A New Methodology for Predicting Teachers' Job Satisfaction Using Machine Learning Approaches - Bangladesh Perspective

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Abstract

Shortage of qualified teachers and higher turnover rates have far-reaching negative effects on students' achievement and overall educational quality. Since satisfied teachers are less likely to quit their jobs and are more likely to deliver high-quality teaching, scholars around the world are trying to better understand the factors that predict teachers' job satisfaction. However, relatively little research employing machine learning (ML) techniques for detecting teachers' job satisfaction has been reported, particularly in developing countries like Bangladesh. Despite having a far-reaching effect on teaching quality which eventually impacts on education, there is a little work done in this regard in Bangladesh, specially in primary and secondary education sector. To bridge this gap, the present study has introduced a machine learning-based expert system framework for predicting teachers' job satisfaction. Data was gathered from 297 teachers of 56 different primary and secondary schools in Bangladesh. Missing values were imputed using multiple imputation techniques and feature selection techniques were adopted to find out the key affecting factors. To find the optimal model, ten supervised machine learning classifiers (Decision Trees, Support Vector Machines, Logistic Regression, K-nearest Neighbors, Random Forests, Gaussian Naive Bayes, Gradient Boosting, AdaBoost, Multi-layer Perceptron, and Quadratic Discriminant Analysis) were trained and tested using five-fold cross-validation. The performance of the classifiers was evaluated using multiple evaluation metrics including confusion matrix, accuracy, precision, recall, F1 score, and roc curve analysis. Findings revealed that Random Forest outperforms the other classifiers with 94% accuracy. The proposed framework is expected to assist the devolved authorities in implementing synchronized policies to improve teachers' job satisfaction and curve turnover rates.

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Chapter 1

Introduction

1.1. Introduction

Education is the building block of a nation. A nation's growth and development depend mostly on the quality of its education. To ensure good quality education we need to focus on teachers' quality, as teachers are one of the vital stakeholders of educational systems. Teachers are the tools that help students to learn and develop. A skilled teacher can help us to develop skilled and educated people, which will lead to a skilled nation. A key factor to teachers' quality performance is teachers' job satisfaction. Job satisfaction culminates in employee's life satisfaction, teachers are no exception. If the teachers are not satisfied with their jobs, they tend to switch careers [1]. So, factors affecting teachers' job satisfaction need to be determined. The factors that impact teachers' job satisfaction, were primarily found through literature review. A good working environment, independent working facility, good educational policy, and good administration are the primary factors [2, 3, 4, 5, 6]. Salary, other financial benefits, social rank, and career growth are the secondary factors that influence teachers' job satisfaction [2, 3, 4, 5]. Also, some personal factors (i.e., gender, age, marital status, health, teaching experience, academic qualifications, etc.) and student-related factors (i.e., students with behavioral problems, classroom discipline climate, teacher-student relationship, etc.) act on teachers' job satisfaction [3, 4, 5, 7].

Most of the existing studies [8, 9, 10, 11, 12, 13, 14] mainly focused on the teachers' quality factors that impact student educational performance. Teachers' professional practice, professional commitment and quality of service are greatly impacted by teachers' job satisfaction [8, 9, 10, 11]. Also, it impacts teachers' evaluation practice and their behavior towards the students [11, 12, 13, 14]. Also, some of the literature works focused on teachers' professionalism [21, 22, 23]. It is found that most of the existing research works [2, 5, 6, 15] used different algorithms to find the correlation between the attributes. Whereas a few research works [4, 24, 25] were concerned with deterministic rule-based processes to measure teachers' job satisfaction. However, a little work was

done to categorize the factors according to their importance and determine teachers' job satisfaction employing Machine Learning Technique, specially in primary and secondary education sectors of Bangladesh. To bridge this gap, the key objectives of this study are:

1. Identifying the factors that influence the job satisfaction of primary and secondary school teachers in Bangladesh.
2. Classifying the factors in terms of their importance in predicting teachers' job satisfaction.
3. Introducing an ML-based expert system framework for predicting teachers' job satisfaction.

1.2. Motivation

During this pandemic a lot of people including teachers have lost their jobs. The most common reason is that the employers need to cut down on the staff members and which was done on the basis of poor performance. After doing the literature review it was found that most of the work done in this regard was based on rule-based system. Hence use of Machine Learning can be a exciting option in this field.

1.3. Present State of the Problem

While the existing literature was reviewed, it was found that this particular topic got less focus despite its importance. Most of the existing articles discussed about attributes that impact on teachers' job satisfaction. There is less work done particularly on finding out the most important also in determining teachers job satisfaction. There is no specific and reliable tool for determining teachers job satisfaction. Most of the work done in this regard is based on the rule-based system, while ML approach got less focus. While doing the background research it was found that in Bangladesh little work has been done in this topic. So, there is a need for a tool which is reliable and available for determining teachers job satisfaction.

1.4. Research Questions

This study focused on answering the following question regarding teachers' job satisfaction.

1. How to Determine Teachers' Job Satisfaction effectively?
2. What are the important attributes for Teachers' Job Satisfaction?

3. Which is the most optimized classifier model that can effectively predict Teachers' Job Satisfaction?

1.5. Research Outcomes

The purpose of the study is to find out the most optimized classifier model to effectively Teachers' Job Satisfaction. However, the following specific outcomes have been expected to achieve the main goal of this paper:

1. Most effective attributes to determine Teachers' Job Satisfaction.
2. Tools (Questionnaire) to determine Teachers' Job Satisfaction.
3. Optimized Predictive Machine Learning Classifier Model.
4. Publication (Submitted to a Journal for Publication).

1.6. Report Layout

We have organized the report as follows:

Chapter 2: Background and Literature Review. The root of the studied issue and the existing literature's findings were discussed related to the current studies in this chapter. To obtain the study goal, the summaries of significant, appropriate research studies were included.

Chapter 3: Research Methodology. This chapter describes the overall methodological parts of the study; this chapter demonstrated, how the study was conducted, how data was collected, pre-processed, analyzed and what statistical measures were used to acquire the purpose of the study.

Chapter 4: Result Analysis. This chapter discussed the results of the investigation.

Chapter 5: Conclusion. This chapter demonstrates the ending part of the report. References and appendices have been included at the end of the report.

Chapter 2

Background and Literature Review

2.1. Background

Education is considered as the backbone of a nation and teacher are' one vital element of an education system. Teachers are the tool that help the students to gain knowledge. Teachers have a great deal of ascendancy on the students' learning process. Teachers' quality of service greatly depends on their job satisfaction. If a teacher is satisfied with his/her job, then the quality of his/her teaching would be good. In short, a happy teacher will provide a good quality lesson and a happy classroom environment.

2.2. Literature Review

Teaching is often considered the most prominent and recognized profession in the world owing to its tremendous influence on students' achievement and overall educational quality [32]. Identifying and retaining skilled teachers has always been a vital part of worldwide teacher recruitment practices. However, the shortage of qualified teachers and higher turnover rates have become a growing concern globally. The increasing teacher turnover rate and the diminishing prestige of the teaching profession have adversely affected the overall learning outcomes. Consequently, teachers' job satisfaction, working environment, burnout syndrome, self-efficacy, motivation, performance, retention, etc. are at the forefront of today's research interest. Scholars from all across the world are working to better understand the determinants of Teachers' Job Satisfaction as satisfied teachers are more likely to offer good performance and are less likely to quit their professions such as working environment [33, 34, 35] career opportunities [33, 36, 37], school leadership [38, 39, 40], financial benefits [36], recognition [41], etc.

Generally, teachers' job satisfaction is measured by traditional rating scale-based approaches. Among them, Teacher' Job Satisfaction Scale (TJJS-9) [42] is an often-cited questionnaire aimed at empirical tools, precisely developed to use in educational contexts.

The three primary components of TJSS-9 are satisfaction with coworkers (3 items), contentment with parents (3 items), and satisfaction with students' behavior (3 items). Similarly, Teaching Satisfaction Scale (TSS) [43] is another five-item based global measure of teaching satisfaction designed based on Life Satisfaction Scale (LSS).

While reviewing the work done in Bangladesh perspective different methodologies were used to determine teacher' job satisfaction. Brayfield-Rothe method which uses 5-points Likert-scale for measurement of the attributes has been used by some of the research works [51, 52]. Another research work [53] used motivation theory to determine teacher' job satisfaction. Despite the presence of multiple scales, no substantial structural modifications have been identified. All of these scales are primarily psychometric measures of behavioral attitudes in which teachers indicate their agreement, or disagreement with a set of statements (items) and then aggregate all of the values where high scores indicate high satisfaction. The main drawback of all existing tools is that the factors are all deemed equally significant in assessing teachers' job satisfaction. However, practically, each factor does not play an equal role in determining satisfaction [44]. Here, in table 2.1, the summary of some of the important previous studies are presented:

Table 2.1 Summary of Previous Works

Ref No.	Data Type	Research Methodology	Research Area	Key Findings
[01]	Primary	Quantitative Research	Assessment of the Impact of Teacher Job Satisfaction Among Teachers	If the teachers are not satisfied with their jobs, they tend to switch careers.
[02]	Primary + Secondary	Survey research	Relationships between factors that usually tend to have contribution in motivating the teachers in terms of their job satisfaction and job performance	Discovered a few elements that frequently contribute to teachers' motivation in terms of their job satisfaction and performance.
[03]	Secondary	Literature review, Survey	Factors that Contribute to Teacher Job Satisfaction	Teachers' job satisfaction relies on 3 main factors: Student Factors, Teacher Characteristic Factors, and School factors. All these factors have sub factors.

[04]	Primary + Secondary	Survey	Factors of teachers' job satisfaction	Discovered some factors of teachers' job satisfaction.
[05]	Primary	Survey	Intrinsic & extrinsic motivational factors & their impact on teachers' job satisfaction	Intrinsic & extrinsic motivational factors have an unusually large impact on teachers' job satisfaction.
[06]	Primary	Mixed methods approach	An investigation of the effects of the organizational climate in Iranian schools on the job satisfaction of English language teachers using a mixed method approach in Iran.	It appears that there is an inter-dependency between school organizational climate and teachers' satisfaction.
[07]	Primary + Secondary	Case Study, Interview	Teachers professional space	The results of the analyses distinguished between bounded and contested agency Trajectories. Both trajectories recognized the significance of both individual and environmental influences.
[08]	Primary + Secondary	Empirical research method	Impact of job satisfaction on teacher qualifications	The impact of the structure of teacher qualifications on the quality of education is ruminated to be influenced by job satisfaction.
[09]	Primary + Secondary	Quantitative and qualitative methods, Survey, Literature review	Relations between teachers' job satisfaction and commitment	Strong correlations between teachers' commitment and job satisfaction are shown, and this favors good relationships between teachers and respondents who are administrators, vice principals, and supervisors.
[10]	Primary	Quantitative research	The effect of job satisfaction on teachers' work performance	Teachers and students: There is a clear connection between teachers' job satisfaction and teachers' performance, student learning results, teacher retention and absence, and preparation of pupil reports.

[11]	Primary + Secondary	Survey	The relationship between teacher evaluation practices and teacher job satisfaction	Teacher evaluation practices and teacher job satisfaction shares a strong relationship.
[12]	Secondary	Literature Review	Impact of teachers' professional development on science students	We need to validate & support teachers' professionalism.
[13]	Primary + Secondary	Data analysis, Survey, Interview	Impact of teachers' psycho-social characteristics and their attitudes on the students with behavioural issues.	Teachers' psycho-social characteristics and their attitudes have an impact on the children whose behaviour they find challenging.
[14]	Primary	Survey, Data Analysis	Relations of Teachers Depressive Symptoms to Classroom Quality and Student Achievement	Teachers Depression has a negative effect on students' performance.
[15]	Primary + Secondary	Interview, Survey Questionnaire, Literature review	Framework for measuring school quality	This study proposed a new framework for measuring school quality.
[16]	Primary	Data analysis	Effectiveness of training programs for the training teachers.	Tutoring as an effective form of pedagogical support must be introduced into the system of higher pedagogical education.
[17]	Primary + Secondary	Data analysis & random assignment experiments	Classroom quality factors that make impact on student achievement	Teacher's experience is one of the factors, however it is unclear how it makes an impact.
[18]	Primary	Survey	The relationship between quality assurance and internal efficiency of primary school teachers	Quality assurance depends on internal efficiency among primary school teachers, which affects children' academic performance and, as a result, the achievement of school objectives.

[19]	Primary	Quantitative research	Teachers job satisfaction	The Ohio Teacher Evaluation System (OTES) has had no impact on teacher job satisfaction.
[20]	Primary + Secondary	Comparative & descriptive data analysis, literature review	Disadvantages of improper distribution & allocation of teaching stuff	Every indicator of student disadvantage (such as FRL, URM, and low past academic achievement) is unequally distributed across every measure of teacher quality (such as experience, licensure exam score, and value-added estimates of effectiveness).
[21]	Secondary	Audit, Literature review, data analysis	New defined professionalism for the teaching profession	New defined professionalism for the teaching profession can be fruitful.
[22]	Secondary	Literature review	Teachers' professionalism	We need to validate & support teachers' professionalism.
[23]	Primary + Secondary	Hierarchical observation, literature review, data analysis, unstructured interviews	Professionalism & Discipline in teachers	In the past, educational institutions have always employed discipline to foster docility, for instance by the use of the facilities, the schedule, or the previous inspectorate system of testing and evaluation.
[24]	Primary	Teachers Job Satisfaction Scale	Survey, Literature review	This study proposed a five-item global measure of teaching satisfaction based on the LSS.
[25]	Primary	Data Analysis and Literature review	Teachers Job Satisfaction Questionnaire	Teachers' Job Satisfaction Questionnaire (TJSQ) frame was developed.

Chapter 3

Methodology

The proposed framework of this study is depicted in Figure 3.1 Since supervised ML-based techniques require labeled data to train models, weak factors can lead to poor approximation. As a result, prior to selecting factors, a detailed investigation of previous studies was conducted in order to identify the factors associated with teachers' job satisfaction. Following that, based on the identified factors, primary data was obtained using face-to-face and electronic questionnaires. Data pre-processing was performed to remove all inconsistent data and feature selection techniques were followed to select the best factors. Finally, ML algorithms were tested and evaluated using standard evaluation metrics, and the best model was chosen as the framework's final model.

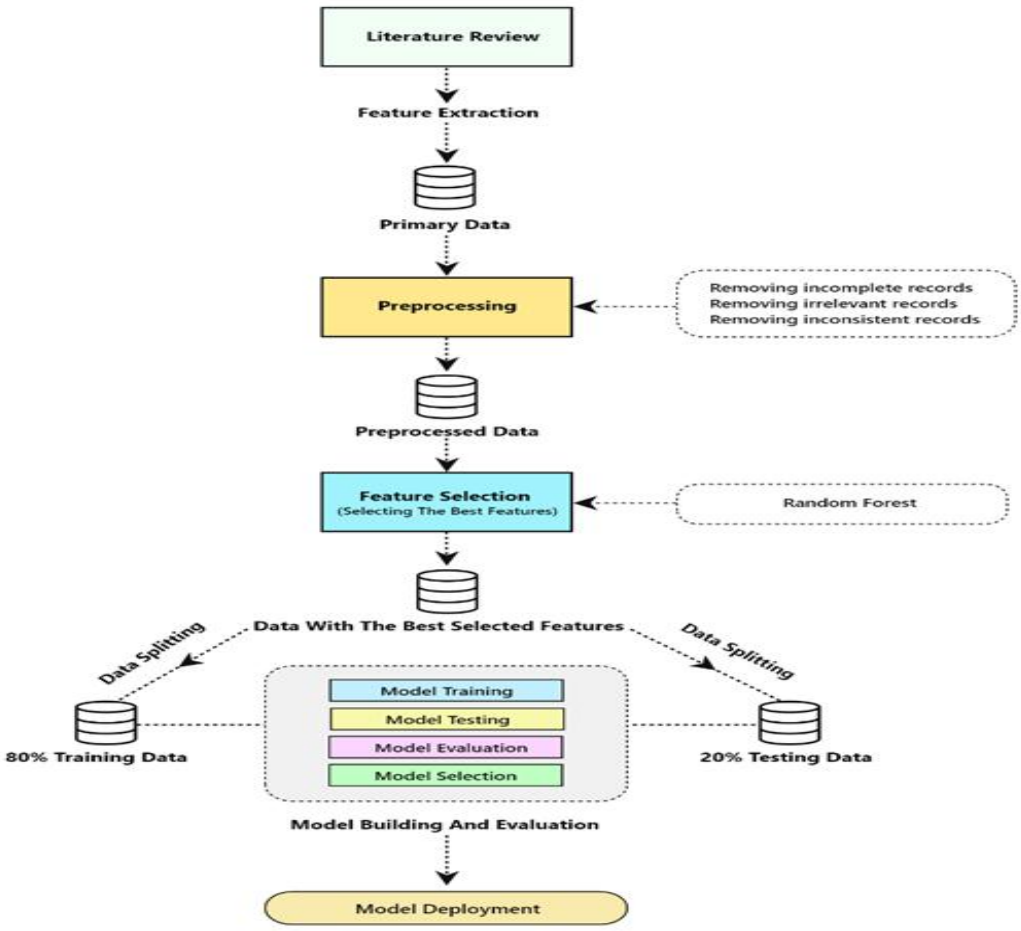

Figure 3.1 Proposed Framework

1

3.1. Study Design and Settings

Adopting a quantitative research design, this study was conducted between 1st March 2022 and 30th June 2022 among primary and secondary level teachers in Bangladesh.

3.2. Data Collection Instrument

A questionnaire was designed by a group of quantitative research experts based on the factors of teacher's job satisfaction. It consisted of 23 self-constructed questions related to teacher's demographic information (3 items), financial benefits (3 items), career opportunities (4 items), school leadership (6 items), recognition (2 items), working environment (4 items), and current satisfaction status (1 item) (see Table 3.1). Before the mass distribution of the questionnaire (both in online and face-to-face), a pilot study was performed on 20 teachers as instructed in [45]. Based on their feed-back, the necessary adjustments have been made to make sure that each question was understandable and clear. Furthermore, the internal consistency of the questions was estimated by Cronbach's alpha (α) as recommended in the study [44] using formula 1. The α value was found 0.87, indicating acceptable inter-item consistency. To ensure the validity, content validity was ensured by the judgment method following the recommendation of the study [46].

$$\alpha = \frac{\mathrm{N}\bar{c}}{\bar{v} + (N-1)\bar{c}} \quad \text{.....(1)}$$

Here,

N= number of items α = Cronbach's alpha

c = average inter-item covariance

v = average variance.

Table 3.1 Category-wise Teacher's Job Satisfaction Questionnaire

Category	Items	Description
Demographic Information	F1	Age
	F2	Gender
	F3	Area of living
Financial Benefits	F4	I get a fair salary for my job
	F5	I am satisfied with my current salary
	F6	I am satisfied with bonus and other financial benefits
Career Opportunities	F7	I have the opportunity to learn new things and develop skills in my job
	F8	I am satisfied with the benefits I receive
	F9	I have a long-range vision for my career in this institute
	F10	I am satisfied with my chances of promotions in this Institute
School Leadership	F11	I am not bounded by too many rules
	F12	My issues are resolved whenever I report authorities
	F13	The administration encourages and supports me
	F14	I have full confidence in the leadership of our institution
	F15	I am satisfied with the leadership and administration
	F16	I am given enough freedom to decide how I do my work
Recognition	F17	I get proper recognition that I should receive
	F18	I am satisfied with the social status with my job (teaching)
Working Environment	F19	I have good relationship with my colleague
	F20	I like the people I work with
	F21	I am satisfied with my working environment
	F22	My working environment is safe and comfortable
Current Satisfaction Status	F23	Considering everything, are you satisfied with your job?

3.3. Data Pre-processing

A total of 1000 questionnaires were distributed, and 297 responses were collected. However, some incomplete (13 records), irrelevant (17 records), and inconsistent (8 records) information was removed. To fit the data with the classifiers, data translation from categorical to numerical was done using one hot encoding. Furthermore, to extract relevant features, improve predictive accuracy, and minimize the model's complexity, was performed using the Random Forest algorithm following the study [47].

3.4. Feature Selection

To improve the classifier's accuracy, score as well as reduce over-fitting, feature selection/ dimensional reduction plays an important role. As a consequence, to select the best features Random Forest algorithm following the study [47] have been used. Here, the results of various non-correlated decision trees have been aggregated to produce a classification result as outputs. In order to accomplish feature selection using this structure, the normalized total reduction in the mathematical criteria used to decide on feature split is determined for each feature during the construction of the forest. To execute feature selection, each feature must be chosen separately. From 22 features, the first nineteen features were taken that helped to get more accuracy.

3.5. Modeling Techniques

Machine learning is a sub-part of Artificial intelligence that deals with the algorithms that can automatically learn through data without explicit support. There are a variety of techniques in ML. However, the most frequently used strategies of machine learning are classification. To explore the best predictive model, various supervised machine learning classifiers (e.g., Decision Tree, Random Forest, Support Vector Machine, Quadratic Discriminant Analysis, Logistic Regression,) will be used in this study to meet the goals. This section will discuss about the Machine Learning Algorithms that are used in this project.

3.5.1. Decision Tree [26]:

Supervised Machine Learning methods like Decision Tree are mostly used to address Classification issues, while they can also be applied to Regression issues. It features a tree-like structure with the root node at the base and other branches growing from it. This

classifier uses the CART algorithm, which stands for Classification and Regression Tree. It consists of two nodes: Leaf Node, which symbolizes the outcome, and Decision Node, which represents the characteristics of a data collection. On the basis of features of the given dataset the decisions or the test are performed. It recursively shifts a data set until it is left with a pure node. Sometimes we do not get a pure leaf node that time we take majority voting to assign the majority class.

The formula for Entropy is shown below:

$$E(S) = - p_{(+)} \log p_{(+)} - p_{(-)} \log p_{(-)}$$

Here,

p_+ is the probability of positive class

p_- is the probability of negative class

S is the subset of the training example

$$Gain = E_{parent} - E_{children}$$

Advantages:

Some advantages of using Decision Tree Classifier:

- It needs less effort for data preparation during pre-processing.
- It does not require data normalization and data scaling.
- Missing data do not cause potential damage in the tree building process.
- It is very easy to explain.

Disadvantages:

Some disadvantages of using Decision Tree Classifier:

- In comparison to other algorithms sometimes the calculations can go far more complex.
- Instability may occur due to slight change in the data.
- Much time is required to train the model.
- It is comparatively expensive.

3.5.2. Support Vector Machine [27]:

A supervised machine learning approach called Support Vector Machine (SVM) is frequently used to solve classification issues, while it can also be applied to problems involving regression. The value of each feature is represented by the value of a certain coordinate, and each piece of data is plotted as a point in n-dimensional space (where n is the number of features we have). The categorization is then completed by identifying the hyper-plane that effectively distinguishes the two classes. To choose the best hyper-plane,

the distances between the nearest data point (of either class) and the hyper-plane are maximized. This distance is called Margin. The highest margin from the observation point as the right hyper plane is taken. The hypothesis function h is:

$$h(xi)=\{+1-1\text{if } w\cdot x+b\geq 0\text{if } w\cdot x+b<0\}$$

Advantages:

Some advantages of using Support Vector Machine Classifier:

- It produces real results with a clear margin of separation.
- It is effective in cases of high dimensional spaces.
- It is effective, where the number of dimensions is greater than the number of samples.
- It is also memory efficient, as it uses a subset of training points in the decision function.

Disadvantages:

Some disadvantages of using Support Vector Machine:

- It does not perform well for large data sets as higher training time is required.
- It also does not perform very well for noisy data sets.
- It is expensive.

3.5.3. Random Forest [28]:

This classifier, a meta estimator, employs averaging to increase predicted accuracy and reduce over-fitting while fitting a number of decision tree classifiers on different sub-samples of the data set. The class with the most votes becomes the model's prediction, which is generated by each individual tree in the random forest. In this case, a committee of many substantially uncorrelated trees will perform better than any of its individual component models. We call it random forest as we randomly select a subset of features from bootstrapped data for each tree. After that we do majority voting & get the prediction, we call this process as aggregation. The formula for Entropy is shown below:

$$E(S) = - p(+)\log p(+) - p(-) \log p(-)$$

Here p+ is the probability of positive class

p– is the probability of negative class

S is the subset of the training example

$$Gain=E\text{ parent} - E\text{ children}$$

Advantages:

Some advantages of using Random Forest Classifier:

- Both regression and classification tasks can be performed by it.
- Predictions produced by it can be understood easily.
- Large datasets can be efficiently handled.
- It provides a higher level of accuracy in predicting outcomes over the decision tree algorithm.

Disadvantages:

Some disadvantages of using Random Forest Classifier:

- More resources are required for computation.
- Compared to a decision tree algorithm, much time is needed.

3.5.4. Logistic Regression [29]:

One of the simplest supervised learning classification techniques, logistic regression is used to estimate the likelihood of a target variable. The target variable's nature is dichotomous; it is binary in nature, with data coded as either 1 (which represents success/yes) or 0 (which represents failure/no). Mathematical Representation:

$$\log p/(1-p)=\beta_0+\beta_1 x_1+\beta_2 x_2 + \ ..+ \beta_m x_m$$

Advantages:

Some advantages of using Logistic Regression Classifier:

- It is easier to implement, interpret, and also very efficient to train.
- It does not make any assumptions about distributions of classes in feature space.
- It can be extended to multiple classes easily.
- It can perform very fast while classifying unknown records.

Disadvantages:

Some disadvantages of using Logistic Regression Classifier:

- It is not suitable in cases which, the number of observations is lesser than the number of features, as it may lead to over-fitting.
- Logistic regression constructs linear boundaries.
- The assumption of linearity between the dependent variable and the independent variables is one of the major limitations.

3.5.5 Quadratic Discriminant Analysis (QDA) [30]:

To find out the variables that restrict one or more naturally occurring categories from another, Discriminant Analysis is used. The most common type of Bayesian discrimination is known as quadratic discriminant analysis (QDA), which is closely connected to linear discriminant analysis (LDA). In QDA, it is presumed that each class' covariance is different. Quadratic discriminant function:

$$\delta k(x) = -12\log|\Sigma k| - 12(x-\mu k)T\Sigma k - 1(x-\mu k) + \log\pi k$$

Classification rule:

$$G\hat{}(x) = \arg\max k \delta k(x)$$

Advantages:

- Quadratic Discrimination Analysis (QDA) is more flexible for the covariance matrix.
- Quadratic Discrimination Analysis (QDA) preforms better than LDA.

Disadvantages:

- Quadratic Discrimination Analysis (QDA) is lengthier and complex.

3.5.6 Naïve Bayes [31]: .

The Naive Bayes classification method bases its use on the Bayes Theorem and the assumption of predictor independence. Naive Bayes classifiers make the assumption that the existence of one feature in a class is unrelated to the existence of any other feature. Mathematical Representation:

$$P(A|B) = P(B|A) * P(A) / P(B)$$

Advantages:

Some advantages of using Naïve Bayes Classifier:

- It is easy and fast to predict the class of a test data set.
- It performs well while predicting multi class data sets.
- It needs less training data.

Disadvantages:

Some disadvantages of using Naïve Bayes Classifier:

- A restriction of this classifier is "Zero Frequency". The Naïve Bayes model will assign a 0 (zero) probability if a categorical variable in a test data set has a category that was not included in the training data set and will not be able to make a prediction.

- One of the most important restrictions is the presumption of independent variables.

3.5.7 AdaBoost [32]:

AdaBoost classifier use iterative ensemble method by combining a number of weak classifiers to produce a high accuracy strong classifier. In order to guarantee correct predictions of uncommon observations, the AdaBoost classifier sets the weights of other classifiers and trains the data sample in each iteration. Any machine learning technique that accepts weights from the training set can be used as the base classifier by an AdaBoost classifier.

Advantages:

- It is easy to implement.
- AdaBoost classifiers are less vulnerable to over-fitting.
- Many classifiers can be used as base classifiers of AdaBoost classifiers.

Disadvantages:

- It is often sensitive to noisy data.

3.5.8 Gradient Boosting [33]:

Gradient Boosting Classifiers frequently combine several ineffective classifiers using Decision Trees to create strong classifiers with high accuracy.

Advantages:

- It can perform better than Random Forest.

Disadvantages:

- Gradient Tree Boosting classifier is vulnerable to over fitting.
- It often models noisy data.

3.5.9 Multi-Layer Perceptron (MLP) [34]:

A fully linked class of feed-forward artificial neural networks is the multi-layer perceptron (MLP) (ANN). It consists of 3-layer nodes (i.e., input layers, hidden layer, and Output layer).

Two common activation function:

$$y(vi) = \tanh(vi) \ldots\ldots\ldots (i) \text{ [range: -1 to 1]}$$

$$y(vi) = (1 + e^{-vi})^{-1} \ldots\ldots\ldots (ii) \text{ [range: 0 to 1]}$$

Here,

y_i is the output of the i th node (neuron)

v_i is the weighted sum of the input connections

Advantages:

- It works well with large input data.
- It provides quicker predictions after training.
- Can be applied to complex non-linear problems.

Disadvantages:

- The quality of training determines the proper functioning of the classifier.

3.5.10 K-nearest Neighbor [35]:

The K-nearest Neighbor classifier, often known as KNN, uses proximity to categorize or predict how a certain data point will be grouped. It is a non-parametric, supervised learning classifier.

Advantages:

- It is easy to implement.
- New data can be added without impacting the classifier accuracy.

Disadvantages:

- It does not work well with large models.
- It is sensitive to noise.

Chapter 4

Result

This section will discuss about the data analysis and results.

4.1. Respondents Profile:

The final questionnaire was distributed to 1000 teachers, of which 297 teachers took part in this survey. The proportion of participants were 38% female and 62% male. Their age varies from 24 to 56 years, where the average age was 32 years (Std. Deviation = 6.5). Table 4.1 represents the gender wise frequency distribution of the overall dataset.

Table 4.1 Frequency Distribution According to Gender

Gender	Frequency	Frequency Distribution	Result	
			Satisfied	Dissatisfied
Male	184	62%	60%	40%
Female	113	38%	63%	37%

4.2. Materials and Feature Selections:

As the key objective is to predict Teachers' job satisfaction, the attributes that impact on Teachers' job satisfaction were identified to design survey questionnaires. 22 individual factors were identified and selected for survey questionnaires to achieve the research goal.

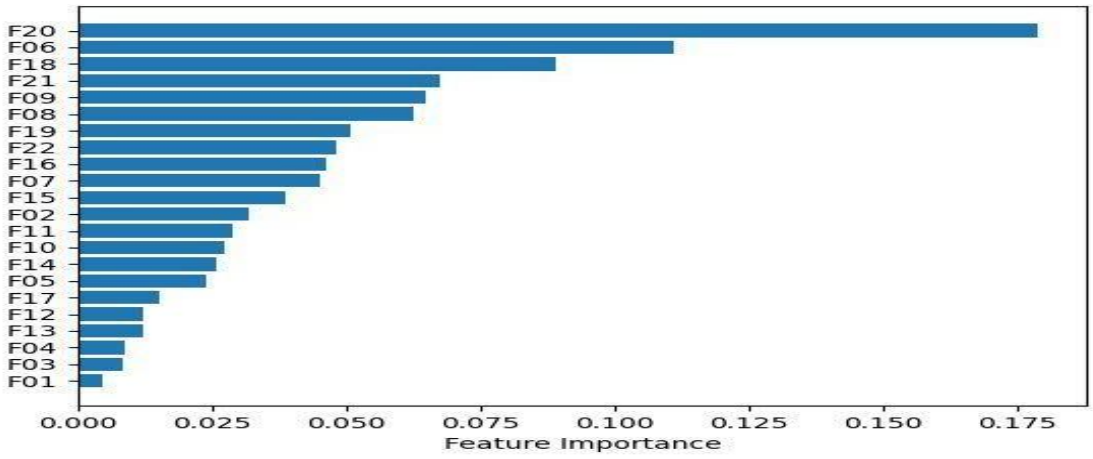

Figure. 4.1 Feature Importance Graph

To improve prediction accuracy and avoid over-fitting, a feature selection algorithm was performed and 19 out of 22 most important features were selected for final analysis (see Table 4.2). Figure 4.1 shows the graphical representation of feature importance. It can be seen that attributes under the factor Working Environment creates most impact on Teachers' job satisfaction. Previous studies [2, 3, 4, 5] also indicated that, a good working environment makes the teachers feel satisfied with their jobs. Attributes under the factors financial benefit and career opportunity are also important, as evidence from the existing literature [2, 4, 6]. Whereas, demographic attributes make no significant impact on teachers' job satisfaction.

Table 4.2 Feature Details

Sl No.	Feature	Category	Feature Rank According to Importance	Final Feature Selection Status
F20	I like the people I work with	Working Environment	1	Yes
F06	I am satisfied with bonus and other financial benefits	Financial Benefits	2	Yes
F18	I am satisfied with the social status with my job (teaching)	Recognition	3	Yes
F21	I am satisfied with my working Environment	Working Environment	4	Yes
F09	I have a long-range vision for my career in this institute	Career Opportunities	5	Yes
F08	I am satisfied with the benefits I Receive	Career Opportunities	6	Yes
F19	I have good relationship with my colleague	Working Environment	7	Yes
F22	My working environment is safe and comfortable	Working Environment	8	Yes
F16	I am given enough freedom to decide how I do my work	School Leadership	9	Yes
F07	I have the opportunity to learn new things and develop skills in my job	Career Opportunities	10	Yes

F15	I am satisfied with the leadership and administration	School Leadership	11	Yes
F02	Gender	Demographic Information	12	Yes
F11	I am not bounded by too many Rules	School Leadership	13	Yes
F10	I am satisfied with my chances of promotions in this institute	School Leadership	14	Yes
F14	I have full confidence in the leadership of our institution	School Leadership	15	Yes
F05	I am satisfied with my current Salary	Financial Benefits	16	Yes
F17	I get proper recognition that I should receive	Recognition	17	Yes
F12	My issues are resolved whenever I report authorities	School Leadership	18	Yes
F13	The administration encourages and supports me	School Leadership	19	Yes
F04	I get a fair salary for my job	Financial Benefits	20	No
F03	Area of living	Demographic Information	21	No
F01	Age	Demographic Information	22	No

4.3.1. Confusion matrix:

A confusion matrix represents the performance of a classification model by a table (see Table 4.3). It summarizes a classifier's correct and incorrect predictions by using certain terminologies: TP, TN, FP, FN. True Positive (TP) and True Negative (TN) represent the correctly predicted positive and negative values. Whereas False Positive (FP) and False Negative (FN) represents the positive and negative values that were predicted incorrectly. Figure. 4.2 graphically represents a confusion matrix of 10 classifiers.

Table 4.3 Confusion Matrix

	Predicted 0	**Predicted 1**
Actual 0	TN	FP
Actual 1	FN	TP

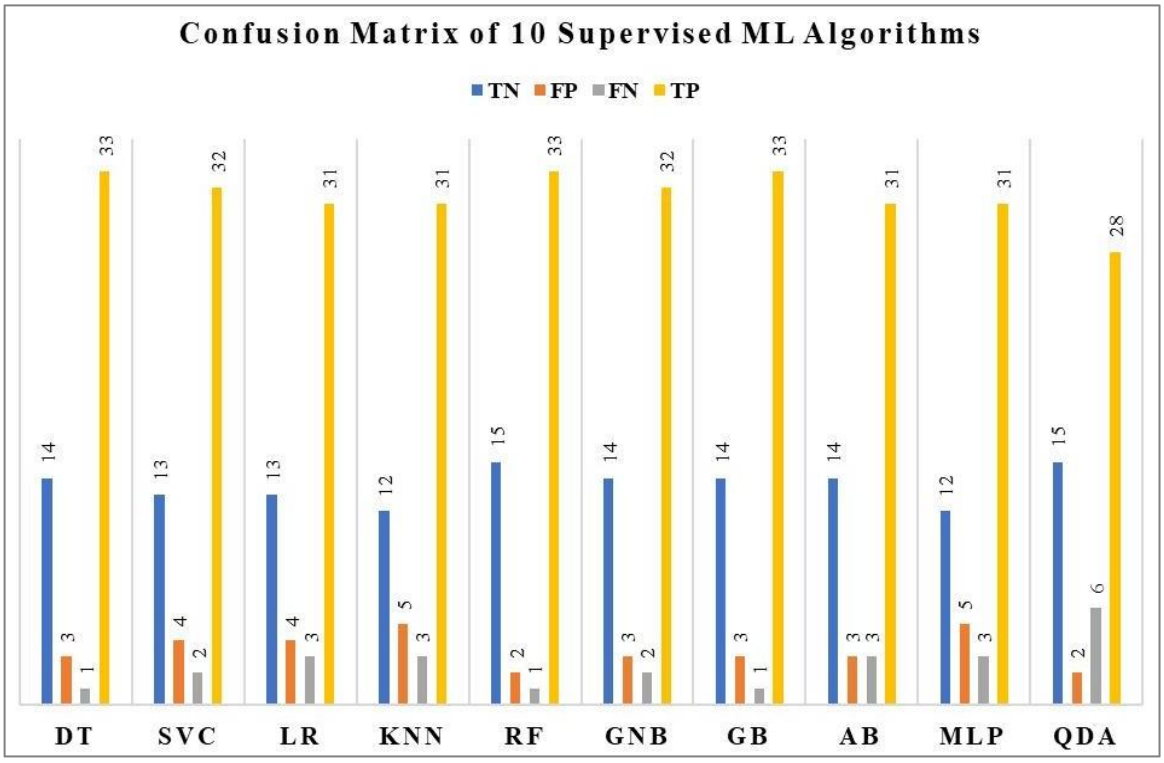

Figure. 4.2 Summary of the Confusion Matrix of the Selected Classifier

4.3.2. Precision:

Precision measures the proportion of correctly predicted positive observations to all positively expected observations. A classification model with a high precision is likely to have a low false-positive rate. Table 4.4 shows the performance evaluation of the selected classifiers.

Precision (P) = TP/ (TP+FP)

4.3.3. Recall:

The ratio of correctly predicted positive observations to all observations in the actual class is termed as Recall.

Recall (Sensitivity) = TP/TP+FN

1

4.3.4. F1-score:

F1-Score is the weighted average of Precision and Recall that measures a test's accuracy.

F1-Score = 2*(Recall * Precision) / (Recall + Precision)

4.3.5 ROC Curve Analysis:

The ROC curve analysis highlights the sensitivity of the classifier model by depicting the rate of true positives with respect to the rate of false positives, to measure the performance of a classifier model. Figure. 4.3 represents ROC Curve of the classifiers.

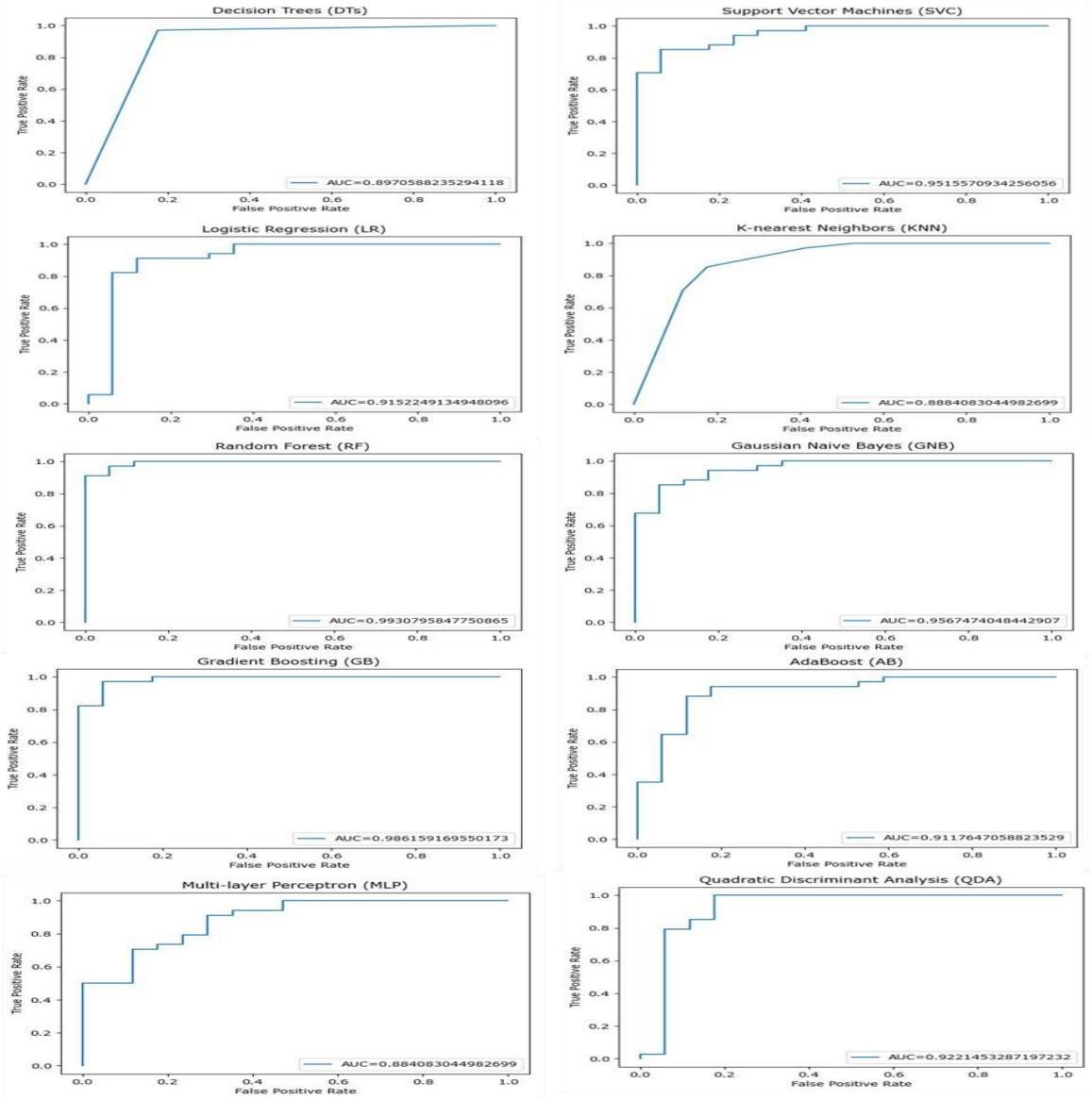

Figure. 4.3 ROC Curve of Different Classifiers

4.4 Discussion:

This study aimed to investigate the affecting factors of primary and secondary level teacher's job satisfaction and introduce an effective data-driven expert system framework for predicting teacher's job satisfaction status. ML-based models learn from data-driven experience rather than adopting a theory-driven technique that necessitates a preconceived premise based on prior knowledge [48]. Currently, traditional rating scale-based approaches are followed to measure teacher's job satisfaction. In contrast, this study used machine learning based approaches to better understand the factors that have an influence on teacher job satisfaction.

According to the findings, the important determinants of teacher job satisfaction are the working environment, job recognition, and career opportunities, whereas school leadership and financial benefits are considered to be less significant factors. Similar proof was produced in study [33], where the author discovered a high association between working conditions in schools and teacher job satisfaction. A recent study [36] found that the job satisfaction of teachers is influenced by both monetary and non-monetary incentives, such as community support. According to the survey, appropriate pay packages commensurate with their labor input, prospects for professional advancement, a clearly defined individual appraisal system, prompt promotion, and required workplace conditions are all factors that contribute to teachers' satisfaction. In contrast, the study [41] emphasized more on teachers' self-fulfillment (recognition, opportunities etc.) rather than salary and other financial benefits. This is because teacher morale cannot be raised even if remuneration increases; rather, it depends on how we encourage and recognize teachers for their achievements and contributions. So, based on previous studies [33, 36, 41, 49] and current findings, we can conclude that the working environment, job recognition, career opportunities, school leadership, and financial benefits play a crucial role in determining teacher job satisfaction.

The present study also proposed a simple, direct, reliable, data-driven expert system framework for the assessment of teacher's job satisfaction. Instead of traditional rating-based scales such as TJSS [50], TSS [43], the proposed system used 10 super-vised machine learning classifiers (Decision Trees, Support Vector Machines, Logistic

Regression, K-nearest Neighbors, Random Forests, Gaussian Naive Bayes, Gradient Tree Boosting, AdaBoost, Multi-layer Perceptron, and Quadratic Discriminant Anal-sis) to predict primary and secondary level teachers' current satisfaction status. From the ROC curve it is seen that AUC (Area Under ROC Curve) of K-nearest Neighbors is 0.88,

which indicates 88% chances of the model making correct predictions. Whereas AdaBoost and Logistic Regression has AUC of 0.91, Gaussian Naive Bayes and Support Vector Machines has AUC of 0.95, and Gradient Tree Boosting has AUC of 0.98. Here, Random Forests has the highest AUC of 0.99, which indicates 99% chances of the model making correct predictions.

Table 4.4 Performance Evaluation of the Selected Classifiers

Classifier	Accuracy	Class	Precision	Recall	F1 Score	Support
Decision Trees (DTs)	0.92	Satisfied	0.92	0.82	0.87	34
		Dissatisfied	0.93	0.97	0.94	17
Support Vector Machines (SVC)	0.88	Satisfied	0.89	0.76	0.81	34
		Dissatisfied	0.87	0.94	0.91	17
Logistic Regression (LR)	0.86	Satisfied	0.89	0.76	0.79	34
		Dissatisfied	0.81	0.91	0.90	17
K-nearest Neighbors (KNN)	0.84	Satisfied	0.86	0.91	0.89	34
		Dissatisfied	0.80	0.71	0.75	17
Random Forest (RF)	**0.94**	**Satisfied**	**0.94**	**0.97**	**0.96**	**34**
		Dissatisfied	**0.94**	**0.88**	**0.91**	**17**
Gaussian Naive Bayes (GNB)	0.90	Satisfied	0.91	0.94	0.93	34
		Dissatisfied	0.88	0.82	0.85	17
Gradient Boosting (GB)	0.92	Satisfied	0.92	0.97	0.94	34
		Dissatisfied	0.93	0.82	0.87	17
AdaBoost (AB)	0.88	Satisfied	0.91	0.91	0.91	34
		Dissatisfied	0.82	0.82	0.82	17
Multi-layer Perceptron (MLP)	0.84	Satisfied	0.86	0.91	0.89	34
		Dissatisfied	0.80	0.71	0.75	17
Quadratic Discriminant Analysis (QDA)	0.84	Satisfied	0.93	0.82	0.87	34
		Dissatisfied	0.71	0.88	0.79	17

Based on classifiers' evaluation metrics such as confusion matrix, accuracy, precision, recall, F1 score, and ROC curve analysis, it is found that Random Forest outperforms the other classifiers with greater accuracy (94%) to predict teacher's job satisfaction status (see detailed information in Table 4.4). Whereas Gradient Boosting and Decision Trees gives out 92%, Support Vector Machines and AdaBoost gives out 88%, and Logistic Regression givers out 86% of accuracy. Here, the classifiers Quadratic Discriminant Analysis, K-nearest Neighbors and Multi-layer Perceptron give out the lowest accuracy of 84%. So, in future, this proposed framework could be implemented as a web/mobile based application that may help school management to better understand the condition of

teachers' job satisfaction. However, significant limitations of the proposed framework must be addressed before widespread use. Since the model is focused primarily on Bangladeshi teachers, it may cause cultural issues when implemented outside of Bangladesh. So, further additional study with diverse data from different countries is required.

Chapter 5

Conclusion

To ensure good quality education we must focus on Teachers' job satisfaction, along with some other factors. A happy teacher means a healthy and hearty classroom environment, which will eventually result in effective learning. There is a lack of proper measurement of teachers' job satisfaction and also there is very less focus in this regard in the present context of Bangladesh. However, teachers' job satisfaction has a huge impact on teachers' performance, and eventually impacts the overall quality of education. Usage of deterministic rule-based processes to measure teachers' job satisfaction is a common practice. Here, machine learning can be an adequate option considering its recent growth in almost every sector. The machine learning algorithms train by real-life data, while the rule-based system adopts a theory-driven approach which is based on a hypothesis established from prior knowledge. As the machine learning approach trains iteratively on the real-life data to improve its predictability rather than depending on a hypothesis based on prior knowledge, it could be a good solution while determining teachers' job satisfaction. The purpose of this study is to find out the attributes which are most important to measure teachers' job satisfaction and provide a tool to measure teachers' job satisfaction using machine learning techniques that are fast, affordable, and reliable. A total of 22 attributes under 6 categories were identified. Among them, 19 factors were selected based on the feature importance. It was observed that the attributes under the category of demographic information were less important, whereas attributes under the factors: working environment, work recognition, and career opportunities are more important. To measure teachers' job satisfaction, this study utilized 10 supervised machine learning algorithms (Decision Trees, Support Vector Machines, Logistic Regression, K-nearest Neighbors, Random Forests, Gaussian Naive Bayes, Gradient Tree Boosting, AdaBoost, Multi-layer Perceptron, and Quadratic Discriminant Analysis) to predict primary and secondary level teachers' current satisfaction status and determine the key influencing factors that affect their job satisfaction. Based on classifiers' evaluation

metrics such as confusion matrix, accuracy, precision, recall, F1 score, and ROC curve analysis, it is found that Random Forest outperforms the other classifiers with greater accuracy (94%) (see Table 4.4). The overall study was conducted on 297 samples where 113 (38%) of the sample were found to be dissatisfied with their jobs and 184 (62%) were found satisfied with their jobs. The survey for this study was mostly done by the teachers from the urban area and are fairly paid, which is a limitation of this study as during pandemic situations it was not possible to reach every nook and corner. This study's future work involves establishing a web-based tool to determine Teachers' job Satisfaction more quickly and establishing this tool for the other professionals.

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1

Appendix

Appendix A

Algorithm: An algorithm is a method for completing a computation or solving a problem. Algorithms function as a precise sequence of instructions that guide hardware- or software-based routines through a series of prescribed actions step by step.

Frequency Distribution: Frequency distribution is a statistical term for a graph or data set that displays the likelihood of each conceivable outcome of a recurring event that has been observed numerous times.

Machine Learning Classifier: An algorithm known as a classifier in machine learning, which automatically arranges or categorizes data into one or more of a set of "classes."

Mathematical Representation: A representation in mathematics expresses similarities (or equivalences) between mathematical objects or structures in a fairly generic way.

Literature Review: A literature review summarizes scholarly articles, books, and other sources of information related to a particular area of research.

Survey: A survey is a research strategy utilized to collect data from a predefined group of respondents to gain information and insights into various topics of interest.

Appendix B

Note: A paper on this thesis report has been submitted to journal for publication.

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