | SVM, high-resolution network, S&E networks | Recognizing the students was attentive in the class or not through the different poses. In this student pose was compare to the already stored poses of database. This model accuracy is 90.1% | Rebuild the recognition algorithm for adding new poses at different time and environments |

5 Algorithms Used for Student Performance Prediction

Various classification and clustering algorithms have been used in student performance prediction like KNN, SVM, neural network, machine learning, binomial regression, random forest, Naive Bayes, multilayer perceptron, and Apriori algorithm.

- The decision tree is a simple and easy algorithm for large and small database sets. Its reasoning process has very easy to use, and it can be immediately transform in decision rules (if-else). Many researchers used a decision tree algorithm for prediction and some users got the best result. The paper used a decision tree and got the best prediction [6, 7, 12, 16, 17].
- A Naive Bayes algorithm is a collection of classification algorithms in one place. It has labelled training data sets for developing the database tables. The paper used Naive Bayes and got the best prediction [5, 6, 9, 10, 14].

- Support vector machine (SVM) acquires database and characterizes the hyper-plane into two classes. The paper used SVM and got the best prediction [8, 11, 18].
- Neural networks have interconnected nodes. Input nodes take the input, middle layers process the input, and the output layer produces the result. The papers got the best prediction [4, 7, 13].
- Binomial regression is similar to binary regression response that comes from either success or failure. The papers got the best prediction [15, 19].
- Random forest is also a good prediction algorithm [20] that gave the best prediction result.

6 Other Areas

Faculty and student feedback is more important area in 2020, and Bas T. Agricola, Frans J. Prins, and Dominique M. A. Sluijsmans studied verbal feedback is more accurate than the subjective and multiple choice feedback (30). Through subjective answer evaluation calculates the accurate performance of students. In 2021, A. Girkar et al. developed the system using natural processing language that gave the accurate marks to the students in subjective answers [21]. Posture recognition recognizes that student is attentive or not in classroom and helps in invigilation. In 2021, author Yiwen Zhang et al. recognize the student gesture in classroom and analysed student is attentive in classroom or not [22].

7 Summary

All researchers have researched educational data mining that is very useful in the new era. Prediction through data mining has a vast area in the computer science field. Through this research, researchers made predictions on students' performance, results, feedback, poses, grade, career, and provide satisfaction related to course selection, job selection, and business selection. Finding out various sets like the weak students, students who are comfortable/uncomfortable with class timetables, class timings, students who have completed their graduation or not. Studied different types of attributes that are helpful in prediction like status, father occupation, previous results, attendance, interest in the subject, related family member's education, and other information. Through posture recognition, whether a student is interested in a lecture or not and feedback is a more important part for teachers that help in teacher self-improvement in various fields. In overall review process, Naive Bayes and decision tree gave the best result.

8 Future Scope

In education, everything relates to another thing like the result is dependent on the acquisitive power of student, interest area depends on how the subject and expertise on it that only come when the student learns the subjects taking the interest, placement depends on the result, good feedback depends on the teaching methodology, course objective, and the result and last but not the least, college ranking depends on the student result, placement, and the feedback. Now the challenge is improve and calculate the performance of college on the basis of improve the performance of weak students, to prepare the students for interview, aware the parents about placement, feedback, compute the college performance, and complete data analysis. Everyone related to institute will do the progress (management, student, teacher, attendants, and parents).

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