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Exploring Sentiment in Educational Tweets: Harnessing NLP and Wordnet for Deeper Insights

[1]Dr. Angeline Prasanna G., [2]Shilpa Krishna

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Abstract: In order to illustrate how online educational services are offered, this article makes use of service blueprint technology. This diagram displays the online learning platform's internal service process, the customer contact point, and the service's user-facing components. Using this top-down approach when defining services helps to minimize difficulties connected with transience. We suggested combining NLP with WORDNET to do sentiment analysis on educational tweets. The dataset was normalized using Natural Language Processing (NLP) and WORDNET POS tagging. In addition, the Principal Component Analysis approach was used for Feature Reduction. During Ensemble Feature Selection, elastic net, recursive feature, and hybrid machine learning (decision tree (DT) and random forest (RF)) were used. Finally, as ML classification algorithms, Linear Support Vector Machine (SVM), Gaussian Naive Bayes (GNB), and Linear Regression (LR) were used. The experimental findings with various performance indicators have been shown.

Keywords*: Ensemble Feature selection, POS, Sentiment Analysis, Education, NLP, WORDNET*

1. Introduction

Humans gain greatly from the rapid growth of computer and system technology in the sectors of education, employment, and lifestyle [1-3]. As a result of the expansion and improvement of hardware in educational and training institutions, the establishment of multimedia classrooms and grounds organized by educational organizations, the development of web technology, and the prevalence of computer help instruction, the methods for evaluating the quality of teaching and demonstrating, as well as assessing students' learning and recognizing their abilities, have undergone significant shifts [4-7]. Online assessments have lately become the standard as a traditional way of evaluation [8].

An online examination and education system is capable of creating a test, monitoring and recording the student's actions while answering questions, grading the test, analyzing the student's grade, and publishing notes and assignments [9-13]. As a result, the strain on lecturers and instructors will be lessened, and the test's validity and reliability will be assured. The cost of developing tests will naturally decrease as a result of this development, but the efficiency with which examinations are conducted will increase [14-17].

The approach for taking an exam online differs from that of taking a conventional examination. The conventional test requires each student to print a copy, but the online approach just requires the question to be put into the system [18-23]. Following that, the technology will automatically produce the student's test questions. Each student's questions are chosen at random [24].

This initiative will address the issue of paper consumption in educational institutions such as colleges and schools. The world's forests are being chopped down at an alarming pace, perhaps leading to the extinction of certain species and the destruction of natural ecosystems. Our goal is to complete this project with an online education and evaluation system that is both more successful than the present system and more user-friendly for today's students. [25-30].

The primary contributions and objectives of this manuscript may be summarized as follows

- Pre-processing (POS tagging with NLP and WORDNET)
- Feature reduction using principal component analysis
- Ensemble feature selection using elastic net, recursive feature and hybrid machine learning classifier (decision tree and random forest)
- Classification has done with Linear SVM, Gaussian naive bayes and Linear regression

The remaining sections of this work are laid out as follows. In Part 2, we looked at recent studies pertaining to Online Learning. The proposed model is shown in Section 3. The investigation's findings and conclusions are summarized in Section 4. The results and next steps are discussed in Section 5.

[1]*Former Associate Professor and Head Department of Computer Science, AJK College of Arts and Science, Coimbatore- 641 105.*
[2]*Research Scholer Department of Computer Science AJK College of Arts and Science, Coimbatore-641 105*
shilpakrishna93@gmail.com

2. Background Study

K. Cotero et al. [3] These authors understand the value of maintaining consistent writing habits. During the second school cycle of the author, face-to-face classes had to be taught virtually, with the use of Information and Communication Technologies (ICT) implemented as the only means of contact between teachers and students, so that the teaching-learning process could continue with as little disruption as possible due to the author's health.

D. Edy et al. [6] These writers' research added to our knowledge of remote learning. At each level of the online classroom experience, teachers must be aware of what motivates their students. However, due to a lack of instructor-student contact, it was impossible to assess students' levels of involvement with online courses. It is critical for educators to use strategies that encourage self-reflection in their pupils, and one such technique is to assign a learning project. The information gathered might assist instructors in identifying and implementing a number of approaches for grabbing and sustaining students' attention.

Gao, H. [7] Due to increased social competitive pressure, there has been an increase in demand for high-quality educational materials among parents and students in recent years. K-12 online education in China began early and has grown rapidly in the technological environment as a result of the government's strong support and the rapid spread of Internet technology. Distance learning supplemented and improved on more traditional ways of education. The Chinese K-12 online education sector's varied kinds, quantity of information, diversity of platforms, and vast size are all to its credit. Despite this, there are advantages and disadvantages to K-12 online schooling.

George-Andrei et al. [8] The resistor values were automatically calculated by the coding system. It was also possible to automatically calculate the equivalent resistance of a parallel or serial connection.

M. Perales et al. [16] The aims indicated at the start of this report should be accomplished as a result of the execution of this educational innovation project. The proposed experimental design aims to answer concerns about the positive effect of the investigated modalities on student learning as well as the financial sustainability of the different investigated techniques.

G. Shadmanova et al. [19] The development of massive open online courses (MOOCs) in higher education introduces new challenges as well as intriguing opportunities for enhancing the state of the art in teaching and learning. It became evident that the changes brought about by the usage of open online courses would go well beyond the simple replacement of the instructor's audit burden, and this was true regardless of how online courses were employed.

Y. Sun et al. [20] These authors describe a Web-based remote learning system. Techniques for recording and replaying web-based operations enable the presentation of dynamic information and real-time interactions, boosting the platform's intelligence and allowing students to get instruction when it is most convenient for them. Some minor difficulties persist in the enabling environment of the Office of Special Education Programs (OSEP), an approachable online education platform. However,

K. K. F. Yuen and A. O. M. Wong [29] Many techniques of online education may be used to provide a course to fit the diverse demands of students. This paper investigates the benefits and drawbacks of online education and proposes a strategy for creating an effective online learning environment.

3. Materials and Methods

The sentiment analysis on educational tweets on dataset was gathered from the Kaggle data repository, which included two datasets. The datasets are pre-processed using NLP and WORDNET POS tagging. The best features were retrieved using the ensemble feature selection approach, and the ML system identified the real label and anticipated label information.

3.1 DATASET COLLECTION

The datasets are collected from https://www.kaggle.com/datasets/sujaradha/online-education-system-review and https://www.kaggle.com/datasets/septa97/100k-courseras-course-reviews-dataset?select=reviews_by_course.csv. The two datasets are combined and moved to the preprocessing stage.

3.2 PRE-PROCESSING

The dataset has numerous characteristics, one of which is used for preprocessing in sentiment analysis. To extract the POS-tags, we need to perform morphological analysis and disambiguation of idiomatic phrases. After calculating the POS-tags, we employed n-grams to determine the most likely POS sequences. This was done so we could determine the best POS-tag sequence for each poem. For example, in the tiny stanza corpus, the sequence "NN-NN-JJ-VB" is valid as a POS tag.

Natural language processing (NLP) is a computer approach for naturally analyzing and describing text in one or more levels of linguistic analysis, with the ultimate goal of gaining the capacity to comprehend the meaning of a phrase as humans do, for a variety of

activities and applications. Natural language processing offers essential tools in the form of theory and software for a variety of businesses.

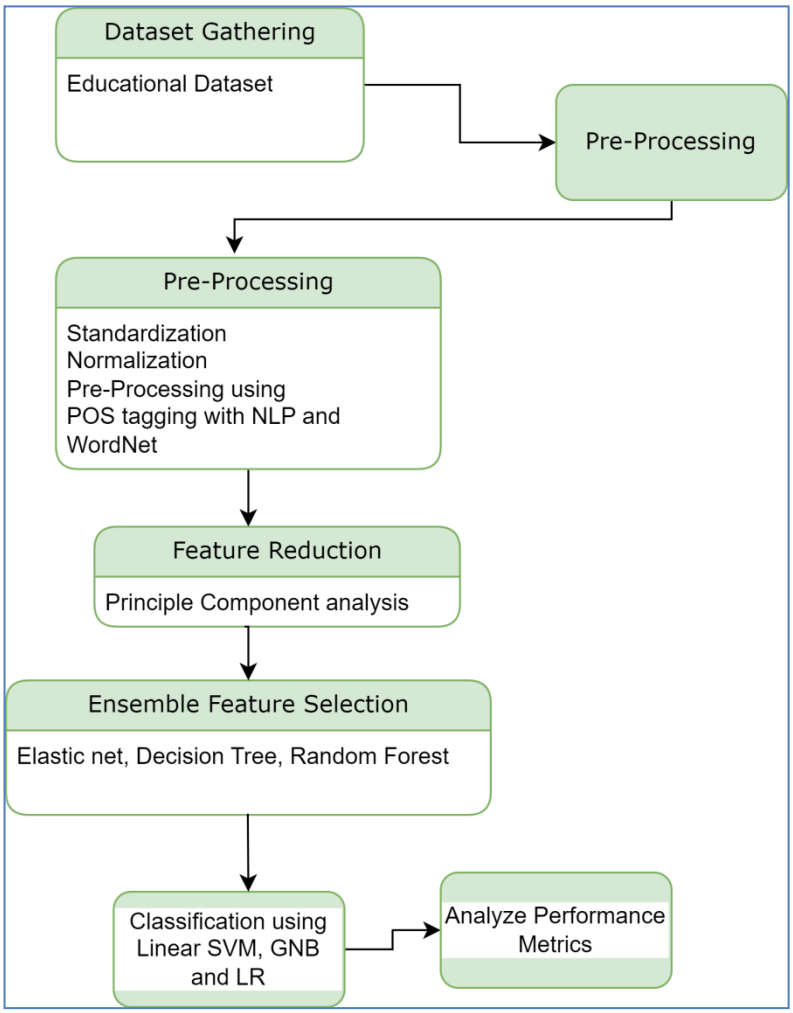


Fig 1: Proposed System Architecture

People began to take notice of WordNet in 1985. Princeton's psychology and linguistics departments collaborated to improve on the "Lexical Database" idea. This notion is described using many phrases such as electronic dictionary, semantic network, and so on. "WordNet" was created to capitalize on the benefits of both dictionaries and thesauruses. The core concept of WordNet is based on the premise of categorizing words based on their meanings. Nouns, verbs, adjectives, and adverbs are the four core meaning categories for the most common English words. Another driving reason behind the development of this technology is to make automated text analysis and artificial intelligence programs more accessible. "WordNet" may therefore be utilized by both people and robots. One advantage is that WordNet may be accessed from any location with an internet connection. WordNet categorizes words according to their meaning as nouns, verbs, adjectives, adverbs, or function words. This is what distinguishes it from the typical dictionary. WordNet includes only parts of speech that may be used as nouns, verbs, adjectives, or adverbs. WordNet is affiliated with various organizations, including:

3.3 Feature Reduction Using Principle Component Analysis

Five-layer autoassociative networks are used to build neural network approximators for basic surfaces. Outside of Hastie and Stuetzle's investigation, other scholars have constructed equivalent networks for nonlinear dimension reduction. The first (input) and fifth (output) layers of such networks are linear, whereas the nodes in the second (hidden) and fourth (exposed) layers are sigmoidally nonlinear. We may define n as the combined size of the input and output layers. A third layer with a width of m n stores the dimension-reduced representation. The term "representation layer" will be used to describe this level. In the representation layer, several research have attempted to employ either a linear or sigmoidal response function. In this example, we are just concerned with the linear response in the representation layer. To avoid the bottleneck in the intermediate layer, networks are often trained to offer a

dimensionality-reduced representation of the data by minimizing the mean squared distance between input and output. Five-layer neural networks may be conceived of as approximators of main surfaces when trained using the mean square error (MSE) criterion, as shown by Hastie and Stuetzle's critical point theorem. 2 Hecht-Nielsen (1995) has recently expanded the use of five-layer autoassociators to encoding, which was previously employed primarily for dimension reduction. The staircase nonlinearity may be noticed in his replicator networks' third layer. When the middle-layer activity is quantized in infinitely steep increments, the input signal is discretely encoded.

3.4 Ensemble Feature Selection

3.4.1 Decision Tree

A tried-and-true strategy that acts as a framework is often used to generate decision trees. ID3 evaluates the splitting function using information gain, which is derived from the concept of information entropy. The degree of disorder in a thermodynamic system may be defined by computing its entropy, a physical quantity. We may use this tool to quantify the degree of uncertainty in our data analysis. The entropy of the information inside a system lowers as more order is added into it.

A more disordered system, on the other hand, would have a greater entropy. In this context, information entropy may be used as a quantitative measure of a system's organization. The dataset s contains n observations that have been uniformly distributed among m categories. The total number of samples in group i is given by ni. The information entropy required to successfully categorize n samples into m categories is

$$S(q) = \sum_{i=1}^{m} P_i \log_2 p_i, \text{ ------ (1)}$$

Pi = ni / n gives the likelihood that every data point in sample s belongs to class Ci. If the splitting attribute is specified, the sample is divided into subsets based on the values of property A. We calculate the entropy of the data used to partition the samples for each group.

$$S(D_j) = \sum_{i=1}^{m} P_i \log_2 P_i, \text{------- (2)}$$

where Dj is a subset of the values in D and pi is the probability that a random selection from Dj falls into class Ci. Ds a result, feature D, the minimum entropy of information necessary to identify all samples, is

$$S(D) = \sum_{v=1}^{v} \frac{sv}{s} S(D_j), \text{------- (3)}$$

The importance of an attribute value is indicated by the ratio of qv to q, where qv is the number of samples contained within the subset of unique attribute values and q is the total number of samples. As a result, data has become

$$\text{gain} = S(q) - S(D) \text{-------- (4)}$$

When ID3 must choose between two split features, it employs a gain-based criteria. Previous research has shown that the character with the highest attribute values also learns the most. More attribute values do not necessarily indicate a higher quality decision tree.

3.4.2 Random forest

The Random Forest algorithm is based on the convergence theorem, generalized error, and out-of-the-box estimates. The random forest formula is as follows:

$$\{h(X, \emptyset_k), k = 1,2, \dots, K\} \text{ --------- (5)}$$

The set of features of the sample conditions (represented by X), the baseline classifier parameter (represented by k), and the sample size (represented by s):

$$T = \{(x_i, y_i), x_i \in X, y_i \in Y, i = 1,2, \dots, N\} \text{ --------- (6)}$$

A collection of M-dimensional attribute vectors is denoted by X, whereas Y is the determining factor.

Random forest generalization mistakes are as follows:

$$PE^{*^{def}} = P_{x,y}(av_k I(h(X, \emptyset_k) = Y) \text{-------- (7)}$$

$$-\max_{j=y} av_k I(h(X, \emptyset_k) = j) < 0) \text{--------- (8)}$$

It quantifies how wrong a random forest is in classifying a specific dataset. The following convergence theorem existed during the period K — :

$$PE^* \xrightarrow{a.s,} P_{X,Y}(P_o(I(h(X, \emptyset) = j) < 0) \text{ -------- (9)}$$

$$-\max_{j=y} P_o(h(X, \emptyset) = j) < 0) \text{-------- (10)}$$

The generalised error limits of random forests are obtained by combining Hoeffding's inequality and Chebyshev's inequality with equation (11):

$$PE^* \leq \frac{p(1-s^2)}{s^2} \text{-------- (12)}$$

Where s is the basic classifier's accuracy and p is the correlation between the two.

3.4.3 Elastic net

To be precise, we are discussing the R package glmnet, which provides an elastic net penalty method for fitting generalized linear models. Each gene's expression value is normalized to zero before being uploaded to glmnet. After that, we turn off the standardize feature of Glmnet. The intercept option of glmnet may be set to true if the distribution of classes (for example, cancer types) in the training set is similar to the expected distribution in the testing set (that is, if they are an accurate prior). The genes might be paired with other factors if necessary.

Categorical variables known as "dummy variables" may be used. In order to make the mean and standard deviation of continuous variables agree with gene expression data, it is recommended to scale them. During training, the classifier gives equal weight to all of the data.

For the elastic net, 'loss + penalty' is the objective function:

$$\min_{\beta 0,\beta} \frac{1}{N}\sum_{i=1}^{N} w_i l(y_i, \beta_o + \beta^T x_i) + \gamma\left(\frac{(1-\alpha)||\beta||2}{2} + \alpha\left|\left|\beta\right|\right|1\right)$$

---- (13)

The value of observation is denoted by the symbol wi. The contribution to the negative logarithm of the probability for making an observation is denoted by the symbol I l(y,). Regularization parameter (which sets the level of shrinkage), Elastic net penalty (which sets the relative weights of ridge and lasso regression), L2-norm of, and t are model-specific functions I (the functional form of l). Because of the weight that each element carries,

$$\sum_{i=1}^{N} w_i = N \text{ ------ (14)}$$

$$w_i = \frac{M}{n_i}, \text{ ------- (15)}$$

where ni is the total number of records in the batch of which i is a part.

3.5 ML Classification

3.5.1 LINEAR SVM

One new Linear SVM training approach, known as the modified Newton l2-SVM methodology [8] (l2-SVM-MFN), shines on sparse datasets with multiple occurrences and perhaps many features. In the following SVM optimization problem, where the input patterns xi 2 Rd (for example, documents) and the labels yi 2 +1,1 are given, l2-SVM-MFN gives an effective primal solution:

$$w^* = \arg\min_{w \in R^d} \frac{1}{2}\sum_{i=1}^{l} l_2(y, w^T x_i) + \frac{\gamma}{2}||W||^2 \text{ ------ (16)}$$

An updated version of Newton's l2-SVM technique [8] For sparse datasets that include many instances but not many features, a novel training technique called (l2-SVM- MFN) has been developed. The following is an example of an SVM optimization issue for which l2-SVM-MFN gives a fast primary solution: Assuming that the input patterns xi are Rd (documents, for instance) and the labels yi are +1,1, the best primary solution is l2-SVM-MFN for a problem with l labelled samples xi, yil i=1.

3.5.2 GNB method

We demonstrated that the NB Method is only applicable to discrete or multinomial data. We employed a number of discretization procedures in the first phase to set the scene for the Naive Bayes approach in the second phase. As a consequence, several methods for applying the NB Method to continuous data have arisen. This technique, however, may have an effect on the NB method's classification bias and variance. Another approach is to use a Gaussian distribution for X and extrapolate its parameters using D (the mean vector and covariance matrix). It is feasible to lower the processing cost of equation (2) by using certain mathematical simplifications:

$$\log[P(w_i|X_1, X_2, \ldots, X_n)] = \log\left[\left(\frac{1}{S}\right) p(w_i) \prod k = 1 P(X_k \backslash w_i)\right] = \log\left(\frac{1}{S}\right) + \log p(w_i) + \sum k = 1 \log[P(X_k \backslash w_i)] \text{ ----- (17)}$$

3.5.3 Linear Regression

The universal set encompassing basic (two-variable) regression and multiple regression as complementary subsets, the generic single-equation linear regression model, may be expressed as

$$Y = a + \sum_{i=1}^{k} b_i x_i + u \text{ ------- (18)}$$

where Y is the response variable, $x_1, x_2, x_i, \ldots, x_k$ are the k independent variables, a and bi are regression coefficients representing the model parameters for a particular population, and u is a stochastic disturbance-term that can be interpreted as the effect of unspecified independent variables and/or a totally random element in the relationship specified.

4. Results and Discussion

The proposed model has implemented by using python programming language.

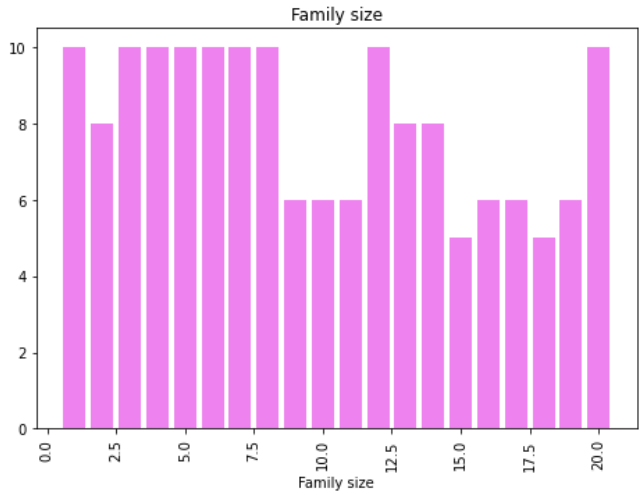


Fig 2: family size

The progression of students participating in online education is seen in figure 2.

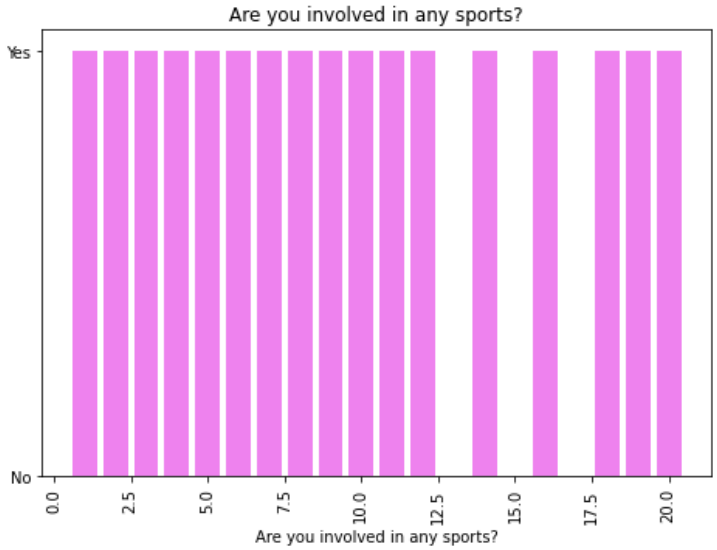


Fig 3: are you involved in any sports

Any students that take part in extracurricular athletic activities are shown in Figure 3.

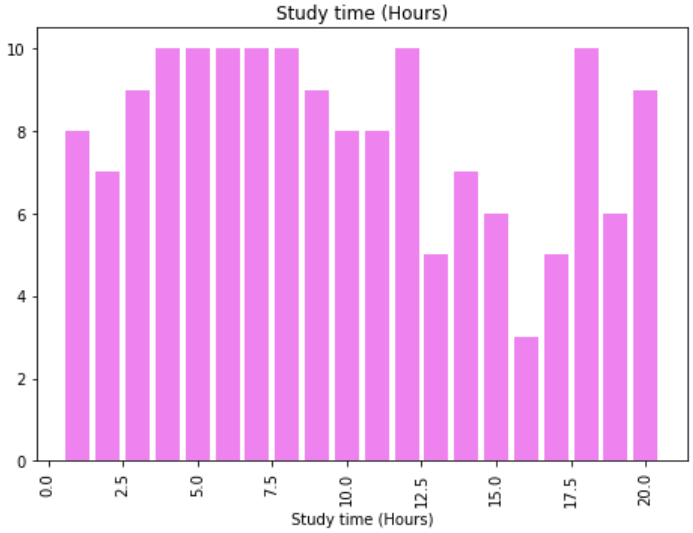


Fig 4 student study time

The findings of the amount of time that students spend participating in extracurricular activities are shown in Figure 4.

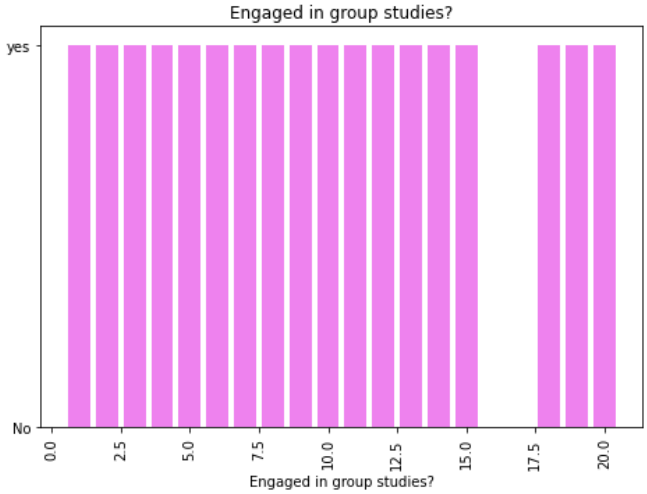


Fig 5 engaged in group studies

The pupils seen in Figure 5 are engaged in a group learning activity.

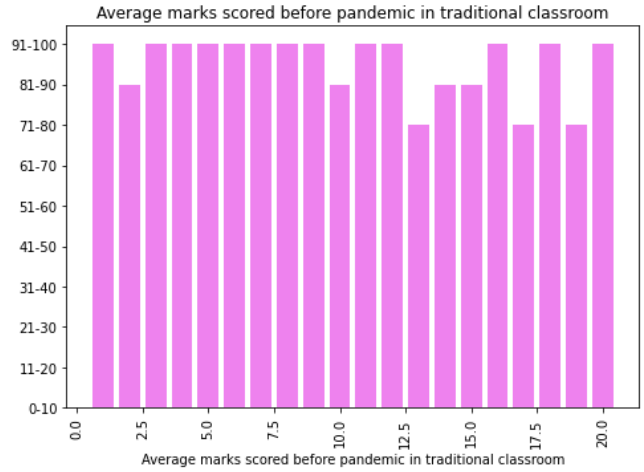


Fig 6 average marks scored before pandemic in traditional classrom

The pupils' overall performance in normal courses before to the outbreak is shown in Figure 6, which includes their average marks.

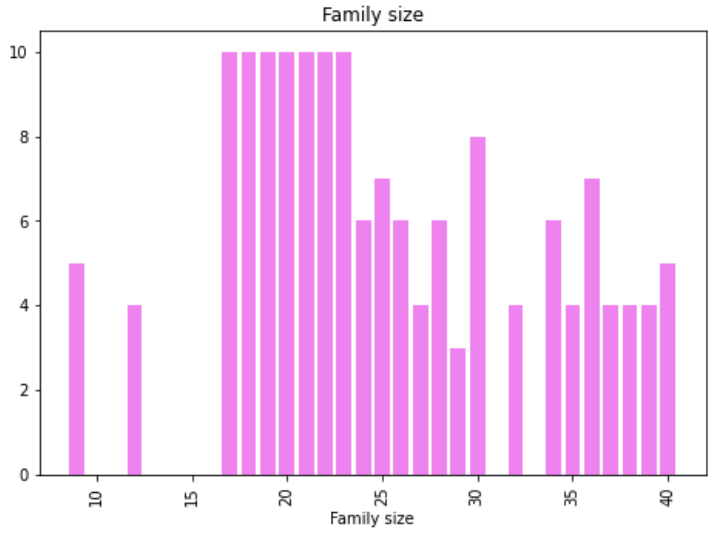


Fig 7 family size

The number of students that are currently enrolled in online courses is shown in Figure 7.

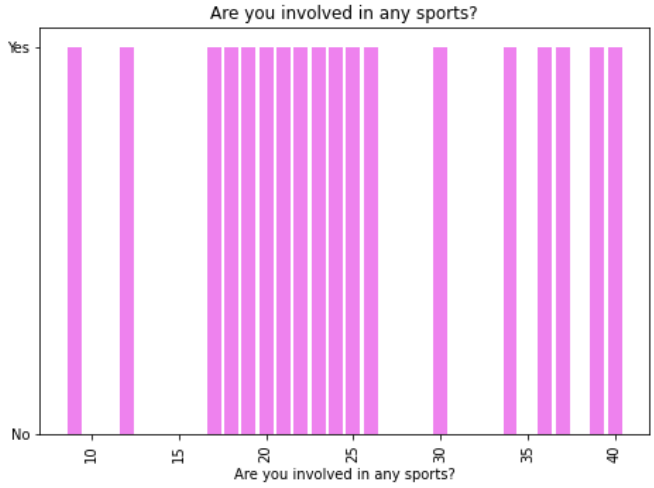


Fig 8 students involved in any sports

As seen by the figure 8, students take part in a broad variety of different sporting events.

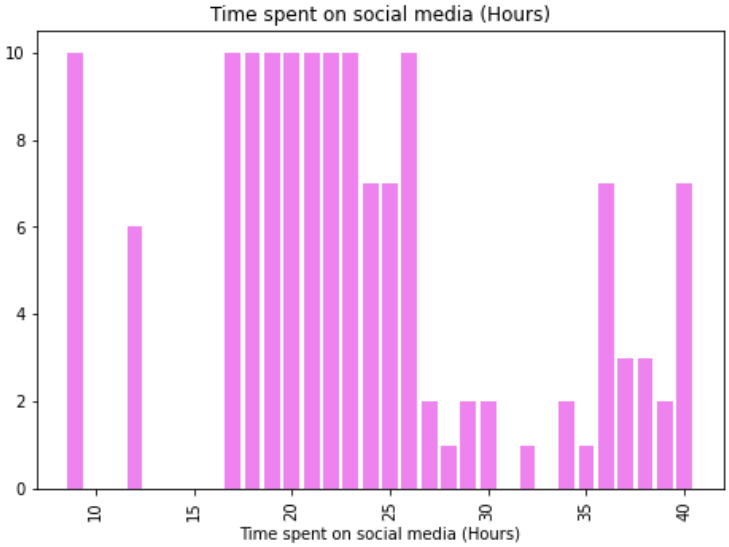


Fig 9 time spent on social media

The usage of social media by students is seen in Figure 9.

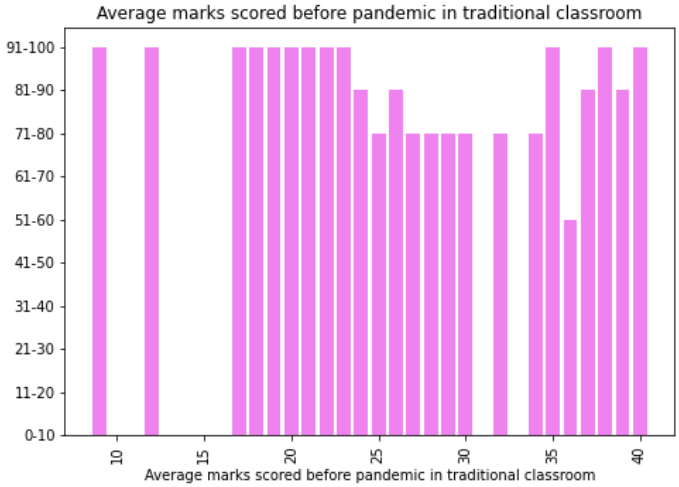


Fig 10 average marks scored before pandemic in traditional classroom

The typical grades that students in normal schools were able to get before to the outbreak are shown in Figure 10.

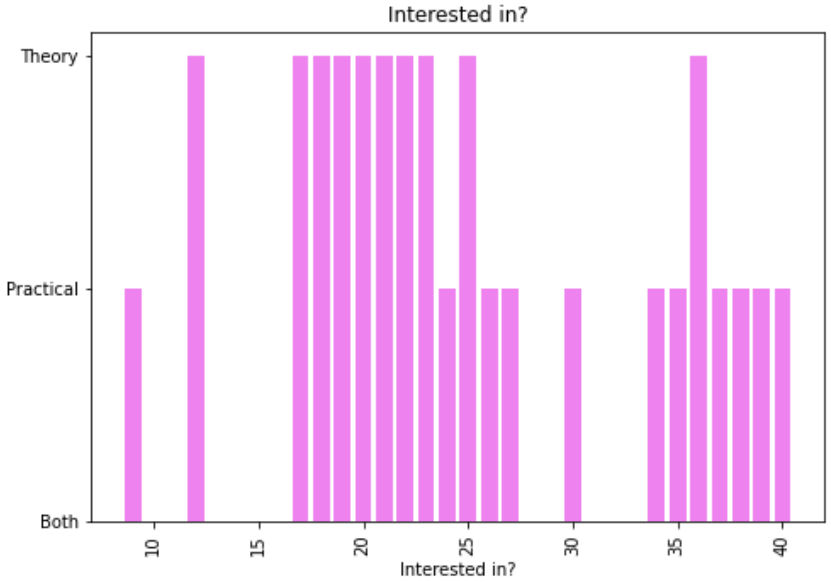


Fig 11 interested category

The level of engagement shown in Figure 11 indicates whether students are more interested in theory or practical.

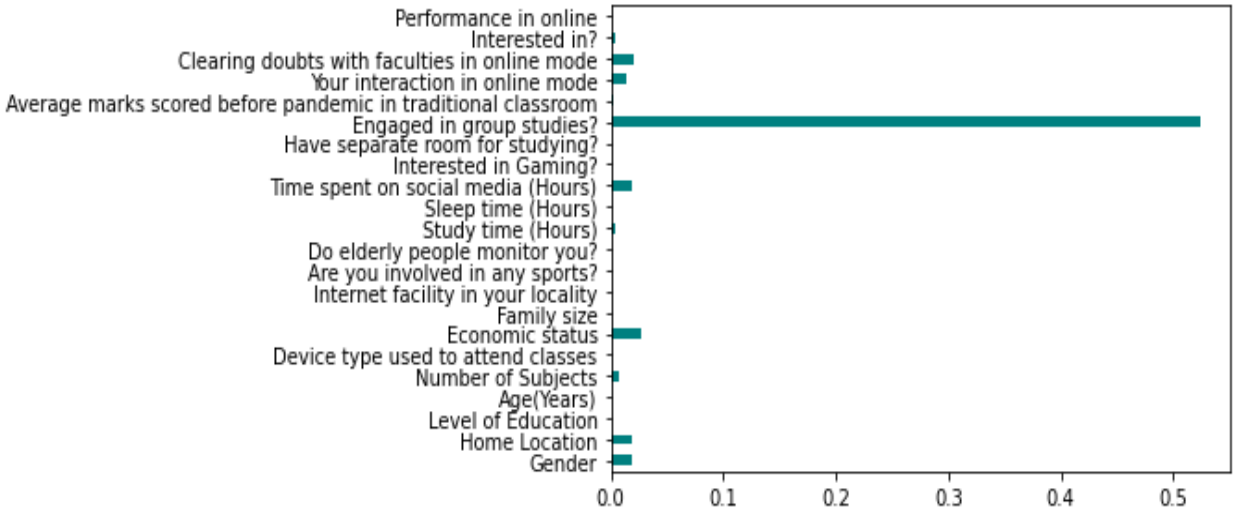
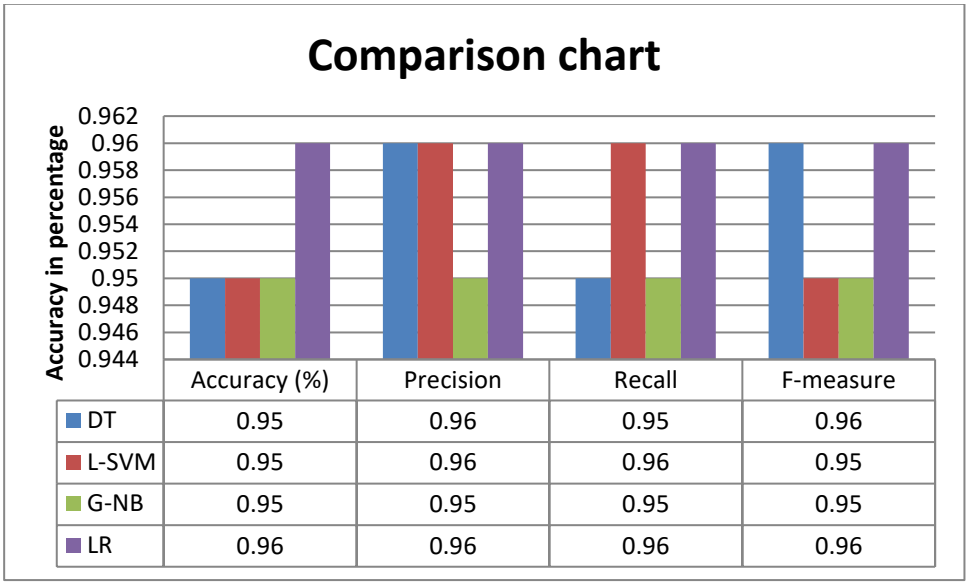


Fig 12: Feature importance

The list of attributes has invoked with ensemble feature section is shown in figure 12. Overall feature high importance is engaged in group studies.

Table 1: Classification performance metrics

Model	Accuracy (%)	Precision	Recall	F-measure
DT	95	96	95	96
L-SVM	0.95	0.96	0.96	0.95
G-NB	0.95	0.95	0.95	0.95
LR	0.96	0.96	0.96	0.96



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G-NB	0.95	0.95	0.95	0.95
LR	0.96	0.96	0.96	0.96

Fig 13: Classification performance metrics

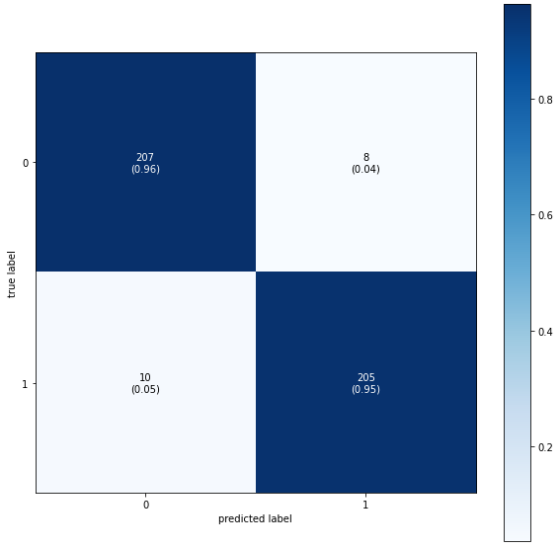

Fig 14: SVM Confusion matrix

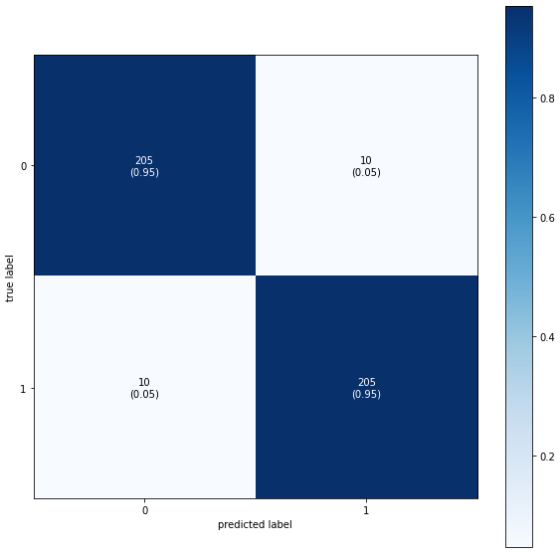

Fig 15: Gaussian Naïve Bayes Confusion matrix

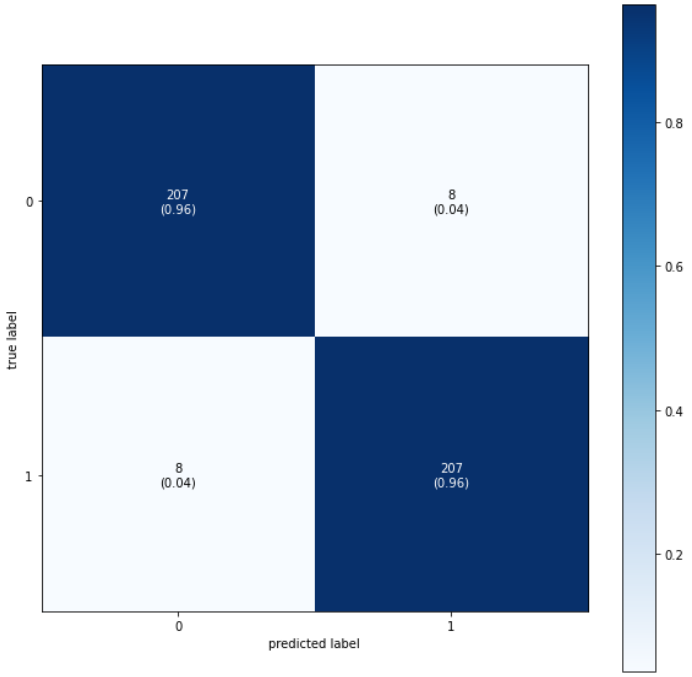

Fig 16: LR Confusion matrix

5. Conclusion

This research offered sentiment analysis on a collection of educational tweets. There are certain noises in any dataset, thus our suggested model has produced a novel framework for reducing noise using POS tagging and NLP with WordNet. Ensemble feature selection is used to extract the best features, while PCA is used to reduce the number of features. Finally, classification was completed using ML Classification techniques. The total accuracy of the LR algorithm is 96%. Several methods will be utilized to assess the quality model's various elements, such as an audit of the management system, an analysis of hidden consumer feedback, and expert opinion. The examination of numerous deep learning models will be prioritized in the future.

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