Import Libraries

In [1]:
```
import pandas as pd
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import nltk
nltk.download('stopwords')
from sklearn.preprocessing import OneHotEncoder, OrdinalEncoder, Label
Encoder, \
StandardScaler, Normalizer
from sklearn.compose import ColumnTransformer
from sklearn.impute import SimpleImputer
from sklearn.metrics import confusion_matrix, accuracy_score, \
plot_confusion_matrix, classification_report
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.metrics import precision_score, recall_score, f1_score, \
roc_curve, roc_auc_score
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_selection import SelectKBest, chi2
from sklearn.pipeline import make_pipeline, Pipeline
from sklearn import tree
from sklearn.linear_model import SGDClassifier
from mlxtend.plotting import plot_decision_regions
from mlxtend.evaluate import bootstrap_point632_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.linear_model import Perceptron
from sklearn.decomposition import NMF, LatentDirichletAllocation
from sklearn.inspection import permutation_importance
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)
warnings.filterwarnings('ignore')
warnings.warn('DelftStack')
warnings.warn('Do not show this message')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

1. Load the Combined Drug Data

In [2]:
```
tsv_file='drugsComTrain_raw.tsv'
csv_table=pd.read_table(tsv_file,sep='\t')
csv_table.to_csv('Data1.csv',index=False)
Data1 = pd.read_csv("Data1.csv")
print(Data1.shape)
Data1.head()

 ## Import DrugsComTest Data Set

tsv_file='drugsComTest_raw.tsv'
csv_table=pd.read_table(tsv_file,sep='\t')
csv_table.to_csv('Data2.csv',index=False)
Data2 = pd.read_csv("Data2.csv")
print(Data2.shape)
Data2.head()


drug = pd.concat([Data1,Data2], ignore_index=True)
```

```
(161297, 7)
(53766, 7)
```

2. Exploratory Data Analysis

Data Cleaning

In [3]:
```
drug.shape
```

Out[3]:
```
(215063, 7)
```

In [4]:
```
#check for duplicates
drug.duplicated().sum()
```

Out[4]:
```
0
```

Our focus is using the text data to prdict the drug rating

In [5]:
```
data = drug[['review', 'rating']]
data.head(2)
```

Out[5]:

	review	rating
0	"It has no side effect, I take it in combinati...	9.0
1	"My son is halfway through his fourth week of ...	8.0

In [6]:
```
#Check for Null values
data.isna().sum()
```

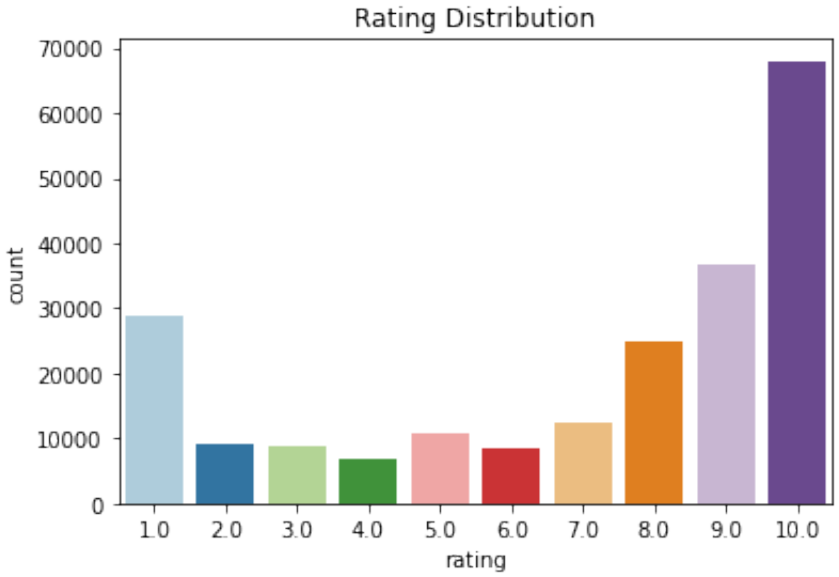
Out[6]:
```
review    0
rating    0
dtype: int64
```

In [7]:
```
data['rating'].unique()
```

Out[7]:
```
array([ 9.,  8.,  5.,  2.,  1., 10.,  4.,  3.,  7.,  6.])
```

In [8]:
```
#Plot rating distribution
sns.countplot(x = data['rating'], palette = "Paired")
plt.title("Rating Distribution")
```

Out[8]:
```
Text(0.5, 1.0, 'Rating Distribution')
```



Combine rating in two positive, neutral and negative

In [9]:
```
# Categorize reviews into positive, negative, or neutral
data.loc[(data['rating'] > 6), 'review_sentiment'] = 'Positive'
data.loc[(data['rating'] < 5), 'review_sentiment'] = 'Negative'
data.loc[((data['rating'] >= 5) & (data['rating'] <=6)  ),
                                                    'review_sentiment'] =
'Neutral'
data['review_sentiment'].value_counts()
```

Out[9]:
```
Positive    142306
Negative     53572
Neutral      19185
Name: review_sentiment, dtype: int64
```

In [10]:
```
data.head()
```

Out[10]:

	review	rating	review_sentiment
0	"It has no side effect, I take it in combinati...	9.0	Positive
1	"My son is halfway through his fourth week of ...	8.0	Positive
2	"I used to take another oral contraceptive, wh...	5.0	Neutral
3	"This is my first time using any form of birth...	8.0	Positive
4	"Suboxone has completely turned my life around...	9.0	Positive

Neutral class are not helpful in this case, so we drop it

In [11]:
```
#Drop neutral value
data.drop(data[data['review_sentiment']=='Neutral'].index, inplace = True)
data.reset_index(drop=True, inplace=True)
data['review_sentiment'].value_counts()
```

Out[11]:
```
Positive    142306
Negative     53572
Name: review_sentiment, dtype: int64
```

In [12]:
```
data['review_sentiment'].unique()
```

Out[12]:
```
array(['Positive', 'Negative'], dtype=object)
```

In [13]:
```
data.head()
```

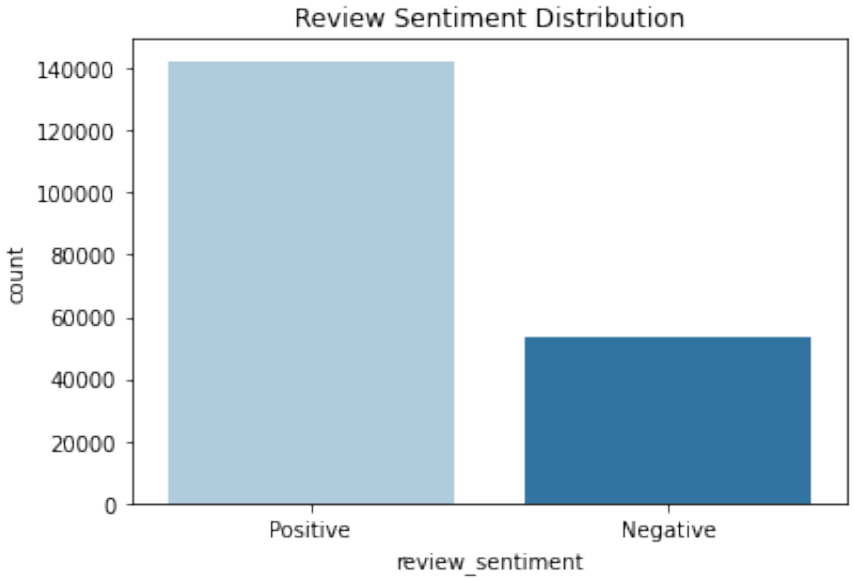
Out[13]:

	review	rating	review_sentiment
0	"It has no side effect, I take it in combinati...	9.0	Positive
1	"My son is halfway through his fourth week of ...	8.0	Positive
2	"This is my first time using any form of birth...	8.0	Positive
3	"Suboxone has completely turned my life around...	9.0	Positive
4	"2nd day on 5mg started to work with rock hard...	2.0	Negative

In [14]:
```
data = data.dropna()
```

In [15]:
```
#Plot Review_Sentiment distribution
sns.countplot(x = data['review_sentiment'], palette = "Paired")
plt.title("Review Sentiment Distribution")
```

Out[15]:
```
Text(0.5, 1.0, 'Review Sentiment Distribution')
```



In [16]:
```
data['review_sentiment'].value_counts(normalize=True)
```

Out[16]:
```
Positive    0.726503
Negative    0.273497
Name: review_sentiment, dtype: float64
```

--> The review sentiment seems to be imbalance, but not too bad.

Cleaning review text

In [17]:
```
def review_clean(review):
    # changing to lower case
    lower = review.str.lower()

    # Replacing the repeating pattern of &#039;
    pattern_remove = lower.str.replace("&#039;", "")

    # Removing all the special Characters
    special_remove = pattern_remove.str.replace(r'[^\w\d\s]',' ')

    # Removing all the non ASCII characters
    ascii_remove = special_remove.str.replace(r'[^\x00-\x7F]+',' ')

    # Removing the leading and trailing Whitespaces
    whitespace_remove = ascii_remove.str.replace(r'^\s+|\s+?$','')

    # Replacing multiple Spaces with Single Space
    multiw_remove = whitespace_remove.str.replace(r'\s+',' ')

    # Replacing Two or more dots with one
    dataframe = multiw_remove.str.replace(r'\.{2,}', ' ')

    return dataframe
```

In [18]:
```
data['review_clean'] = review_clean(data['review'])
data.head(8)
```

Out[18]:

	review	rating	review_sentiment	review_clean
0	"It has no side effect, I take it in combinati...	9.0	Positive	it has no side effect i take it in combination...
1	"My son is halfway through his fourth week of ...	8.0	Positive	my son is halfway through his fourth week of i...
2	"This is my first time using any form of birth...	8.0	Positive	this is my first time using any form of birth ...
3	"Suboxone has completely turned my life around...	9.0	Positive	suboxone has completely turned my life around ...
4	"2nd day on 5mg started to work with rock hard...	2.0	Negative	2nd day on 5mg started to work with rock hard ...
5	"He pulled out, but he cummed a bit in me. I t...	1.0	Negative	he pulled out but he cummed a bit in me i took...
6	"Abilify changed my life. There is hope. I was...	10.0	Positive	abilify changed my life there is hope i was on...
7	" I Ve had nothing but problems with the Kepp...	1.0	Negative	i ve had nothing but problems with the keppera...

In [19]:
```
from nltk.corpus import stopwords
#Removing the stopwords
stop_words = set(stopwords.words('english'))
data['review_clean'] = data['review_clean'].apply(lambda x: ' '.join(w
ord for word in x.split() if word not in stop_words))
```

In [20]:
```
data.head(8)
```

Out[20]:

	review	rating	review_sentiment	review_clean
0	"It has no side effect, I take it in combinati...	9.0	Positive	side effect take combination bystolic 5 mg fis...
1	"My son is halfway through his fourth week of ...	8.0	Positive	son halfway fourth week intuniv became concern...
2	"This is my first time using any form of birth...	8.0	Positive	first time using form birth control im glad we...
3	"Suboxone has completely turned my life around...	9.0	Positive	suboxone completely turned life around feel he...
4	"2nd day on 5mg started to work with rock hard...	2.0	Negative	2nd day 5mg started work rock hard erections h...
5	"He pulled out, but he cummed a bit in me. I t...	1.0	Negative	pulled cummed bit took plan b 26 hours later t...
6	"Abilify changed my life. There is hope. I was...	10.0	Positive	abilify changed life hope zoloft clonidine fir...
7	" I Ve had nothing but problems with the Kepp...	1.0	Negative	nothing problems keppera constant shaking arms...

In [21]:
```
data.isna().sum()
```

Out[21]:
```
review              0
rating              0
review_sentiment    0
review_clean        0
dtype: int64
```

Training/test Split

In [22]:
```
#Set data frame for predictor and target variable
X= data[['review_clean']]
y= data[['review_sentiment']]
# Encode Review_Sentiment
y['review_sentiment']= pd.DataFrame(LabelEncoder().fit_transform(y))
y.head()

#Split the data into train (80%) and test (20%), random state= 42
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
20,
                                                    random_state=42)
y_train.head(2)
```

Out[22]:

	review_sentiment
194752	1
74017	1

In [23]:
```
#Overview of the text on the train data
X_train.describe()
```

Out[23]:

	review_clean
count	156702
unique	105891
top	good
freq	107

Feature Enginerring

In [24]:
```
#transform text data usign TF-IDF
spmat= TfidfVectorizer(analyzer='word',stop_words= 'english', max_features=5000) #Remove stop words
matrix = spmat.fit_transform(X_train['review_clean'])
X_testvec = spmat.transform(X_test['review_clean'])
# Create a new dataframe with column names
feat_names= spmat.get_feature_names_out()
X_trainvec= pd.DataFrame.sparse.from_spmatrix(matrix, columns=feat_names)
X_testvec= pd.DataFrame.sparse.from_spmatrix(X_testvec, columns=feat_names)
X_trainvec.head()
```

Out[24]:

	00	000	00am	00pm	01	02	04	05	06	07	...	zoloft	zolpidem	zombie	zomig	zo
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	

5 rows × 5000 columns

In [25]:
```
#Here we see the Nans
y_train.shape
```

Out[25]:
```
(156702, 1)
```

In [26]:
```
y_train.reset_index(inplace=True, drop=True)
y_test.reset_index(inplace=True, drop=True)
#y_train
```

4. Modeling

In [27]:
```
# Create function to return model results

from sklearn.metrics import accuracy_score, precision_recall_fscore_su
pport
def calculate_results(y_true, y_pred):
    """
    Calculates model accuracy, precision, recall and f1 score of a bin
ary classification model.

    Args:
        y_true: true labels in the form of a 1D array
        y_pred: predicted labels in the form of a 1D array

    Returns a dictionary of accuracy, precision, recall, f1-score.
    """
    # Calculate model accuracy
    model_accuracy = accuracy_score(y_true, y_pred) * 100
    # Calculate model precision, recall and f1 score using "weighted a
verage
    model_precision, model_recall, model_f1, _ = precision_recall_fsco
re_support(y_true, y_pred, average="weighted")
    model_results = {"accuracy": model_accuracy,
                     "precision": model_precision,
                     "recall": model_recall,
                     "f1": model_f1}
    return model_results
```

Decision Tree

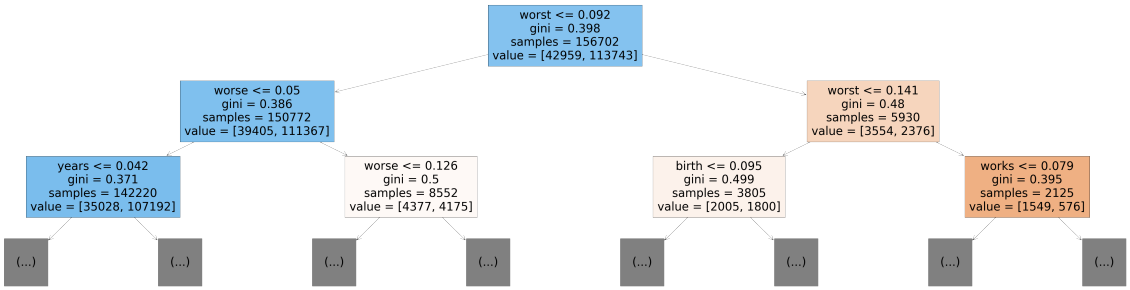
In [ ]:
```
#test
#create standard tree for all words
dtree_model= tree.DecisionTreeClassifier(random_state=42)
dtree_model = dtree_model.fit(X_trainvec, y_train)
y_pred_tree = dtree_model.predict(X_testvec)
print('standard tree accuracy %2.2f ' % accuracy_score(y_test,y_pred_t
ree))
print(classification_report(y_test,y_pred_tree))
```

```
standard tree accuracy 0.91
              precision    recall  f1-score   support

           0       0.82      0.83      0.83     10613
           1       0.94      0.93      0.94     28563

    accuracy                           0.91     39176
   macro avg       0.88      0.88      0.88     39176
weighted avg       0.91      0.91      0.91     39176
```

In [ ]:
```
cf_matrixtree = confusion_matrix(y_test, y_pred_tree)

print(cf_matrixtree)
```

```
[[ 8851  1762]
 [ 1885 26678]]
```

In [ ]:
```
from sklearn.tree import plot_tree, export_text
plt.figure(figsize =(80,20))

plot_tree(dtree_model, feature_names=X_trainvec.columns, max_depth=2,
filled=True);
```

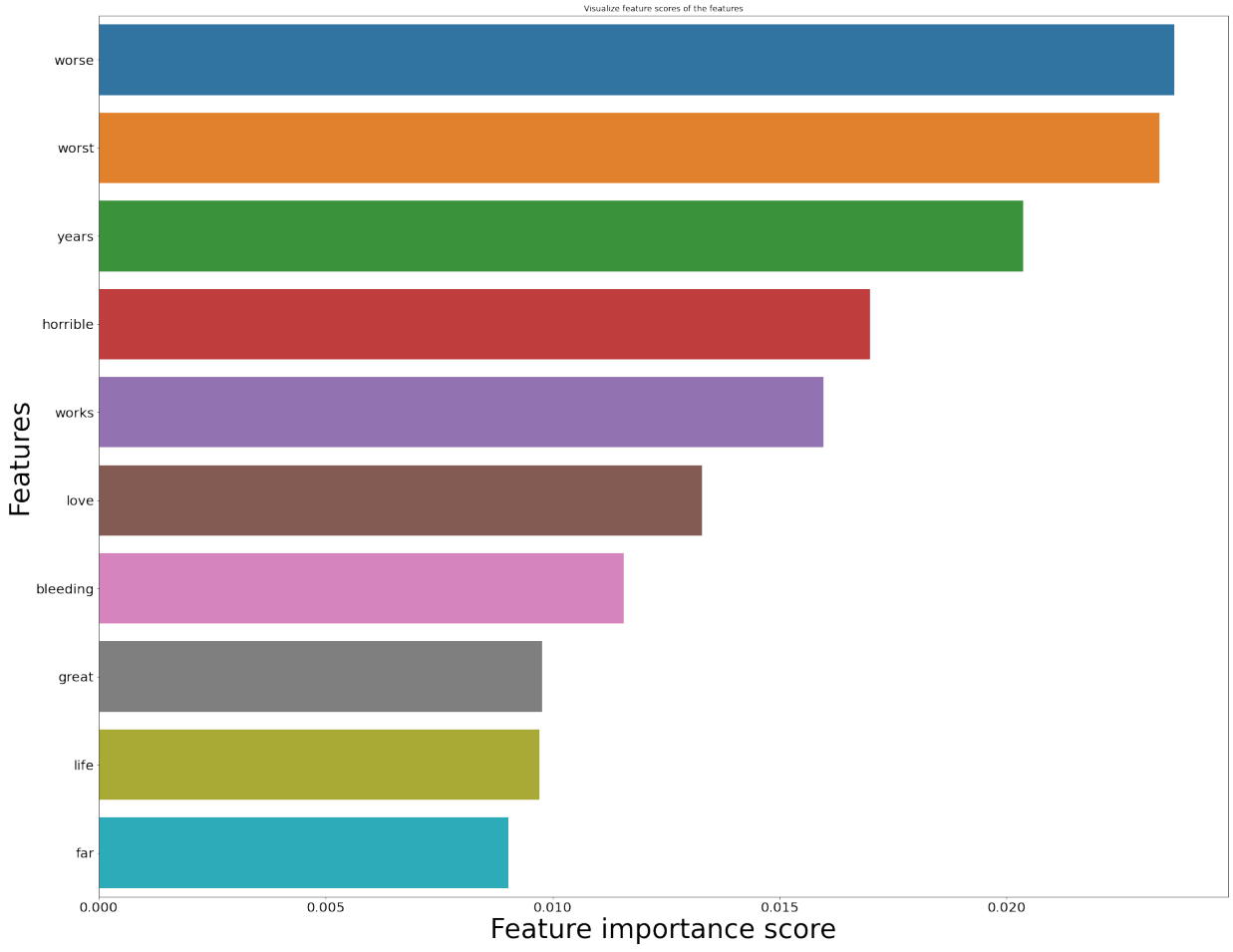


In [ ]:
```
#Print depth of the model tree
dtree_model.tree_.max_depth
```

Out[ ]: 712

In [ ]:

```
from sklearn.inspection import permutation_importance
#Feature importance
feature_scores_all = pd.Series(dtree_model.feature_importances_,
                               index= X_trainvec.columns).sort_values(
ascending=False)
#Select most important 10 feature
features_mask = pd.DataFrame(feature_scores_all).iloc[:10,:]
# Bar plot of feature importance
f, ax = plt.subplots(figsize=(30, 24))
ax = sns.barplot(x=(features_mask.iloc[:,0]), y=features_mask.index)
ax.set_title("Visualize feature scores of the features")
ax.set_yticklabels(features_mask.index)
ax.set_xlabel("Feature importance score", fontsize = 40)
ax.set_ylabel("Features", fontsize = 40)
plt.xticks(fontsize=20)
plt.yticks(fontsize=20)
plt.show()
```



In [ ]:
```
#Tuning
tune = [50,200,400,600]
result = []
for i in tune:
  dtree = tree.DecisionTreeClassifier(max_depth= i, random_state=42)
  dtree.fit(X_trainvec, y_train)
  dtreecv = cross_val_score(dtree , X_trainvec, y_train, cv=5, scoring
= 'accuracy',
                            n_jobs= 2)
  dtreecv_mean = dtreecv.mean()

  result.append({'max_depth': i, 'Train Accuracy': dtreecv_mean,'Test
Accuracy': dtree.score(X_testvec, y_test)})
print(result)
```

```
[{'max_depth': 50, 'Train Accuracy': 0.8289683329190705, 'Test Accur
acy': 0.8485807637328977}, {'max_depth': 200, 'Train Accuracy': 0.86
65237166066735, 'Test Accuracy': 0.898177455585052}, {'max_depth': 4
00, 'Train Accuracy': 0.8705696046170349, 'Test Accuracy': 0.9060394
118848274}, {'max_depth': 600, 'Train Accuracy': 0.8700080284908497,
'Test Accuracy': 0.9052225852562793}]
```

In [ ]:
```
result= pd.DataFrame(result)
result
```

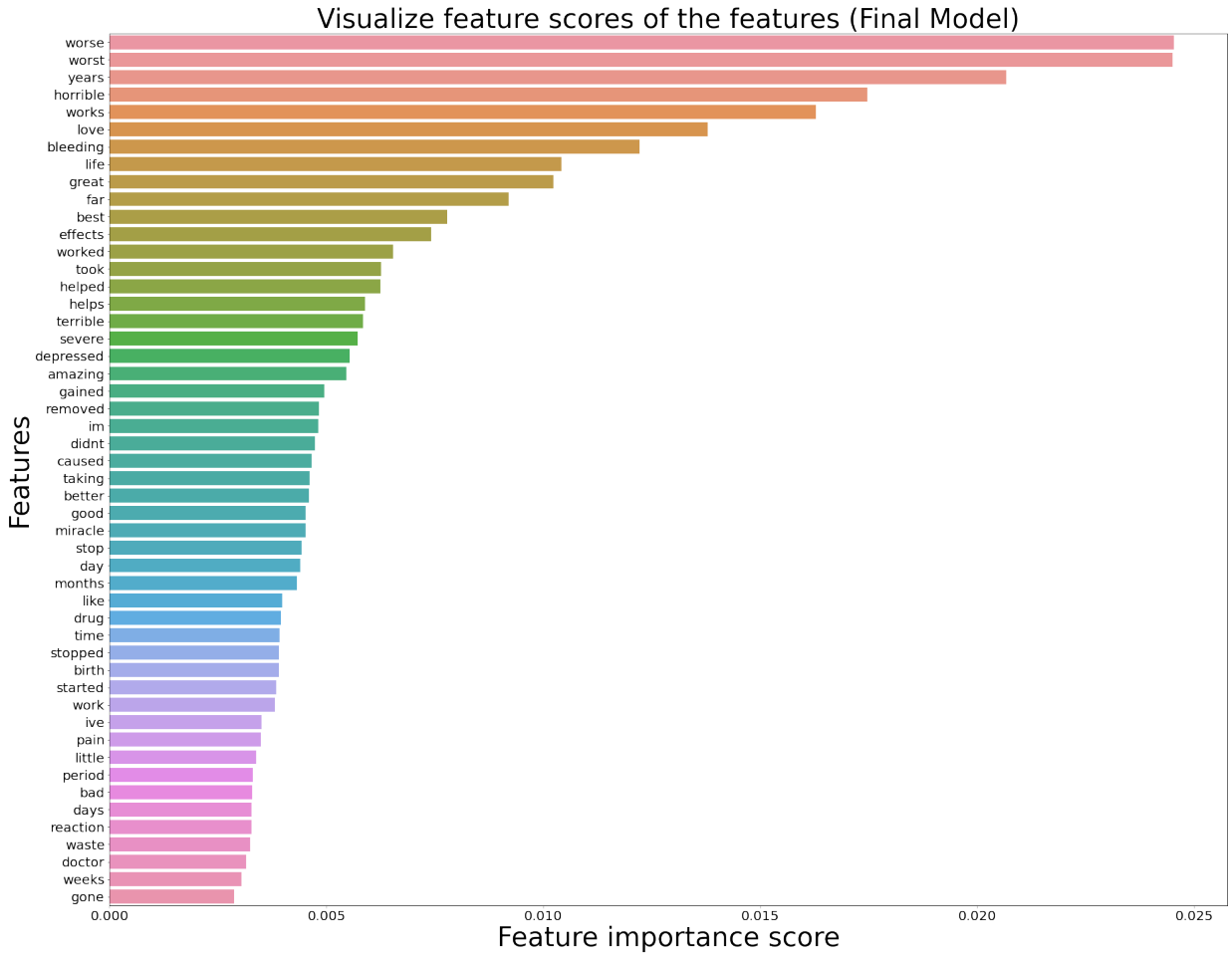
Out[ ]:

	max_depth	Train Accuracy	Test Accuracy
0	50	0.828968	0.848581
1	200	0.866524	0.898177
2	400	0.870570	0.906039
3	600	0.870008	0.905223

In [ ]:
```
Final_dtree_model= tree.DecisionTreeClassifier(random_state=42, max_de
pth = 200)  # Best Tuned Model
Final_dtree_model = Final_dtree_model.fit(X_trainvec, y_train)
y_pred_tree_final = Final_dtree_model.predict(X_testvec)
print('standard tree accuracy %2.2f ' % accuracy_score(y_test,y_pred_t
ree_final))
print(classification_report(y_test,y_pred_tree_final))
```

```
standard tree accuracy 0.90
              precision    recall  f1-score   support

           0       0.82      0.80      0.81     10613
           1       0.93      0.93      0.93     28563

    accuracy                           0.90     39176
   macro avg       0.87      0.87      0.87     39176
weighted avg       0.90      0.90      0.90     39176
```

In [ ]:
```
#Feature importance
feature_scores_all = pd.Series(Final_dtree_model.feature_importances_,
                               index= X_trainvec.columns).sort_values(
ascending=False)
#Select most important 10 feature
features_mask = pd.DataFrame(feature_scores_all).iloc[:50,:]
# Bar plot of feature importance
f, ax = plt.subplots(figsize=(30, 24))
ax = sns.barplot(x=(features_mask.iloc[:,0]), y=features_mask.index)
ax.set_title("Visualize feature scores of the features (Final Model)",
fontsize = 40)
ax.set_yticklabels(features_mask.index)
ax.set_xlabel("Feature importance score", fontsize = 40)
ax.set_ylabel("Features", fontsize = 40)
plt.xticks(fontsize=20)
plt.yticks(fontsize=20)
plt.show()
```



Logistic, SVM, and Perceptron

In [ ]:
```
#Loop to run logistic, svm, and perceptron
loss_f = ['log', 'hinge', 'perceptron']
sgdclfs = [SGDClassifier(loss=loss, random_state=42).fit(X_trainvec, y
_train) for loss in loss_f]
scores_list = []
avg_list = []
#Create different method with both 5-cv and boostrap632
for i, loss in enumerate(loss_f):
  cv = cross_val_score(sgdclfs[i], X_trainvec, y_train, cv=5, scoring=
'accuracy')
  scores_list.append({'Model': loss, 'Cross Validation': cv})
  avg_list.append({'Model': loss, 'Average Cross Validation': cv.mean(
)})
```

In [ ]:
```
pd.DataFrame(avg_list)
```

Out[ ]:

	Model	Average Cross Validation
0	log	0.838075
1	hinge	0.851476
2	perceptron	0.807616

In [28]:
```
#Use SVM model
l1clf = SGDClassifier(loss='hinge', random_state=42)
l1clf = l1clf.fit(X_trainvec, y_train)
y_pred_hinge = l1clf.predict(X_testvec)
print('Hinge Model Accuracy: %2.2f ' % accuracy_score(y_test,y_pred_hi
nge ))
print(classification_report(y_test,y_pred_hinge ))
```

```
Hinge Model Accuracy: 0.85
              precision    recall  f1-score   support

           0       0.82      0.57      0.67     10613
           1       0.86      0.96      0.90     28563

    accuracy                           0.85     39176
   macro avg       0.84      0.76      0.79     39176
weighted avg       0.85      0.85      0.84     39176
```

In [29]:
```
#Use perceptron model
l2clf = SGDClassifier(loss='perceptron', random_state=42)
l2clf = l1clf.fit(X_trainvec, y_train)
y_pred_per = l2clf.predict(X_testvec)
print('Perceptron Model Accuracy ' % accuracy_score(y_test,y_pred_per)
)
print(classification_report(y_test,y_pred_per ))
```

```
Perceptron Model Accuracy
              precision    recall  f1-score   support

           0       0.82      0.57      0.67     10613
           1       0.86      0.96      0.90     28563

    accuracy                           0.85     39176
   macro avg       0.84      0.76      0.79     39176
weighted avg       0.85      0.85      0.84     39176
```

In [30]:
```
#Use Log model
l3clf = SGDClassifier(loss='log', random_state=42)
l3clf = l3clf.fit(X_trainvec, y_train)
y_pred_log = l1clf.predict(X_testvec)
print('Perceptron Model Accuracy ' % accuracy_score(y_test,y_pred_log)
)
print(classification_report(y_test,y_pred_log ))
```

```
Perceptron Model Accuracy
              precision    recall  f1-score   support

           0       0.82      0.57      0.67     10613
           1       0.86      0.96      0.90     28563

    accuracy                           0.85     39176
   macro avg       0.84      0.76      0.79     39176
weighted avg       0.85      0.85      0.84     39176
```

Logistic Regression- SGD Classifier - Log Loss, L1 and L2 Regularization

In [ ]:
```
#Log Loss, L1 Regularization
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1]
result = []
for a in alphas:
  #Classifier with loss='log', penalty='l1', alpha=a, Then fit it on X
and y
  l1clf = SGDClassifier(loss='log', penalty='l1', alpha=a, random_stat
e=42).fit(X_trainvec, y_train)
  print('Finished training, alpha=%f' % a)
  # Compute cross_val_score for l1clf, cv=5, scoring='accuracy' and me
an
  l1cv = cross_val_score(l1clf , X_trainvec, y_train, cv=5, scoring= '
accuracy',
                         n_jobs= 2)
  l1_acc_mean = l1cv.mean()
  print('Finished 5-fold CV, alpha=%f' % a)
  result.append({'alpha': a, 'log L1': l1_acc_mean})
```

```
Finished training, alpha=0.000010
Finished 5-fold CV, alpha=0.000010
Finished training, alpha=0.000100
Finished 5-fold CV, alpha=0.000100
Finished training, alpha=0.001000
Finished 5-fold CV, alpha=0.001000
Finished training, alpha=0.010000
Finished 5-fold CV, alpha=0.010000
Finished training, alpha=0.100000
Finished 5-fold CV, alpha=0.100000
Finished training, alpha=1.000000
Finished 5-fold CV, alpha=1.000000
```

In [ ]:
```
l1_acc = pd.DataFrame(result)
l1_acc
```

Out[ ]:

	alpha	log L1
0	0.00001	0.860091
1	0.00010	0.828764
2	0.00100	0.740112
3	0.01000	0.725855
4	0.10000	0.725855
5	1.00000	0.725855

In [ ]:
```
#Log Loss, L2 Regularization
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1]
result = []
for a in alphas:
  #Classifier with loss='log', penalty='l2', alpha=a, Then fit it on X and y
  l2clf = SGDClassifier(loss='log', penalty='l2', alpha=a, random_state=42).fit(X_trainvec, y_train)
  print('Finished training, alpha=%f' % a)
  # Compute cross_val_score for l1clf, cv=5, scoring='accuracy' and mean
  l2cv = cross_val_score(l2clf , X_trainvec, y_train, cv=5, scoring= 'accuracy',
                         n_jobs= 2)
  l2_acc_mean = l2cv.mean()
 # print('Finished 5-fold CV, alpha=%f' % a)
  result.append({'alpha': a, 'log L2': l2_acc_mean})
```

```
Finished training, alpha=0.000010
Finished training, alpha=0.000100
Finished training, alpha=0.001000
Finished training, alpha=0.010000
Finished training, alpha=0.100000
Finished training, alpha=1.000000
```

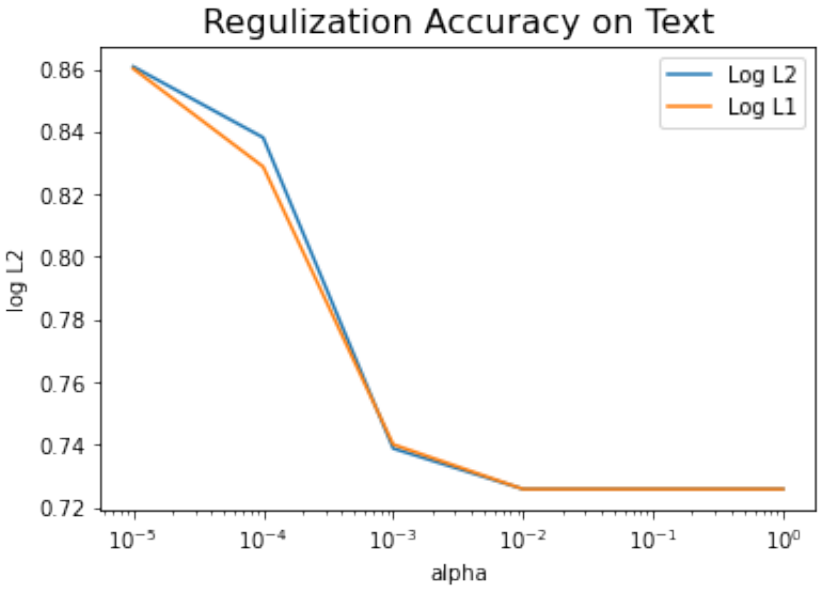
In [ ]:
```
l2_acc = pd.DataFrame(result)
l2_acc
```

Out[ ]:

	alpha	log L2
0	0.00001	0.860723
1	0.00010	0.838075
2	0.00100	0.738848
3	0.01000	0.725855
4	0.10000	0.725855
5	1.00000	0.725855

L1/L2 Accuracy Plot

In [ ]:
```
#Plot accuracy of L1 and L2 models
sns.lineplot(l2_acc['alpha'], l2_acc['log L2'])
sns.lineplot((l1_acc['alpha']), l1_acc['log L1'])
plt.title('Regulization Accuracy on Text', size=16)
plt.legend(labels=["Log L2","Log L1"])
plt.xscale('log')
plt.show()
```



--> Seems like the logistic regression doesn't need regularizaton. A regular logistic regression method could be used

In [ ]:
```
#Use Logistic model with no reguliztion
l1clf = SGDClassifier(loss='log', penalty='l1', alpha=0.00001, random_
state=42)
l1clf = l1clf.fit(X_trainvec, y_train)
y_pred_log = l1clf.predict(X_testvec)
print('standard tree accuracy %2.2f ' % accuracy_score(y_test,y_pred_l
og ))
print(classification_report(y_test,y_pred_log ))
```

```
standard tree accuracy 0.86
              precision    recall  f1-score   support

           0       0.78      0.67      0.72     10613
           1       0.88      0.93      0.91     28563

    accuracy                           0.86     39176
   macro avg       0.83      0.80      0.81     39176
weighted avg       0.86      0.86      0.86     39176
```

In [ ]:
```
calculate_results(y_test,y_pred_log)
```

Out[ ]:
```
{'accuracy': 86.060343067184,
 'f1': 0.8570364398053675,
 'precision': 0.8566981362912787,
 'recall': 0.8606034306718399}
```

In [ ]:
```
l1cv = cross_val_score(l1clf , X_trainvec, y_train, cv=5, scoring= 'ac
curacy',
                       n_jobs= 2)
print(l1cv)
```

```
[0.86047031 0.8590664  0.85893427 0.85973197 0.86225271]
```

Select KBest

In [ ]:
```
#feature selection
#Univariate feature selection
kbest = SelectKBest(chi2, k=10)
X_new= kbest.fit_transform(X_trainvec, y_train)
print('Top 10 features %s' % X_trainvec.columns[kbest.get_support()].t
olist())
```

```
Top 10 features ['best', 'bleeding', 'great', 'horrible', 'love', 't
errible', 'works', 'worse', 'worst', 'years']
```

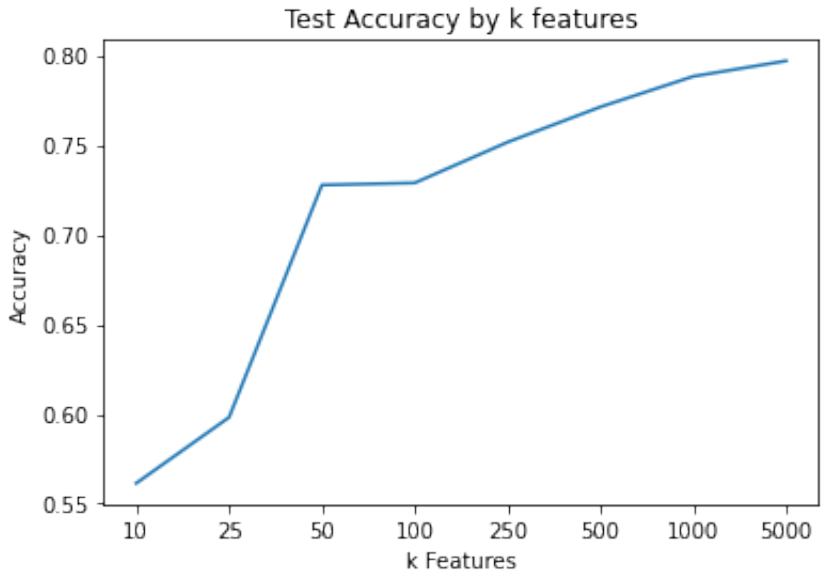
In [ ]:
```
k_vals = [10,25,50,100,250,500,1000,5000]
results1 = []
for k in k_vals:
    kbest = SelectKBest(chi2, k=k)
    X_new = kbest.fit_transform(X_trainvec, y_train)
    perc = Perceptron().fit(X_new, y_train)
    train_acc = np.mean(cross_val_score(perc, X_new, y_train, cv=5, sc
oring='accuracy'))
    # Test Accuracy using kbest features from training
    Xtest_new = kbest.transform(X_testvec)
    test_acc = np.mean(cross_val_score(perc, Xtest_new, y_test, cv=5,
scoring='accuracy'))

    results1.append({'k-value': k, 'Training Accuracy': train_acc, 'Te
st Accuracy':test_acc})
```

In [ ]:
```
results1_df = pd.DataFrame(results1)
results1_df
```

Out[ ]:

	k-value	Training Accuracy	Test Accuracy
0	10	0.733469	0.561415
1	25	0.655347	0.598145
2	50	0.735970	0.727690
3	100	0.745504	0.728865
4	250	0.759422	0.751582
5	500	0.783608	0.771237
6	1000	0.798292	0.788263
7	5000	0.815676	0.796891

In [ ]:
```
plt.plot(results1_df['Test Accuracy'])
plt.title('Test Accuracy by k features')
plt.xlabel('k Features')
plt.ylabel('Accuracy')
plt.xticks(range(len(k_vals)), k_vals)
plt.show();
```



In [ ]:
```
kbest = SelectKBest(chi2, k=5000)
X_new= kbest.fit_transform(X_trainvec, y_train)
perc = Perceptron().fit(X_new, y_train)
y_predKbest = perc.predict(X_testvec)
cf_matrixKbest = confusion_matrix(y_test, y_predKbest)

print(cf_matrixKbest)
```

```
[[ 6665  3948]
 [ 3270 25293]]
```

In [ ]:
```
kbestreecv = cross_val_score(perc , X_trainvec, y_train, cv=5, scoring
= 'accuracy',
                             n_jobs= 2)
print(kbestreecv)
```

```
[0.81436457 0.81229061 0.81263561 0.82137843 0.817709  ]
```

In [ ]:
```
calculate_results(y_test,y_predKbest)
```

Out[ ]:
```
{'accuracy': 81.57545435981213,
 'f1': 0.8137954045514426,
 'precision': 0.8123949424243453,
 'recall': 0.8157545435981213}
```

In [ ]:
```
print('KNN/Perceptron Accuracy: %2.2f ' % accuracy_score(y_test,y_pred
Kbest))
```

```
KNN/Perceptron Accuracy: 0.82
```

Naive Bayes Classifier

In [ ]:
```
from sklearn.naive_bayes import BernoulliNB

# initializaing the NB
classifer = BernoulliNB()

# training the model
classifer.fit(X_trainvec, y_train)

# testing the model
y_predNB = classifer.predict(X_testvec)

print('Naive Bayes Accuracy %2.2f ' % accuracy_score(y_test,y_predNB))
```

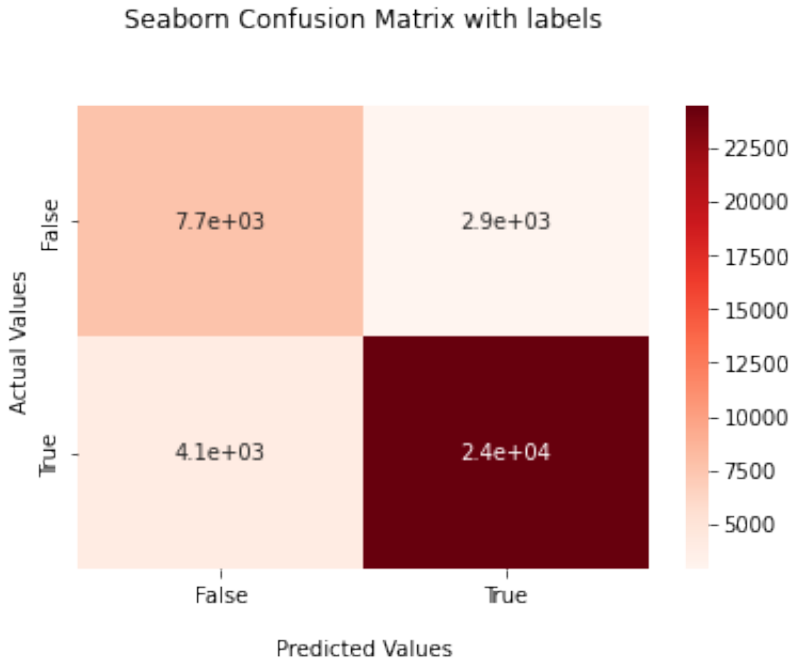
```
Naive Bayes Accuracy 0.82
```

In [ ]:
```
#cf_matrix Bernoulli Naive Bayes

cf_matrixNB = confusion_matrix(y_test, y_predNB)
print(cf_matrixNB)
```

```
[[ 7729  2884]
 [ 4074 24489]]
```

In [ ]:
```
#Naive Bayes Confusion Matrix
import seaborn as sns

ax = sns.heatmap(cf_matrixNB, annot=True, cmap='Reds')
ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])
```

Out[ ]:
```
[Text(0, 0.5, 'False'), Text(0, 1.5, 'True')]
```



In [ ]:
```
calculate_results(y_test,y_predNB)
```

Out[ ]:
```
{'accuracy': 82.23912599550745,
 'f1': 0.8252163727009926,
 'precision': 0.8296755807906638,
 'recall': 0.8223912599550746}
```

KNN Classifier

In [ ]:
```
#KNN Model Classifier
from sklearn.neighbors import KNeighborsClassifier
neigh = KNeighborsClassifier(n_neighbors=3)
neigh.fit(X_trainvec, y_train)
y_pred2 = neigh.predict(X_testvec)
```

In [ ]:
```
y_pred2 = neigh.predict(X_testvec)
```

In [ ]:
```
print('KNN Accuracy: %2.2f ' % accuracy_score(y_test,y_pred2))
```

```
KNN Accuracy: 0.74
```

In [ ]:
```
neighcv = cross_val_score(neigh , X_trainvec, y_train, cv=5, scoring=
'accuracy',
                          n_jobs= 2)
print(neighcv)
```

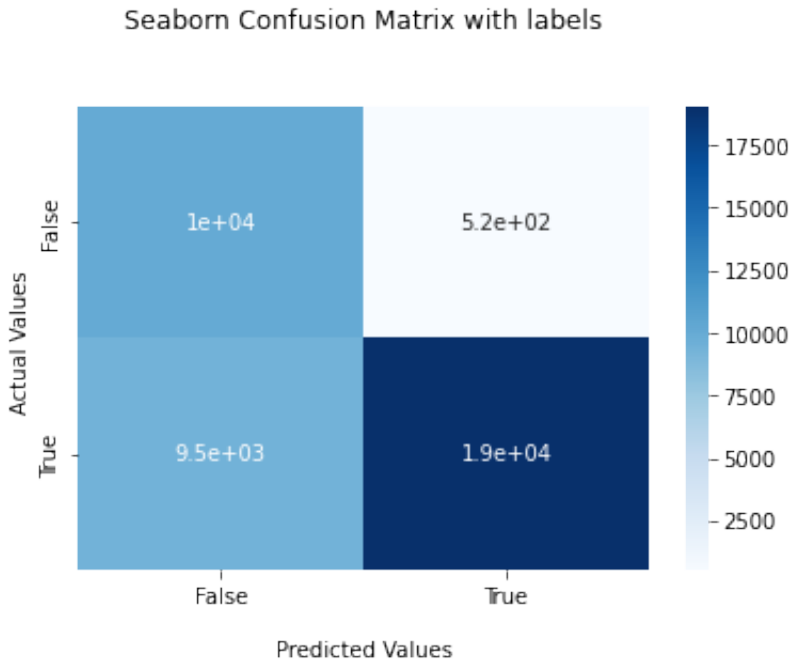
```
[0.73220382 0.66778341 0.66442246 0.66305041 0.66678366]
```

In [ ]:
```
#Confusion Matrix
cf_matrixKNN = confusion_matrix(y_test, y_pred2)
print(cf_matrixKNN)
```

```
[[10091   522]
 [ 9492 19071]]
```

In [ ]:
```
#KNN Confusion Matrix


ax = sns.heatmap(cf_matrixKNN, annot=True, cmap='Blues')
ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])
```

Out[ ]:
```
[Text(0, 0.5, 'False'), Text(0, 1.5, 'True')]
```



In [ ]:
```
calculate_results(y_test,y_pred2)
```

Out[ ]:
```
{'accuracy': 74.43843169287318,
 'f1': 0.7585440952168544,
 'precision': 0.8492657155449553,
 'recall': 0.7443843169287319}
```

ADA Boost Classifier

In [ ]:
```
from numpy import mean
from numpy import std
from sklearn.datasets import make_classification
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import RepeatedStratifiedKFold
from sklearn.ensemble import AdaBoostClassifier

# ADAboost model
modelADA = AdaBoostClassifier()
modelADA.fit(X_trainvec, y_train)
y_pred1 = modelADA.predict(X_testvec)
```

In [ ]:
```
print('ADA Boost Accuracy: %2.2f ' % accuracy_score(y_test,y_pred1))
```

```
ADA Boost Accuracy: 0.79
```

In [ ]:
```
adacv = cross_val_score(modelADA , X_trainvec, y_train, cv=5, scoring=
'accuracy',
                        n_jobs= 2)
print(adacv)
```

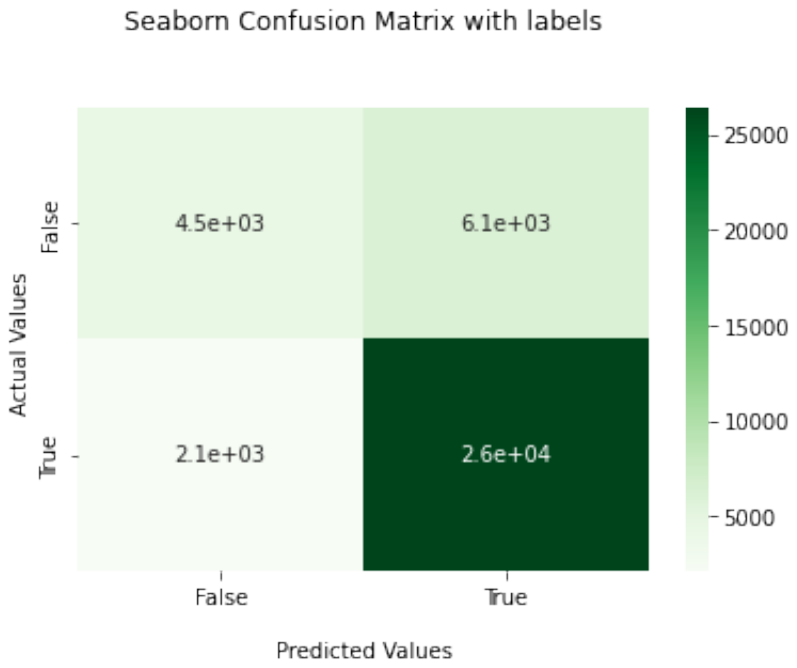
```
[0.79059379 0.78947704 0.78828973 0.78723676 0.79033184]
```

In [ ]:
```
#cf_matrix ADA Boost

cf_matrixADA = confusion_matrix(y_test, y_pred1)
print(cf_matrixADA)
```

```
[[ 4491  6122]
 [ 2103 26460]]
```

In [ ]:
```
#ADA Boost Confusion Matrix

ax = sns.heatmap(cf_matrixADA, annot=True, cmap='Greens')
ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])
```

Out[ ]:
```
[Text(0, 0.5, 'False'), Text(0, 1.5, 'True')]
```



In [ ]:
```
calculate_results(y_test,y_pred1)
```

Out[ ]:
```
{'accuracy': 79.00500306309985,
 'f1': 0.7724311625998657,
 'precision': 0.7766077662127545,
 'recall': 0.7900500306309985}
```

Top Words

In [ ]:
```
def plot_top_words(model, feature_names, n_top_words, title):
    fig, axes = plt.subplots(2, 5, figsize=(30, 15), sharex=True)
    axes = axes.flatten()
    for topic_idx, topic in enumerate(model.components_):
        top_features_ind = topic.argsort()[: -n_top_words - 1 : -1]
        top_features = [feature_names[i] for i in top_features_ind]
        weights = topic[top_features_ind]

        ax = axes[topic_idx]
        ax.barh(top_features, weights, height=0.7)
        ax.set_title(f"Topic {topic_idx +1}", fontdict={"fontsize": 30
})
        ax.invert_yaxis()
        ax.tick_params(axis="both", which="major", labelsize=20)
        for i in "top right left".split():
            ax.spines[i].set_visible(False)
        fig.suptitle(title, fontsize=40)

    plt.subplots_adjust(top=0.90, bottom=0.015, wspace=0.90, hspace=0.
3)
    plt.show()
```

In [ ]:
```
Vectorizer= CountVectorizer(analyzer='word',stop_words= 'english')
spmat1 = Vectorizer.fit_transform(X_train['review_clean'])
feat_names1= Vectorizer.get_feature_names_out()
```

In [ ]:
```
lda1 = LatentDirichletAllocation(
              n_components=10,
              max_iter=5,
              learning_method="online",
              learning_offset=50.0,
              random_state=0,)
lda1.fit(spmat1)
```

Out[ ]:
```
LatentDirichletAllocation(learning_method='online', learning_offset=
50.0,
                          max_iter=5, random_state=0)
```

In [ ]:
```
n_top_words=20
plot_top_words(lda1, feat_names1, n_top_words, "Topics in LDA model")
```