Assignment : DT

In [2]:
```
import pandas as pd
import pickle
import nltk
import seaborn as sn
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import roc_curve, auc
from sklearn.metrics import confusion_matrix
from nltk.sentiment.vader import SentimentIntensityAnalyzer
from tqdm.notebook import tqdm_notebook #https://www.analyticsvidhya.com/blog/2021/05/
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.preprocessing import StandardScaler
from scipy.sparse import hstack
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from wordcloud import WordCloud, STOPWORDS

%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import plotly.offline as offline
import  plotly.graph_objs as go
offline.init_notebook_mode()
```

In [7]:
```
import nltk
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
```
Out[7]: True

A - Loading Data

In [3]:
```
Data = pd.read_csv('preprocessed_data.csv')
```

In [4]:
```
Data.columns
```

Out[4]:
```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price'],
      dtype='object')
```

B- Calculate Sentiment Scores for the essay feature

In [8]:
```
sid = SentimentIntensityAnalyzer()
Negative,Neutral,Positive,Compound = [],[],[],[]
for text in tqdm_notebook(Data['essay']):
    ss = sid.polarity_scores(text)
    Negative.append(ss['neg'])
    Neutral.append(ss['neu'])
    Positive.append(ss['pos'])
    Compound.append(ss['compound'])
```

In [9]:
```
Data['neg'] = Negative
Data['neu'] = Neutral
Data['pos'] = Positive
Data['compound'] = Compound
```

C - Split your data

In [10]:
```
y = Data['project_is_approved'].values
y.shape
```

Out[10]: (109248,)

In [11]:
```
x = Data.drop(['project_is_approved'],axis = 1)
x.shape
```

Out[11]: (109248, 12)

In [12]:
```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.33,stratify=y,ra
```

In [13]:
```
print("x_train shape:",x_train.shape)
print("y_train shape:",y_train.shape)
print("------------------------")
print("x_test shape:",x_test.shape)
print("y_test shape:",y_test.shape)
```

```
x_train shape: (73196, 12)
y_train shape: (73196,)
------------------------
x_test shape: (36052, 12)
y_test shape: (36052,)
```

D - Perform TFIDF Vectorization of text data (essay)

In [14]:
```
vectorizer_tfidf = TfidfVectorizer(min_df=10)
vectorizer_tfidf.fit(x_train['essay'].values) # fit has to happen only on train data
```

Out[14]: TfidfVectorizer(min_df=10)

In [15]:
```
essay_tfidf_x_train = vectorizer_tfidf.transform(x_train['essay'].values)
essay_tfidf_x_test = vectorizer_tfidf.transform(x_test['essay'].values)
```

In [16]:
```
print(essay_tfidf_x_train.shape)
print(essay_tfidf_x_test.shape)
```

```
(73196, 14266)
(36052, 14266)
```

E - Perform w2v vectorization of text data

In [17]:
```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

I - Avg w2v

In [18]:
```
# average Word2Vec
# compute average word2vec for each review.
train_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm_notebook(x_train['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_avg_w2v_vectors.append(vector)

print(len(train_avg_w2v_vectors))
print(len(train_avg_w2v_vectors[0]))
```

```
73196
300
```

In [19]:
```
# average Word2Vec
# compute average word2vec for each review.
test_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm_notebook(x_test['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_avg_w2v_vectors.append(vector)

print(len(test_avg_w2v_vectors))
print(len(test_avg_w2v_vectors[0]))
```

```
36052
300
```

II - TFIDF weighted W2V

In [20]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(x_train['essay'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [21]:
```
# TFIDF weighted W2V
# compute average word2vec for each review.
train_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm_notebook(x_train['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((se
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # g
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_tfidf_w2v_vectors.append(vector)

print(len(train_tfidf_w2v_vectors))
print(len(train_tfidf_w2v_vectors[0]))
```

```
73196
300
```

In [22]:
```
# TFIDF weighted W2V
# compute average word2vec for each review.
test_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm_notebook(x_test['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((se
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # g
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_tfidf_w2v_vectors.append(vector)

print(len(test_tfidf_w2v_vectors))
print(len(test_tfidf_w2v_vectors[0]))
```

```
36052
300
```

F - Perform Encoding of Categorical Features

State State

In [23]:
```
vectorizer = CountVectorizer(binary=True)
vectorizer.fit(x_train['school_state'].values) # fit has to happen only on train data
```

Out[23]: CountVectorizer(binary=True)

In [24]:
```
# we use the fitted CountVectorizer to convert the text to vector
OHE_X_train_state = vectorizer.transform(x_train['school_state'].values)
OHE_X_test_state = vectorizer.transform(x_test['school_state'].values)
```

In [25]:
```
print("OHE_X_train_state:",OHE_X_train_state.shape)
print("OHE_X_test_state:",OHE_X_test_state.shape)
```

```
OHE_X_train_state: (73196, 51)
OHE_X_test_state: (36052, 51)
```

Teacher Prefix

In [26]:
```
vectorizer = CountVectorizer(binary=True)
vectorizer.fit(x_train['teacher_prefix'].values) # fit has to happen only on train da
```

Out[26]: CountVectorizer(binary=True)

In [27]:
```
# we use the fitted CountVectorizer to convert the text to vector
OHE_X_train_teacher_prefix = vectorizer.transform(x_train['teacher_prefix'].values)
OHE_X_test_teacher_prefix = vectorizer.transform(x_test['teacher_prefix'].values)
```

In [28]:
```
print("OHE_X_train_teacher_prefix:",OHE_X_train_teacher_prefix.shape)
print("OHE_X_test_teacher_prefix:",OHE_X_test_teacher_prefix.shape)
```

```
OHE_X_train_teacher_prefix: (73196, 5)
OHE_X_test_teacher_prefix: (36052, 5)
```

Project Grade Category

In [29]:
```
vectorizer = CountVectorizer(binary=True)
vectorizer.fit(x_train['project_grade_category'].values)
```

Out[29]: CountVectorizer(binary=True)

In [30]:
```
# we use the fitted CountVectorizer to convert the text to vector
OHE_X_train_grade_catagory = vectorizer.transform(x_train['project_grade_category'].va
OHE_X_test_grade_catagory = vectorizer.transform(x_test['project_grade_category'].valu
```

In [31]:
```
print("OHE_X_train_grade_catagory:",OHE_X_train_grade_catagory.shape)
print("OHE_X_test_grade_catagory:",OHE_X_test_grade_catagory.shape)
```

```
OHE_X_train_grade_catagory: (73196, 4)
OHE_X_test_grade_catagory: (36052, 4)
```

Clean Categories

In [32]:
```
vectorizer = CountVectorizer(binary=True)
vectorizer.fit(x_train['clean_categories'].values)
```

Out[32]: CountVectorizer(binary=True)

In [33]:
```
# we use the fitted CountVectorizer to convert the text to vector
OHE_X_train_clean_categories = vectorizer.transform(x_train['clean_categories'].values
OHE_X_test_clean_categories= vectorizer.transform(x_test['clean_categories'].values)
```

In [34]:
```
print("OHE_X_train_clean_categories:",OHE_X_train_clean_categories.shape)
print("OHE_X_test_clean_categories:",OHE_X_test_clean_categories.shape)
```

```
OHE_X_train_clean_categories: (73196, 9)
OHE_X_test_clean_categories: (36052, 9)
```

clean Subcategories

In [35]:
```
vectorizer = CountVectorizer(binary=True)
vectorizer.fit(x_train['clean_subcategories'].values)
```

Out[35]: CountVectorizer(binary=True)

In [36]:
```
# we use the fitted CountVectorizer to convert the text to vector
OHE_X_train_clean_subcategories = vectorizer.transform(x_train['clean_subcategories']
OHE_X_test_clean_subcategories= vectorizer.transform(x_test['clean_subcategories'].va
```

In [37]:
```
print("OHE_X_train_clean_subcategories:",OHE_X_train_clean_subcategories.shape)
print("OHE_X_test_clean_subcategories:",OHE_X_test_clean_subcategories.shape)
```

```
OHE_X_train_clean_subcategories: (73196, 30)
OHE_X_test_clean_subcategories: (36052, 30)
```

G - Perform Encoding of Numerical Features

Teacher Number of Previously Posted Projects

In [38]:
```
scaler = StandardScaler()
scaler.fit(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1
```

Out[38]: StandardScaler()

In [39]:
```
scaler_X_train_teacher_number_of_previously_posted_projects = scaler.transform(x_train
scaler_X_test_teacher_number_of_previously_posted_projects = scaler.transform(x_test[
```

In [40]:
```
print("scaler_X_train_teacher_number_of_previously_posted_projects:",scaler_X_train_te
print("scaler_X_test_teacher_number_of_previously_posted_projects:",scaler_X_test_teac
```

```
scaler_X_train_teacher_number_of_previously_posted_projects: (73196, 1)
scaler_X_test_teacher_number_of_previously_posted_projects: (36052, 1)
```

Price

In [41]:
```
scaler = StandardScaler()
scaler.fit(x_train['price'].values.reshape(-1,1))
```

Out[41]: StandardScaler()

In [42]:
```
scaler_X_train_price = scaler.transform(x_train['price'].values.reshape(-1,1))
scaler_X_test_price = scaler.transform(x_test['price'].values.reshape(-1,1))
```

In [43]:
```
print("scaler_X_train_price:",scaler_X_train_price.shape)
print("scaler_X_test_price:",scaler_X_test_price.shape)
```

```
scaler_X_train_price: (73196, 1)
scaler_X_test_price: (36052, 1)
```

Negative Sentiment Scores

In [44]:
```
scaler = StandardScaler()
scaler.fit(x_train['neg'].values.reshape(-1,1))
```

Out[44]: StandardScaler()

In [45]:
```
scaler_X_train_NSS = scaler.transform(x_train['neg'].values.reshape(-1,1))
scaler_X_test_NSS = scaler.transform(x_test['neg'].values.reshape(-1,1))
```

In [46]:
```
print("scaler_X_train_NSS:",scaler_X_train_NSS.shape)
print("scaler_X_test_NSS:",scaler_X_test_NSS.shape)
```

```
scaler_X_train_NSS: (73196, 1)
scaler_X_test_NSS: (36052, 1)
```

Neutral Sentiment Scores

In [47]:
```
scaler = StandardScaler()
scaler.fit(x_train['neu'].values.reshape(-1,1))
```

Out[47]: StandardScaler()

In [48]:
```
scaler_X_train_NUSS = scaler.transform(x_train['neu'].values.reshape(-1,1))
scaler_X_test_NUSS = scaler.transform(x_test['neu'].values.reshape(-1,1))
```

In [49]:
```
print("scaler_X_train_NUSS:",scaler_X_train_NUSS.shape)
print("scaler_X_test_NUSS:",scaler_X_test_NUSS.shape)
```

```
scaler_X_train_NUSS: (73196, 1)
scaler_X_test_NUSS: (36052, 1)
```

Positive Sentiment Scores

In [50]:
```
scaler = StandardScaler()
scaler.fit(x_train['pos'].values.reshape(-1,1))
```

Out[50]: StandardScaler()

In [51]:
```
scaler_X_train_PSS = scaler.transform(x_train['pos'].values.reshape(-1,1))
scaler_X_test_PSS = scaler.transform(x_test['pos'].values.reshape(-1,1))
```

In [52]:
```
print("scaler_X_train_PSS:",scaler_X_train_PSS.shape)
print("scaler_X_test_PSS:",scaler_X_test_PSS.shape)
```

```
scaler_X_train_PSS: (73196, 1)
scaler_X_test_PSS: (36052, 1)
```

Compound Sentiment Scores

In [53]:
```
scaler = StandardScaler()
scaler.fit(x_train['compound'].values.reshape(-1,1))
```

Out[53]: StandardScaler()

In [54]:
```
scaler_X_train_CSS = scaler.transform(x_train['compound'].values.reshape(-1,1))
scaler_X_test_CSS = scaler.transform(x_test['compound'].values.reshape(-1,1))
```

In [55]:
```
print("scaler_X_train_CSS:",scaler_X_train_CSS.shape)
print("scaler_X_test_CSS:",scaler_X_test_CSS.shape)
```

```
scaler_X_train_CSS: (73196, 1)
scaler_X_test_CSS: (36052, 1)
```

G - For Task-1 Set-1 (TFIDF) stack up all the features

In [56]:
```
train_set_1 = hstack((essay_tfidf_x_train, OHE_X_train_state, OHE_X_train_teacher_pre
                     OHE_X_train_clean_categories,OHE_X_train_clean_subcategories, sca
                     scaler_X_train_price, scaler_X_train_NSS, scaler_X_train_NUSS, sc
print(train_set_1.shape,  y_train.shape)
```

```
(73196, 14371) (73196,)
```

In [57]:
```
test_set_1 = hstack((essay_tfidf_x_test, OHE_X_test_state, OHE_X_test_teacher_prefix,
                     OHE_X_test_clean_categories,OHE_X_test_clean_subcategories, scale
                     scaler_X_test_price, scaler_X_test_NSS, scaler_X_test_NUSS, scale

print(test_set_1.shape,  y_test.shape)
```

```
(36052, 14371) (36052,)
```

H - For Task-1 Set-2 (TFIDF_w2v) stack up all the features

In [58]:
```
train_set_2 = hstack((train_tfidf_w2v_vectors, OHE_X_train_state, OHE_X_train_teacher_
                     OHE_X_train_clean_categories,OHE_X_train_clean_subcategories, sca
                     scaler_X_train_price, scaler_X_train_NSS, scaler_X_train_NUSS, sc
print(train_set_2.shape,  y_train.shape)
```

```
(73196, 405) (73196,)
```

In [59]:
```
test_set_2 = hstack((test_tfidf_w2v_vectors, OHE_X_test_state, OHE_X_test_teacher_pre
                     OHE_X_test_clean_categories,OHE_X_test_clean_subcategories, scale
                     scaler_X_test_price, scaler_X_test_NSS, scaler_X_test_NUSS, scale

print(test_set_2.shape,  y_test.shape)
```

```
(36052, 405) (36052,)
```

I - Perform Hyperparameter Tuning & Plot either Heatmap or 3d Plot

Task - 1

Set - 1

In [60]:
```
param_grid = {'max_depth':[1,3,10,30],'min_samples_split':[5,10,100,500]}
```

In [61]:
```
DT = DecisionTreeClassifier()
```

In [62]:
```
search = GridSearchCV(DT, param_grid, n_jobs=-1, scoring="roc_auc", cv=3, return_trai
search.fit(train_set_1,y_train)
```

Out[62]:
```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(), n_jobs=-1,
             param_grid={'max_depth': [1, 3, 10, 30],
                         'min_samples_split': [5, 10, 100, 500]},
             return_train_score=True, scoring='roc_auc')
```

In [63]:
```
estimator = search.best_estimator_
print("Best Estimator:",estimator)
```

```
Best Estimator: DecisionTreeClassifier(max_depth=10, min_samples_split=500)
```

In [64]:
```
score = search.best_score_
print("Best Score:",score)
```

```
Best Score: 0.6444997372575579
```

In [65]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearc
result = search.cv_results_
mean_train_score = result["mean_train_score"]
mean_test_score  = result['mean_test_score']
print("mean_train_score:",mean_train_score)
print("-----------------------------------------------------")
print("mean_test_score:",mean_test_score)
```

```
mean_train_score: [0.54937496 0.54937496 0.54937496 0.54937496 0.6091472  0.6091472
 0.6091472  0.6091472  0.70604193 0.70516132 0.70083849 0.69438828
 0.85450947 0.84926587 0.8211391  0.78749895]
-----------------------------------------------------
mean_test_score: [0.54847504 0.54847504 0.54847504 0.54847504 0.60196747 0.60196747
 0.60196747 0.60196747 0.63553778 0.63604691 0.63996102 0.64449974
 0.56291083 0.57539338 0.60335215 0.63178284]
```

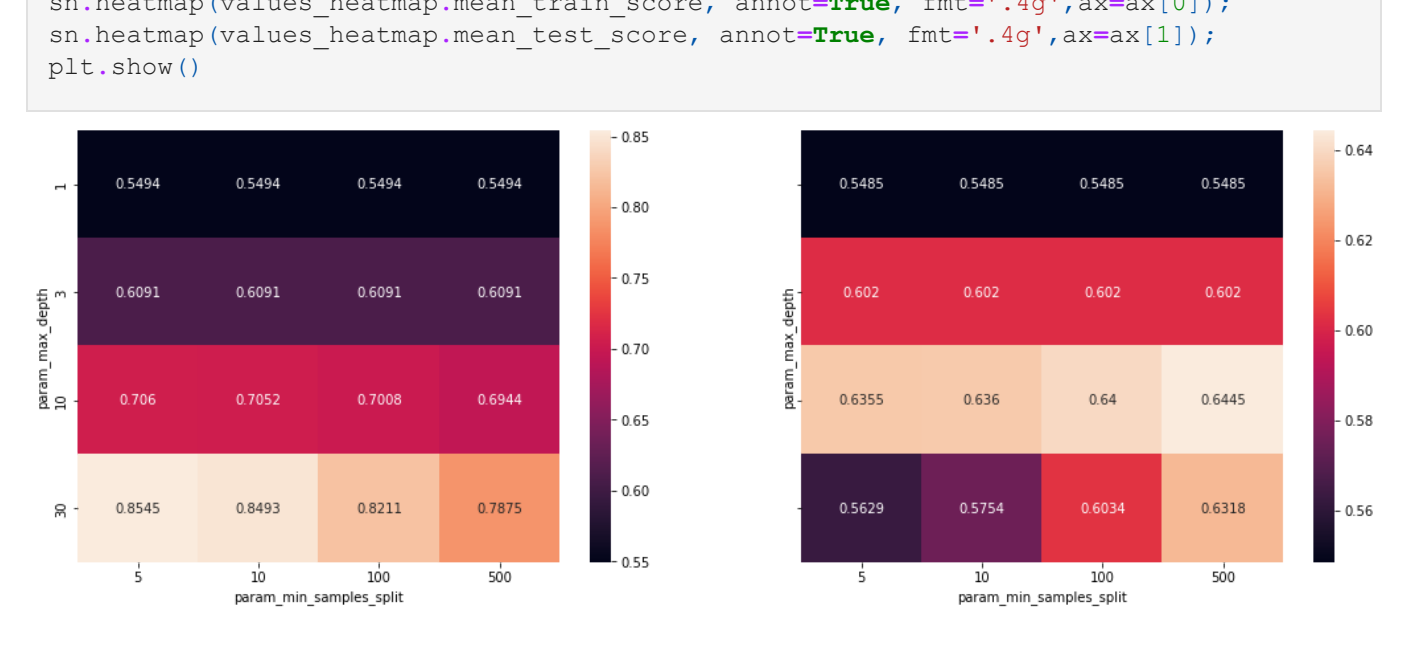
In [66]:
```
x = param_grid['max_depth']
y = param_grid['min_samples_split']
train_auc_z = mean_train_score
test_auc_z = mean_test_score
```

In [68]:
```
# https://stackoverflow.com/questions/56302647/how-to-plot-a-heatmap-and-find-best-hy
values_heatmap = pd.DataFrame(search.cv_results_)
values_heatmap = values_heatmap.groupby(['param_max_depth','param_min_samples_split'])
values_heatmap = values_heatmap.unstack()[['mean_test_score', 'mean_train_score']]
values_heatmap.head()
```

Out[68]:

	mean_test_score				mean_train_score			
param_min_samples_split	5	10	100	500	5	10	100	500
param_max_depth								
1	0.548475	0.548475	0.548475	0.548475	0.549375	0.549375	0.549375	0.549375
3	0.601967	0.601967	0.601967	0.601967	0.609147	0.609147	0.609147	0.609147
10	0.635538	0.636047	0.639961	0.644500	0.706042	0.705161	0.700838	0.694388
30	0.562911	0.575393	0.603352	0.631783	0.854509	0.849266	0.821139	0.787499

In [69]:
```
# https://stackoverflow.com/questions/56478320/how-to-create-multiple-seaborn-heatmap
fig, ax = plt.subplots(ncols=2, sharey=True,figsize=(18,6))
sn.heatmap(values_heatmap.mean_train_score, annot=True, fmt='.4g',ax=ax[0]);
sn.heatmap(values_heatmap.mean_test_score, annot=True, fmt='.4g',ax=ax[1]);
plt.show()
```



Using the Best Parameters, fit the model. Plot ROC-AUC curve(using predict proba method)

In [70]:
```
clf = DecisionTreeClassifier(max_depth=search.best_params_['max_depth'],
                             min_samples_split=search.best_params_['min_samples_spli
```

In [71]:
```
clf.fit(train_set_1,y_train)
```

Out[71]: DecisionTreeClassifier(max_depth=10, min_samples_split=500)

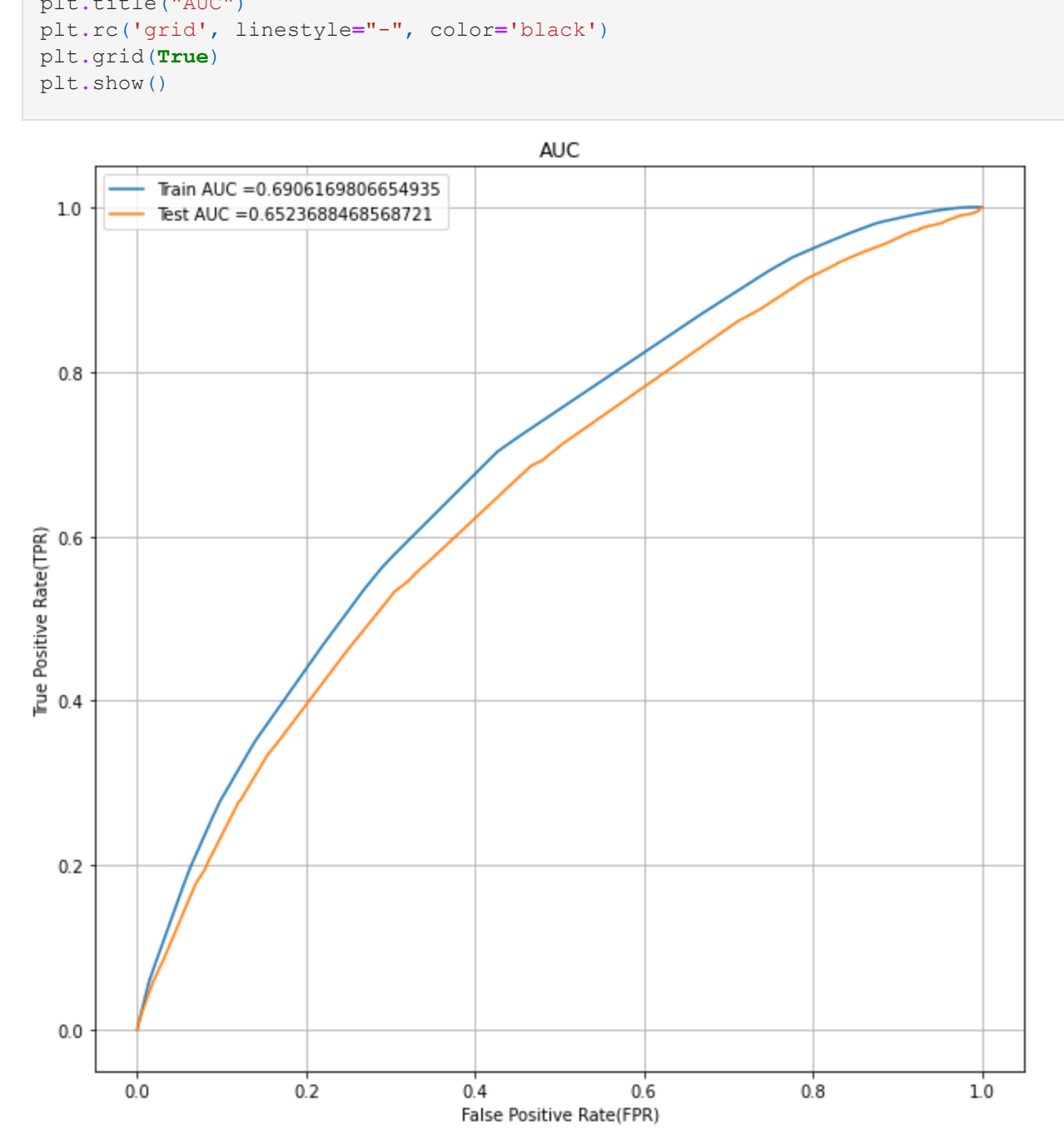
In [72]:
```
train_value = clf.predict_proba(train_set_1)
train_set_1_y = train_value[:,1]
print("train_set_1_y:",train_set_1_y.shape)
test_value = clf.predict_proba(test_set_1)
test_set_1_y = test_value[:,1]
print("test_set_1_y:",test_set_1_y.shape)
```

```
train_set_1_y: (73196,)
test_set_1_y: (36052,)
```

In [73]:
```
train_fpr, train_tpr, train_thresholds = roc_curve(y_train,train_set_1_y)
Train_AUC = auc(train_fpr, train_tpr)
test_fpr, test_tpr, test_thresholds = roc_curve(y_test,test_set_1_y)
Test_AUC = auc(test_fpr, test_tpr)
print("Train AUC:",Train_AUC)
print("Test AUC:",Test_AUC)
```

```
Train AUC: 0.6906169806654935
Test AUC: 0.6523688468581271
```

In [74]:
```
plt.figure(figsize=(10,10))
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(Train_AUC))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(Test_AUC))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.rc('grid', linestyle="-", color='black')
plt.grid(True)
plt.show()
```



Plot confusion matrix based on best threshold value

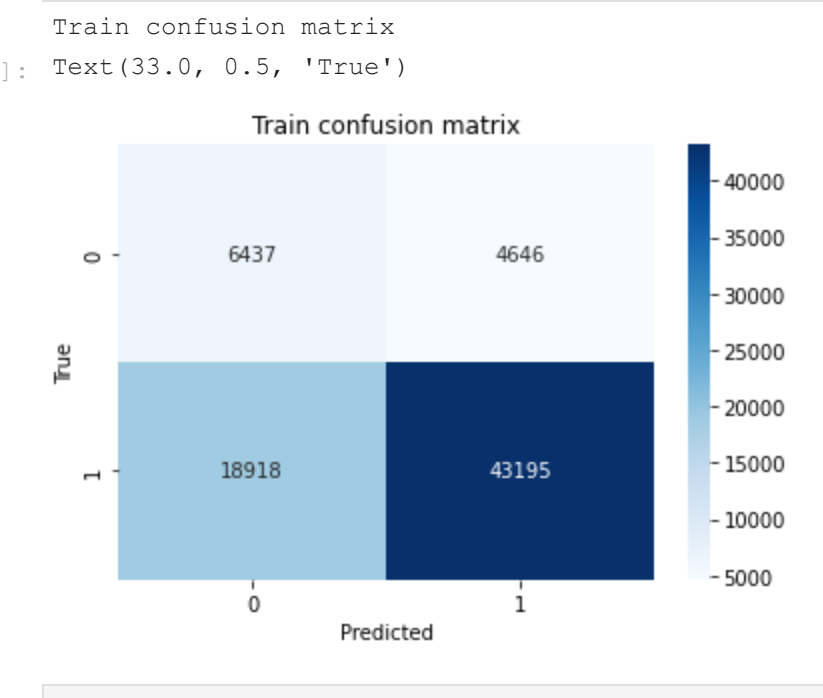
In [75]:
```
from sklearn.metrics import confusion_matrix

# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.r
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [76]:
```
best_t = find_best_threshold(train_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(train_set_1_y, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(test_set_1_y, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.403903064681679 for threshold 0.852
Train confusion matrix
[[ 6437  4646]
 [18918 43195]]
Test confusion matrix
[[ 2914  2545]
 [ 9621 20972]]
```

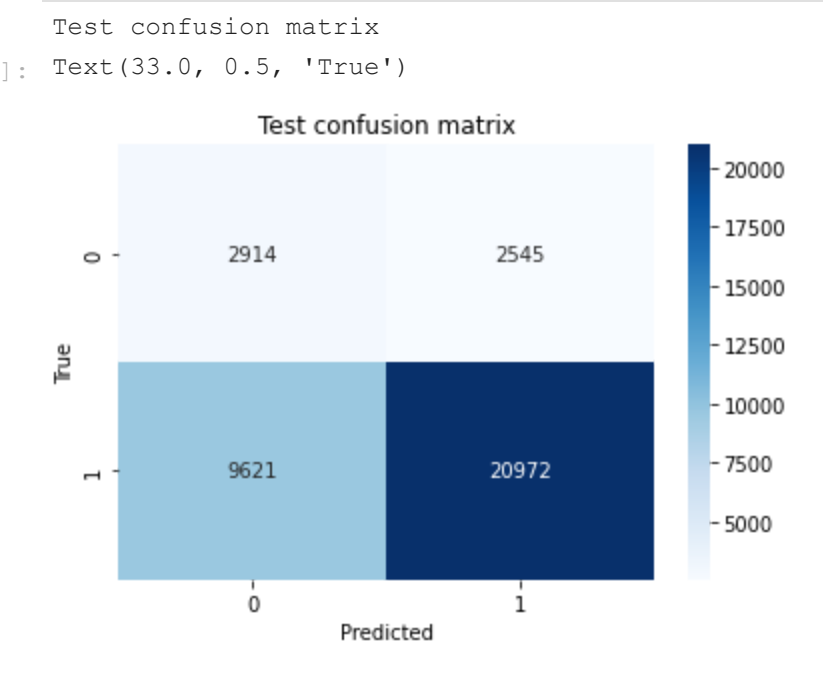
In [77]:
```
import seaborn as sns
import matplotlib.pyplot as plt
print("Train confusion matrix")
plt.title("Train confusion matrix")
sns.heatmap(confusion_matrix(y_train, predict_with_best_t(train_set_1_y, best_t)), an
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Train confusion matrix
```
Out[77]: Text(33.0, 0.5, 'True')



In [78]:
```
import seaborn as sns
import matplotlib.pyplot as plt
print("Test confusion matrix")
plt.title("Test confusion matrix")
sns.heatmap(confusion_matrix(y_test, predict_with_best_t(test_set_1_y, best_t)), anno
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Test confusion matrix
```
Out[78]: Text(33.0, 0.5, 'True')



Find all the false positive data points and plot wordcloud of essay text and pdf of teacher_number_of_previously_posted_projects.

In [79]:
```
predict_values = predict_with_best_t(test_set_1_y,best_t)
```

In [80]:
```
false_pos = []
for x in range(len(y_test)):
    if(y_test[x]==0) and (predict_values[x]==1)):
        false_pos.append(x)
print("false_pos:",len(false_pos))
```

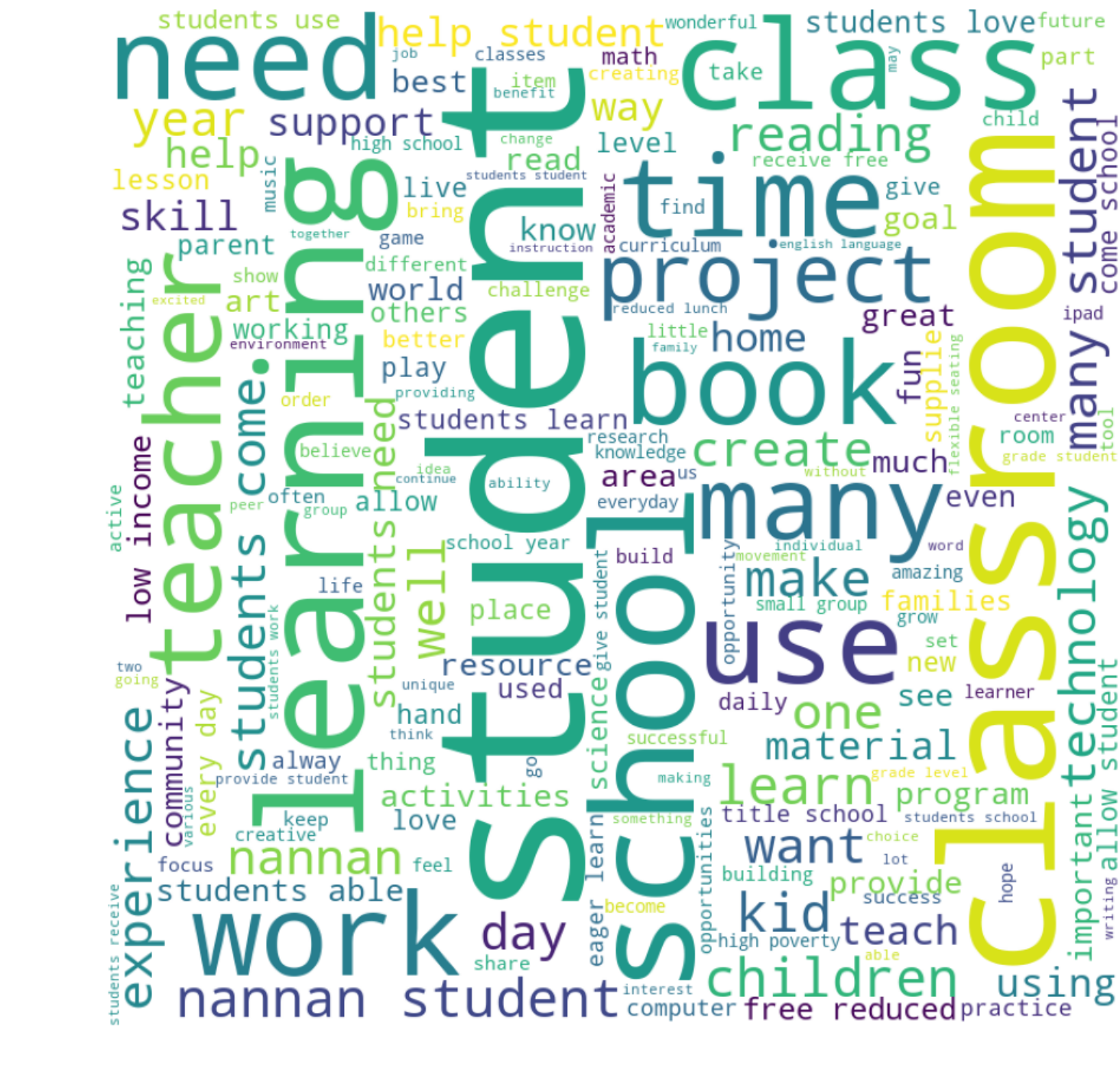
```
false_pos: 2545
```

In [81]:
```
features = x_test.columns
false_pos_ds = pd.DataFrame(columns=features)
false_pos_ds = x_test.iloc[false_pos]
print("false_pos_ds:",false_pos_ds.shape)
```

```
false_pos_ds: (2545, 12)
```

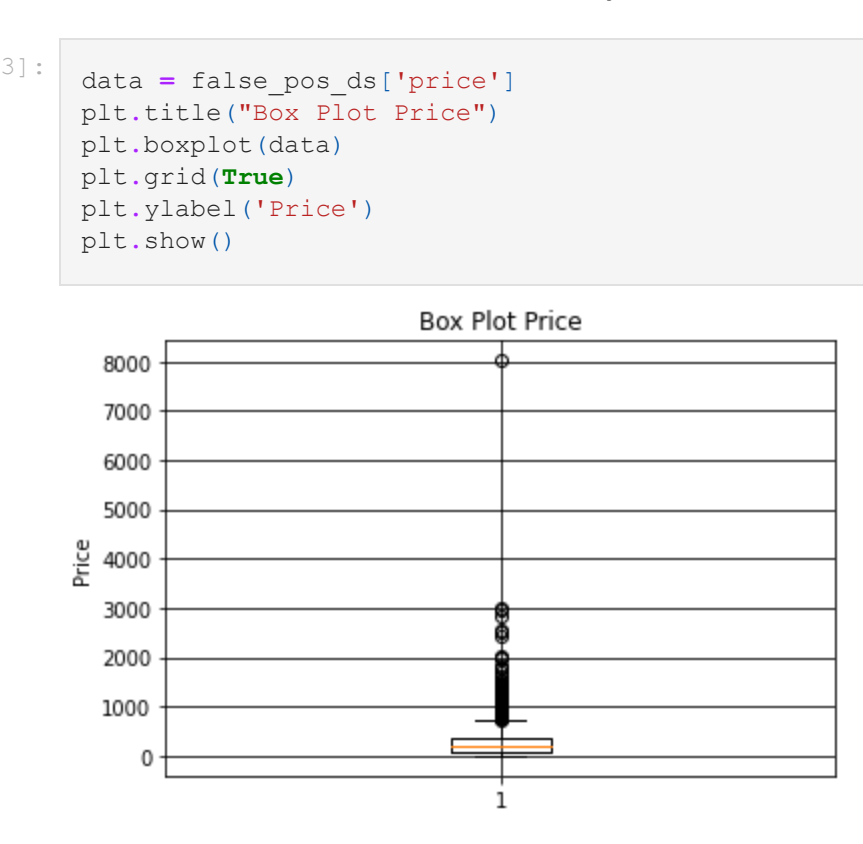
Plot the WordCloud(https://www.geeksforgeeks.org/generating-word-cloud-python/) with the words of essay text of these `false positive data points

In [82]:
```
# https://www.geeksforgeeks.org/generating-word-cloud-python/
comment_words = ''
stopwords = set(STOPWORDS)
for val in false_pos_ds["essay"]:
    val = str(val)
    tokens = val.split()
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()
    comment_words += " ".join(tokens)+" "
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='white',
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (12, 12), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



Plot the box plot with the *price* of these $false positive data p \oint s$

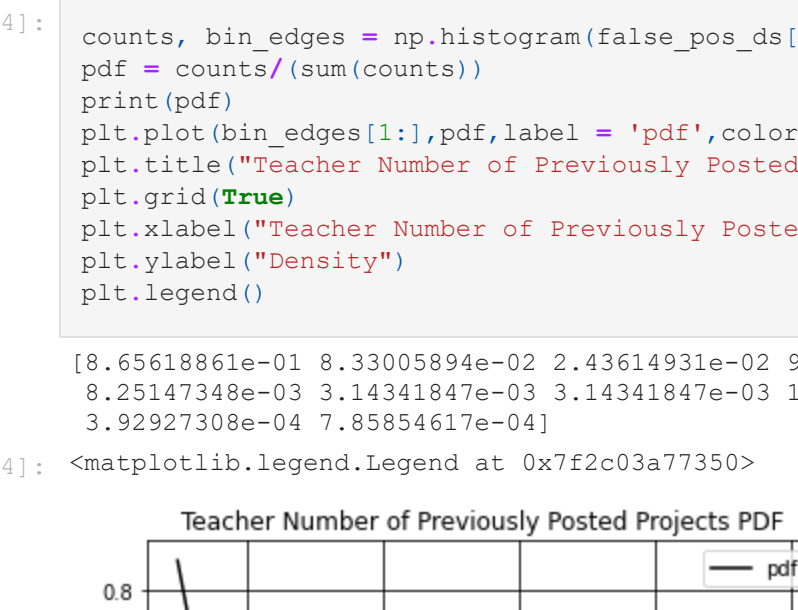
```
data = false_pos_ds['price']
plt.title("Box Plot Price")
plt.boxplot(data)
plt.grid(True)
plt.ylabel('Price')
plt.show()
```



Plot the pdf with the $teacher_number_of_previously_posted_projects$ of these $false positive data p \oint s$

```
counts, bin_edges = np.histogram(false_pos_ds['teacher_number_of_previously_posted_pro
pdf = counts/(sum(counts))
print(pdf)
plt.plot(bin_edges[1:],pdf,label = 'pdf',color='black')
plt.title("Teacher Number of Previously Posted Projects PDF")
plt.grid(True)
plt.xlabel("Teacher Number of Previously Posted Projects")
plt.ylabel("Density")
plt.legend()
```

```
[8.65618861e-01 8.33005894e-02 2.43614931e-02 9.82318271e-03
 8.25147348e-03 3.14341847e-03 1.14931894e-03 1.17878193e-03
 3.92927308e-04 7.85854617e-04]
<matplotlib.legend.Legend at 0x7f2c03a77350>
```



Set - 2

```
train_set_2 = hstack((train_tfidf_w2v_vectors, OHE_X_train_state, OHE_X_train_teacher_
                      ONE_X_train_clean_categories,ONE_X_train_clean_subcategories, sc
                      scaler_X_train_price, scaler_X_train_NSS, scaler_X_train_NUSS, s
print(train_set_2.shape,  y_train.shape)
```

```
(73196, 405) (73196,)
```

```
test_set_2 = hstack((test_tfidf_w2v_vectors, OHE_X_test_state, OHE_X_test_teacher_pre
                     ONE_X_test_clean_categories,ONE_X_test_clean_subcategories, scale
                     scaler_X_test_price, scaler_X_test_NSS, scaler_X_test_NUSS, scale

print(test_set_2.shape,  y_test.shape)
```

```
(36052, 405) (36052,)
```

```
param_grid = {'max_depth':[1,3,10,30],'min_samples_split':[5,10,100,500]}
```

```
search = GridSearchCV(DT, param_grid, n_jobs=-1, scoring="roc_auc", cv=3, return_trai
search.fit(train_set_2,y_train)
```

```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(), n_jobs=-1,
             param_grid={'max_depth': [1, 3, 10, 30],
                         'min_samples_split': [5, 10, 100, 500]},
             return_train_score=True, scoring='roc_auc')
```

```
estimator = search.best_estimator_
print("Best Estimator:",estimator)
```

```
Best Estimator: DecisionTreeClassifier(max_depth=10, min_samples_split=500)
```

```
score = search.best_score_
print("Best Score:",score)
```

```
Best Score: 0.6270240938739212
```

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearc
result = search.cv_results_
mean_train_score = result['mean_train_score']
mean_test_score  = result['mean_test_score']
print("mean_train_score:",mean_train_score)
print("--------------------------------")
print("mean_test_score:",mean_test_score)
```

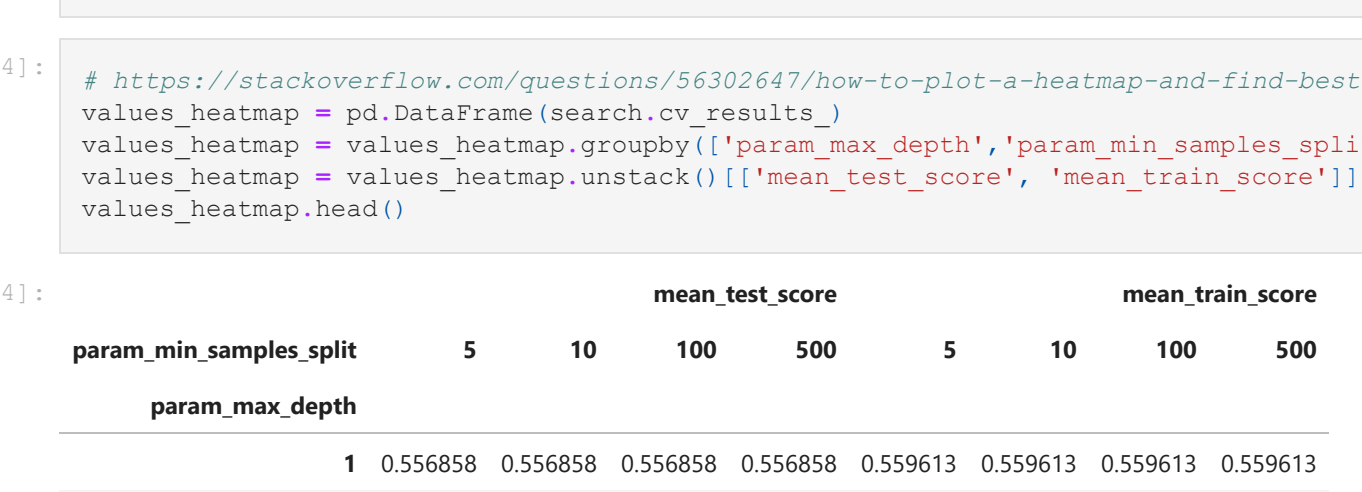
```
mean_train_score: [0.55961343 0.55961343 0.55961343 0.55961343 0.62181246 0.62181246
 0.62181246 0.62181246 0.76814409 0.76600393 0.7487139  0.72362014
 0.99576362 0.99171946 0.91868122 0.78320164]
--------------------------------
mean_test_score: [0.55685778 0.55685778 0.55685778 0.55685778 0.61195749 0.61195749
 0.61195749 0.61195749 0.6092810  0.6106834  0.61800101 0.62702409
 0.50837454 0.51455788 0.56721786 0.61566837]
```

```
x = param_grid['max_depth']
y = param_grid['min_samples_split']
train_auc_2 = mean_train_score
test_auc_2 = mean_test_score
```

```
# https://stackoverflow.com/questions/56302647/how-to-plot-a-heatmap-and-find-best-hy
values_heatmap = pd.DataFrame(search.cv_results_)
values_heatmap = values_heatmap.groupby(['param_max_depth','param_min_samples_split'])
values_heatmap = values_heatmap.unstack()[['mean_test_score', 'mean_train_score']]
values_heatmap.head()
```

	mean_test_score				mean_train_score			
param_min_samples_split	5	10	100	500	5	10	100	500
param_max_depth								
1	0.556858	0.556858	0.556858	0.556858	0.559613	0.559613	0.559613	0.559613
3	0.611957	0.611957	0.611957	0.611957	0.621812	0.621812	0.621812	0.621812
10	0.609281	0.610683	0.618004	0.627024	0.768144	0.766004	0.748714	0.723620
30	0.508375	0.514558	0.567218	0.615668	0.995764	0.991719	0.918681	0.783202

```
# https://stackoverflow.com/questions/56478320/how-to-create-multiple-seaborn-heatmap
fig, ax = plt.subplots(ncols=2, sharey=True,figsize=(18,6))
sn.heatmap(values_heatmap.mean_train_score, annot=True, fmt='.4g',ax=ax[0]);
sn.heatmap(values_heatmap.mean_test_score, annot=True, fmt='.4g',ax=ax[1]);
plt.show()
```



Using the Best Parameters, fit the model. Plot ROC-AUC curve(using predict proba method)

```
clf = DecisionTreeClassifier(max_depth=search.best_params_['max_depth'],
                             min_samples_split=search.best_params_['min_samples_split
```

```
clf.fit(train_set_2,y_train)
```

```
DecisionTreeClassifier(max_depth=10, min_samples_split=500)
```

```
train_value = clf.predict_proba(train_set_2)
train_set_2_y = train_value[:,1]
print("train_set_1_y:",train_set_2_y.shape)
test_value = clf.predict_proba(test_set_2)
test_set_2_y = test_value[:,1]
print("test_set_1_y:",test_set_2_y.shape)
```

```
train_set_1_y: (73196,)
test_set_1_y: (36052,)
```

```
train_fpr, train_tpr, train_thresholds = roc_curve(y_train,train_set_2_y)
Train_AUC = auc(train_fpr, train_tpr)
print("Train AUC:",Train_AUC)
test_fpr, test_tpr, test_thresholds = roc_curve(y_test,test_set_2_y)
Test_AUC = auc(test_fpr, test_tpr)
print("Test AUC:",Test_AUC)
```

```
Train AUC: 0.720581626325997
Test AUC: 0.6340100920327459
```

```
plt.figure(figsize=(10,10))
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(Train_AUC))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(Test_AUC))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.rc('grid', linestyle="-", color='black')
plt.grid(True)
plt.show()
```

Plot confusion matrix based on best threshold value

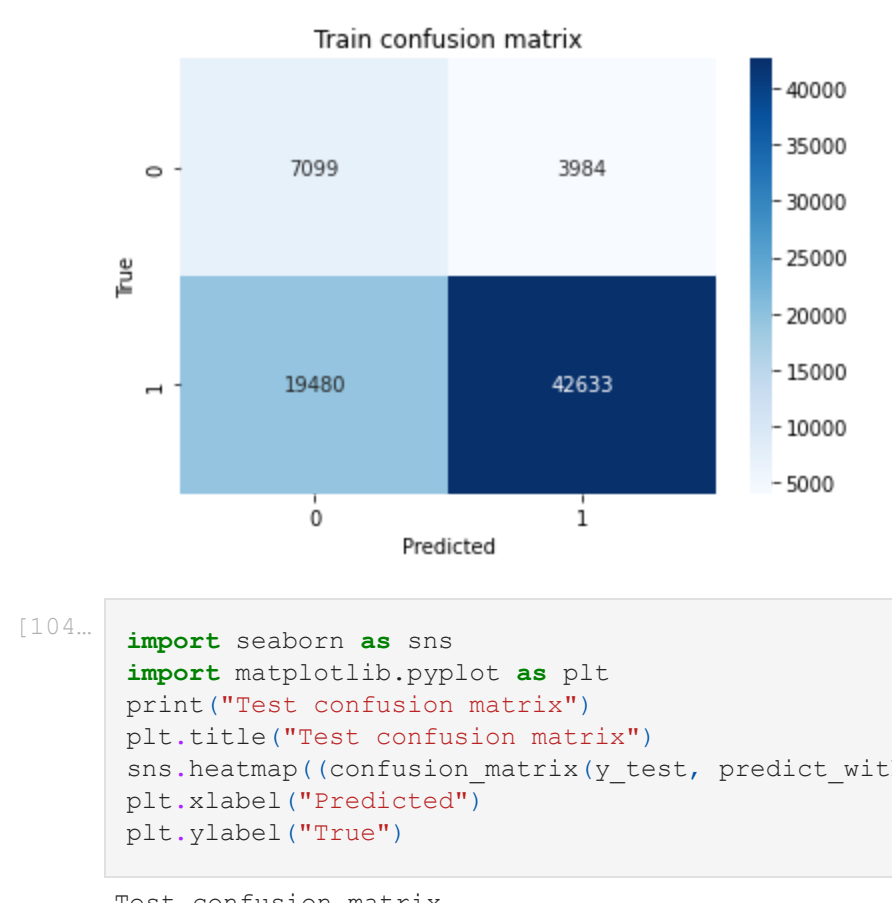
```
from sklearn.metrics import confusion_matrix

# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.ro
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

```
best_t = find_best_threshold(train_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(train_set_2_y, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(test_set_2_y, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.43986104298933 for threshold 0.858
Train confusion matrix
[[ 7099  3984]
 [19480 42633]]
Test confusion matrix
[[ 2830  2529]
 [10174 20419]]
```

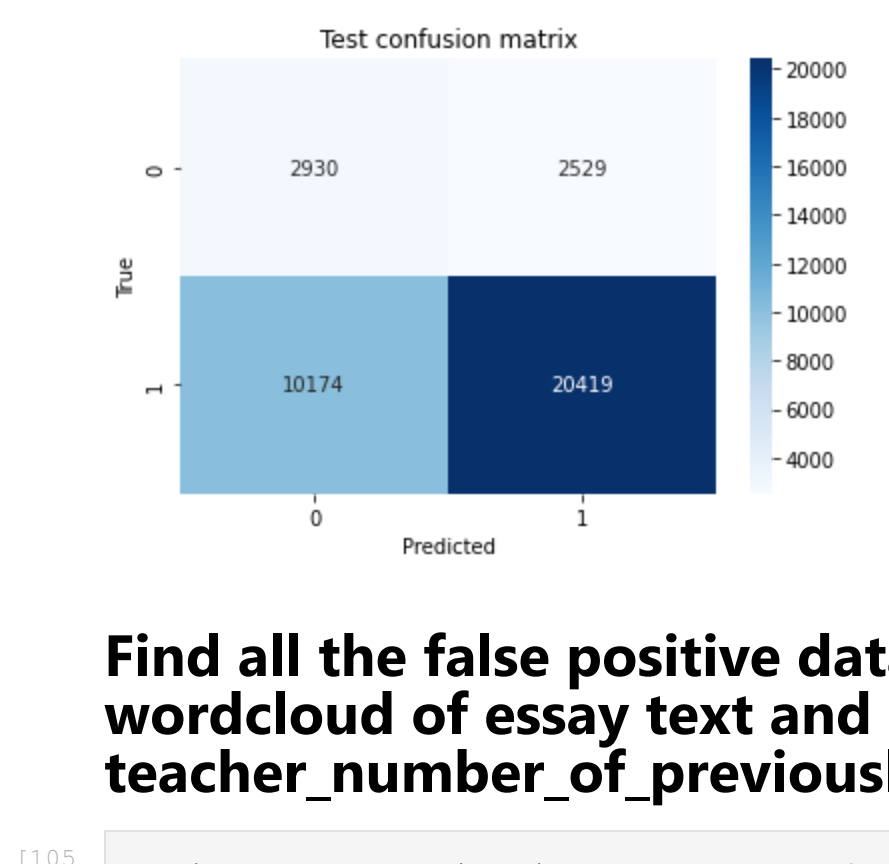
```
import seaborn as sns
import matplotlib.pyplot as plt
plt.title("Train confusion matrix")
sns.heatmap(confusion_matrix(y_train, predict_with_best_t(train_set_2_y, best_t)), an
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Train confusion matrix
Text(33.0, 0.5, 'True')
```



```
import seaborn as sns
import matplotlib.pyplot as plt
plt.title("Test confusion matrix")
sns.heatmap(confusion_matrix(y_test, predict_with_best_t(test_set_2_y, best_t)), anno
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Test confusion matrix
Text(33.0, 0.5, 'True')
```



Find all the false positive data points and plot wordcloud of essay text and pdf of teacher_number_of_previously_posted_projects.

```
predict_value = predict_with_best_t(test_set_2_y,best_t)
```

```
false_pos = []
for i in range(len(y_test)):
    if(y_test[i]==0) and (predict_value[i]==1):
        false_pos.append(i)
print("false_pos_shape:",len(false_pos))

features = x_test.columns
false_pos_ds = pd.DataFrame(columns=features)
false_pos_ds = x_test.iloc[false_pos]
print("false_pos_ds:",false_pos_ds.shape)
```

```
false_pos_shape: 2529
false_pos_ds: (2529, 12)
```

```
features = x_test.columns
false_pos_ds = pd.DataFrame(columns=features)
false_pos_ds = x_test.iloc[false_pos]
print("false_pos_ds:",false_pos_ds.shape)
```

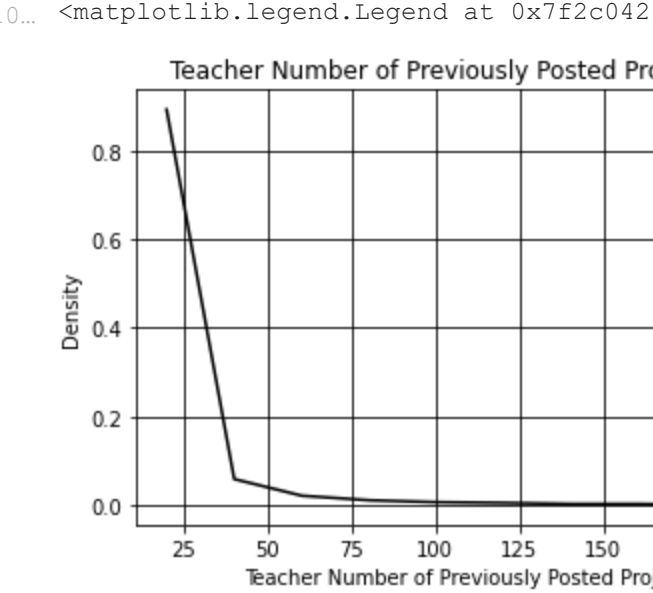
```
false_pos_ds: (2529, 12)
```

Plot the WordCloud(https://www.geeksforgeeks.org/generate-word-cloud-python/) with the words of essay text of these false positive data points

```
# https://www.geeksforgeeks.org/generating-word-cloud-python/
comment_words = ''
stopwords = set(STOPWORDS)
for val in false_pos_ds["essay"]:
    val = str(val)
    tokens = val.split()
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()
    comment_words += " ".join(tokens)+" "
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='white',
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (12, 12), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

Plot the box plot with the *price* of these $false positive data p \oint s$

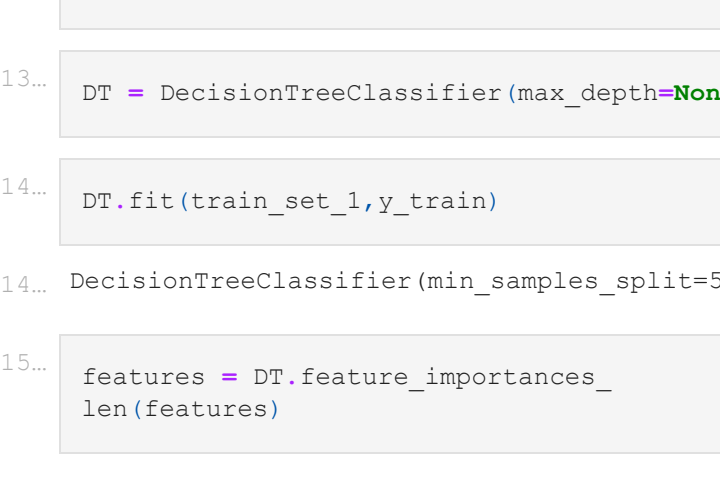
```
data = false_pos_ds['price']
plt.title("Box Plot Price")
plt.boxplot(data)
plt.grid(True)
plt.ylabel('Price')
plt.show()
```



Plot the pdf with the $teacher_number_of_previously_posted_projects$ of these $false positive data p \oint s$

```
counts, bin_edges = np.histogram(false_pos_ds['teacher_number_of_previously_posted_pro
pdf = counts/(sum(counts))
print(pdf)
plt.plot(bin_edges[1:],pdf,label = 'pdf',color='black')
plt.title("Teacher Number of Previously Posted Projects PDF")
plt.grid(True)
plt.xlabel("Teacher Number of Previously Posted Projects")
plt.ylabel("Density")
plt.legend()
```

```
[8.92447608e-01 5.85211546e-02 2.09569000e-02 1.06761566e-02
 6.32661131e-03 4.74495848e-03 2.37247924e-03 2.37247924e-03
 3.95413207e-04 1.18623962e-03]
<matplotlib.legend.Legend at 0x7f2c0423c810>
```



Task - 2

```
train_set_1 = hstack((essay_tfidf_x_train, OHE_X_train_state, OHE_X_train_teacher_pre
                      OHE_X_train_clean_categories,OHE_X_train_clean_subcategories, sca
                      scaler_X_train_price, scaler_X_train_NSS, scaler_X_train_NUSS, sc
print(train_set_1.shape,  y_train.shape)

test_set_1 = hstack((essay_tfidf_x_test, OHE_X_test_state, OHE_X_test_teacher_prefix,
                     OHE_X_test_clean_categories,OHE_X_test_clean_subcategories, scale
                     scaler_X_test_price, scaler_X_test_NSS, scaler_X_test_NUSS, scale

print(test_set_1.shape,  y_test.shape)
```

```
(73196, 14371) (73196,)
(36052, 14371) (36052,)
```

```
param_grid = {'max_depth':[1,3,10,30],'min_samples_split':[5,10,100,500]}
```

```
DT = DecisionTreeClassifier(max_depth=None,min_samples_split=500)
```

```
DT.fit(train_set_1,y_train)
```

```
DecisionTreeClassifier(min_samples_split=500)
```

```
features = DT.feature_importances_
len(features)
```

```
14371
```

```
non_zero_feature = []
for i in range(len(features)):
    if(features[i]>0):
        non_zero_feature.append(features[i])
print(len(non_zero_feature))
```

```
2742
```

```
new_train_set_1 = train_set_1[:,non_zero_feature]
print(new_train_set_1.shape,y_train.shape)
new_test_set_1 = test_set_1[:,non_zero_feature]
print(new_test_set_1.shape,y_test.shape)
```

```
(73196, 2742) (73196,)
(36052, 2742) (36052,)
```

```
search = GridSearchCV(DT, param_grid, n_jobs=-1, scoring="roc_auc", cv=3, return_trai
search.fit(new_train_set_1,y_train)
```

```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(min_samples_split=500),
             n_jobs=-1,
             param_grid={'max_depth': [1, 3, 10, 30],
                         'min_samples_split': [5, 10, 100, 500]},
             return_train_score=True, scoring='roc_auc')
```

```
score = search.best_score_
print("Best Score:",score)
```

```
Best Score: 0.500580705932128
```

```
estimator = search.best_estimator_
print("Best Estimator:",estimator)
```

```
Best Estimator: DecisionTreeClassifier(max_depth=30, min_samples_split=10)
```

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearc
result = search.cv_results_
mean_train_score = result['mean_train_score']
mean_test_score  = result['mean_test_score']
print("mean_train_score:",mean_train_score)
print("--------------------------------")
print("mean_test_score:",mean_test_score)
```

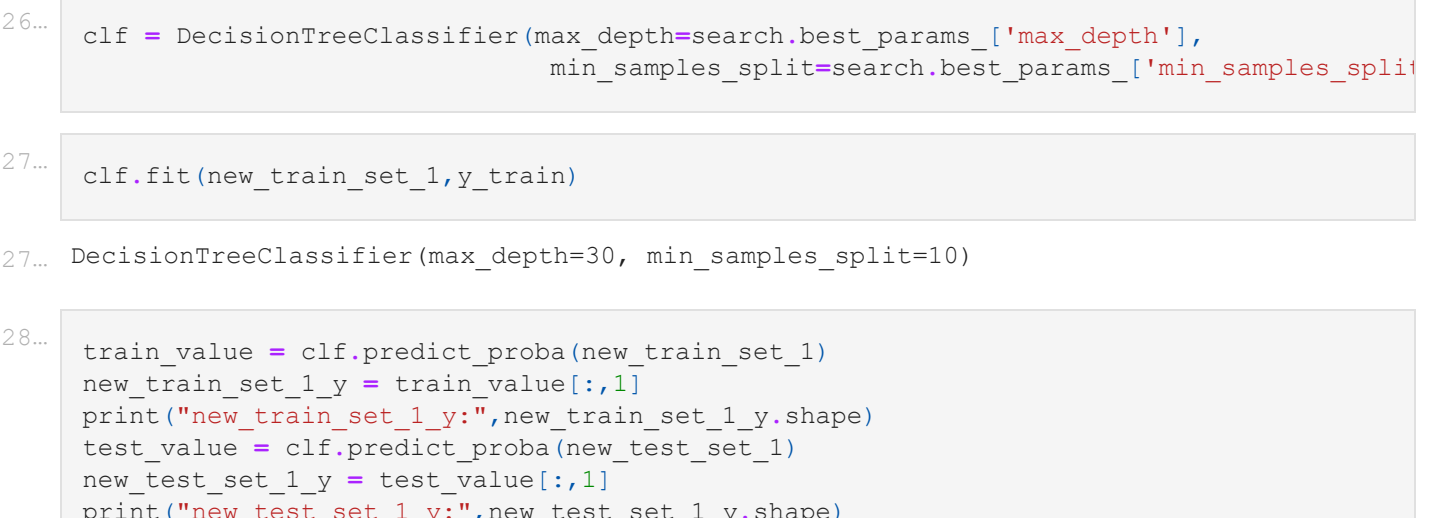
```
mean_train_score: [0.50018775 0.50018775 0.50018775 0.50018775 0.50070417 0.50070417
 0.50057892 0.50057892 0.50160948 0.50150496 0.50107055 0.50107055
 0.50195192 0.50176713 0.50127965 0.50127965]
--------------------------------
mean_test_score: [0.50007901 0.50007901 0.50007901 0.50007901 0.50011072 0.50011072
 0.49985671 0.49985671 0.50031518 0.50023477 0.5000098  0.5000098
 0.50057725 0.50058071 0.50014337 0.50014337]
```

```
x = param_grid['max_depth']
y = param_grid['min_samples_split']
train_auc_2 = mean_train_score
test_auc_2 = mean_test_score
```

```
# https://stackoverflow.com/questions/56302647/how-to-plot-a-heatmap-and-find-best-hy
values_heatmap = pd.DataFrame(search.cv_results_)
values_heatmap = values_heatmap.groupby(['param_max_depth','param_min_samples_split'])
values_heatmap = values_heatmap.unstack()[['mean_test_score', 'mean_train_score']]
values_heatmap.head()
```

	mean_test_score				mean_train_score			
param_min_samples_split	5	10	100	500	5	10	100	500
param_max_depth								
1	0.500079	0.500079	0.500079	0.500079	0.500188	0.500188	0.500188	0.500188
3	0.500111	0.500111	0.499857	0.499857	0.500704	0.500704	0.500579	0.500579
10	0.500315	0.500235	0.500010	0.500010	0.501609	0.501505	0.501071	0.501071
30	0.500577	0.500581	0.500143	0.500143	0.501952	0.501767	0.501280	0.501280

```
# https://stackoverflow.com/questions/56478320/how-to-create-multiple-seaborn-heatmap
fig, ax = plt.subplots(ncols=2, sharey=True,figsize=(18,6))
sn.heatmap(values_heatmap.mean_train_score, annot=True, fmt='.4g',ax=ax[0]);
sn.heatmap(values_heatmap.mean_test_score, annot=True, fmt='.4g',ax=ax[1]);
plt.show()
```



```
clf = DecisionTreeClassifier(max_depth=search.best_params_['max_depth'],
                             min_samples_split=search.best_params_['min_samples_split
```

```
clf.fit(new_train_set_1,y_train)
```

```
DecisionTreeClassifier(max_depth=30, min_samples_split=10)
```

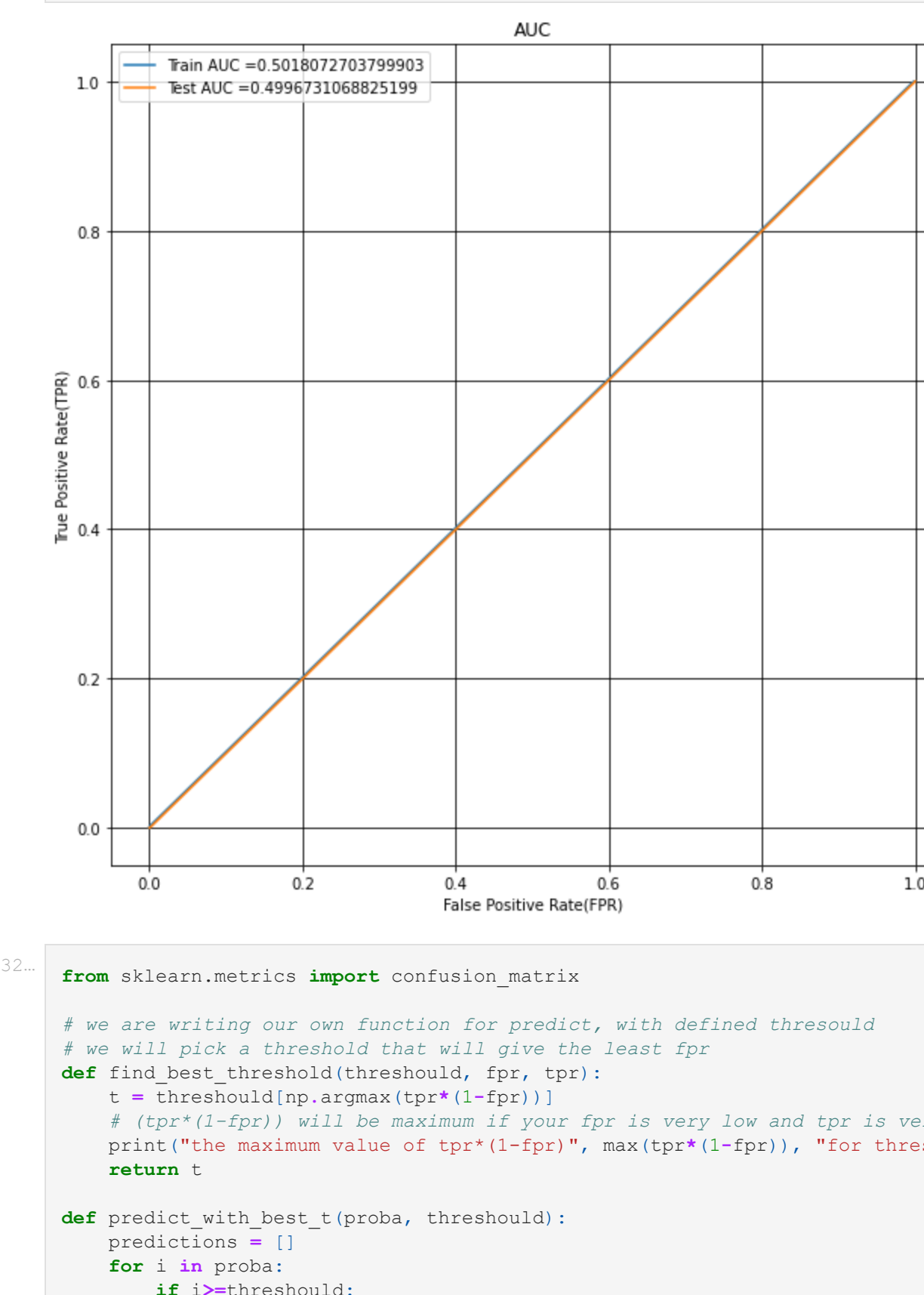
```
train_value = clf.predict_proba(new_train_set_1)
new_train_set_1_y = train_value[:,1]
print("new_train_set_1_y:",new_train_set_1_y.shape)
test_value = clf.predict_proba(new_test_set_1)
new_test_set_1_y = test_value[:,1]
print("new_test_set_1_y:",new_test_set_1_y.shape)
```

```
new_train_set_1_y: (73196,)
new_test_set_1_y: (36052,)
```

```
train_fpr, train_tpr, train_thresholds = roc_curve(y_train,new_train_set_1_y)
Train_AUC = auc(train_fpr, train_tpr)
print("Train AUC:",Train_AUC)
test_fpr, test_tpr, test_thresholds = roc_curve(y_test,new_test_set_1_y)
Test_AUC = auc(test_fpr, test_tpr)
print("Test AUC:",Test_AUC)
```

```
Train AUC: 0.5018072703799903
Test AUC: 0.4996731068825199
```

```
plt.figure(figsize=(10,10))
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(Train_AUC))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(Test_AUC))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.rc('grid', linestyle="-", color='black')
plt.grid(True)
plt.show()
```



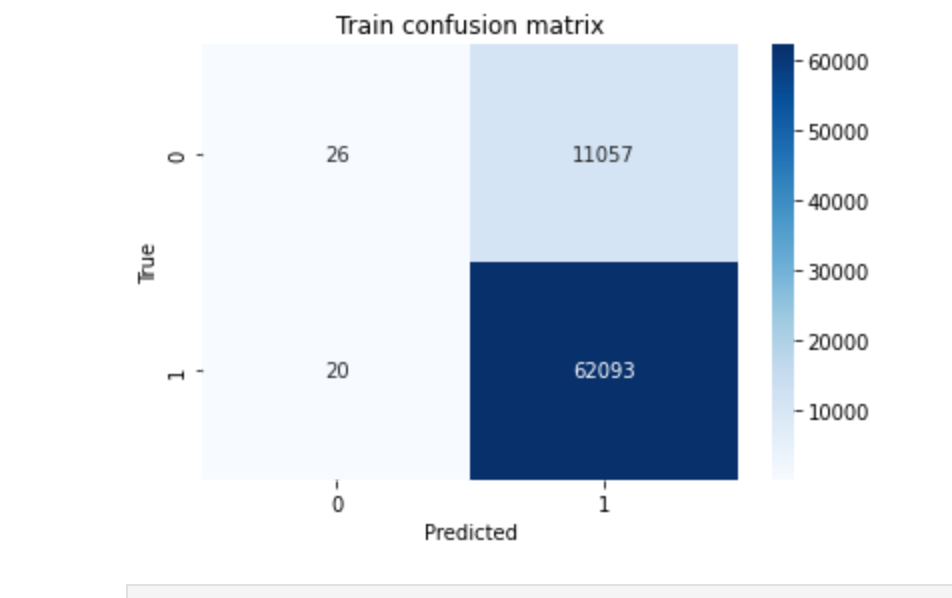

```
from sklearn.metrics import confusion_matrix

# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.ro
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

```
best_t = find_best_threshold(train_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(new_train_set_1_y, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(new_test_set_1_y, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.00234579835935902 for threshold 0.849
Train confusion matrix
[[   24 11057]
 [   20 62093]]
Test confusion matrix
[[    5  5354]
 [   28 30565]]
```

```
import seaborn as sns
import matplotlib.pyplot as plt
plt.title("Train confusion matrix")
sns.heatmap(confusion_matrix(y_train, predict_with_best_t(new_train_set_1_y, best_t)),
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Train confusion matrix
Text(33.0, 0.5, 'True')
```

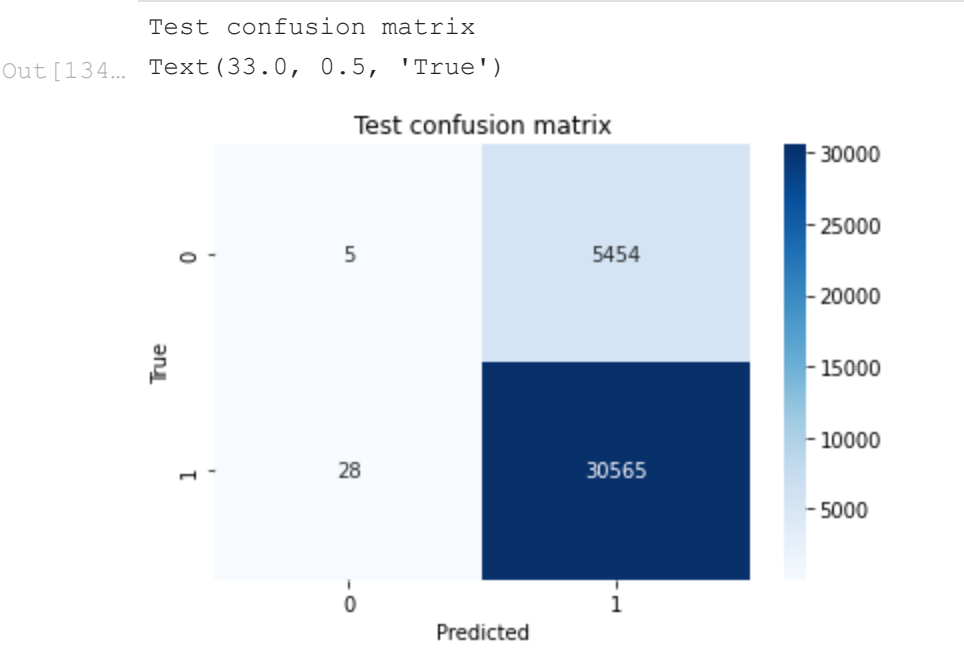


In [134]:

```
import seaborn as sns
import matplotlib.pyplot as plt
print("Test confusion matrix")
plt.title("Test confusion matrix")
sns.heatmap(confusion_matrix(y_test, predict_with_best_t(new_test_set_1_y, best_t)),
plt.xlabel("Predicted")
plt.ylabel("True")
```

Test confusion matrix

Out[134]: Text(33.0, 0.5, 'True')



In [135]:

```
predict_values = predict_with_best_t(new_test_set_1_y,best_t)
```

In [136]:

```
false_pos = []
for x in range(len(y_test)):
    if(y_test[x]==0) and (predict_values[x]==1):
        false_pos.append(x)
print("false_pos_shape:",len(false_pos))
```

false_pos_shape: 5454

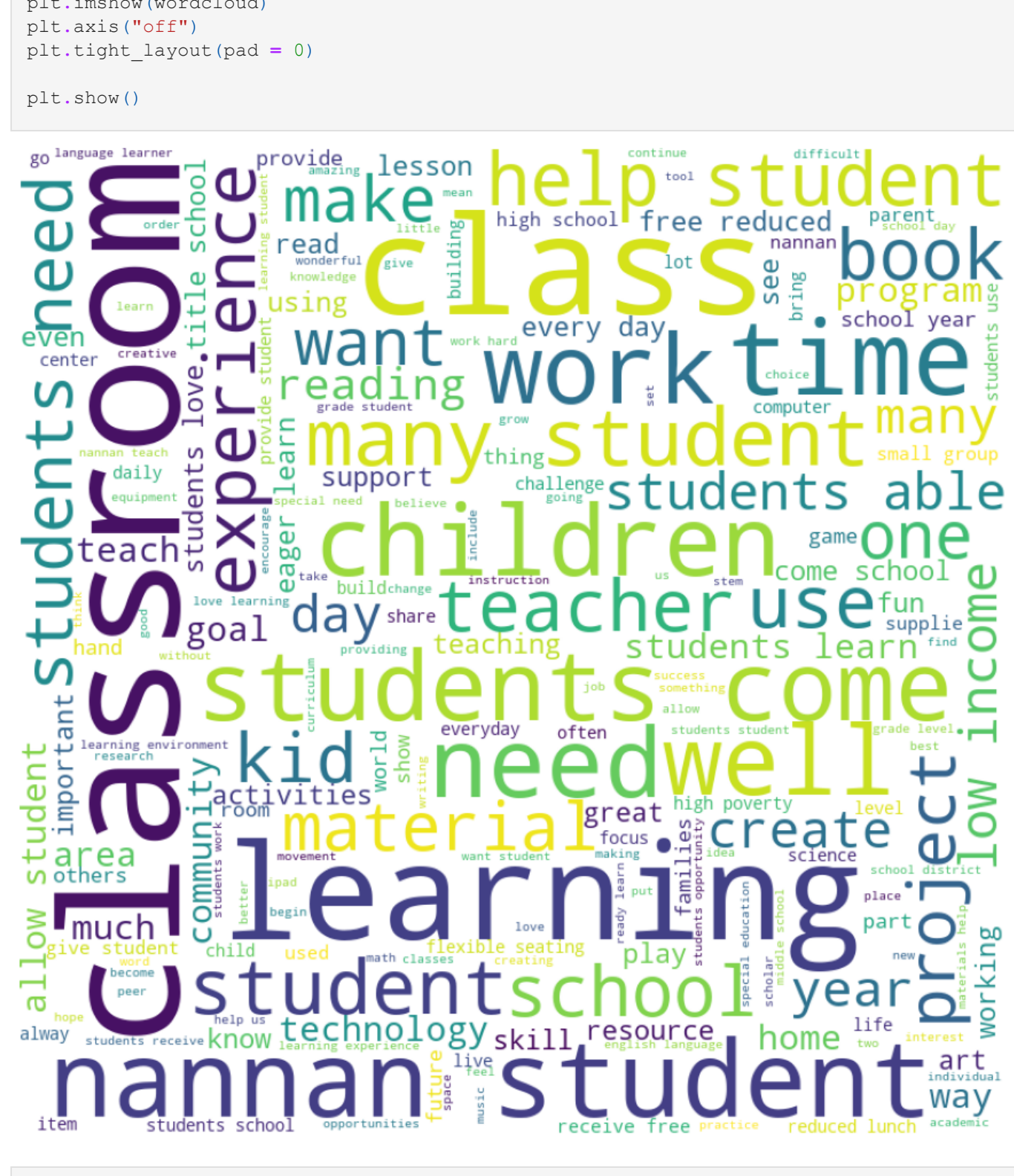
In [137]:

```
features = x_test.columns
false_pos_ds = pd.DataFrame(columns=features)
false_pos_ds = x_test.iloc[false_pos]
print("False_pos_ds:",false_pos_ds.shape)
```

False_pos_ds: (5454, 12)

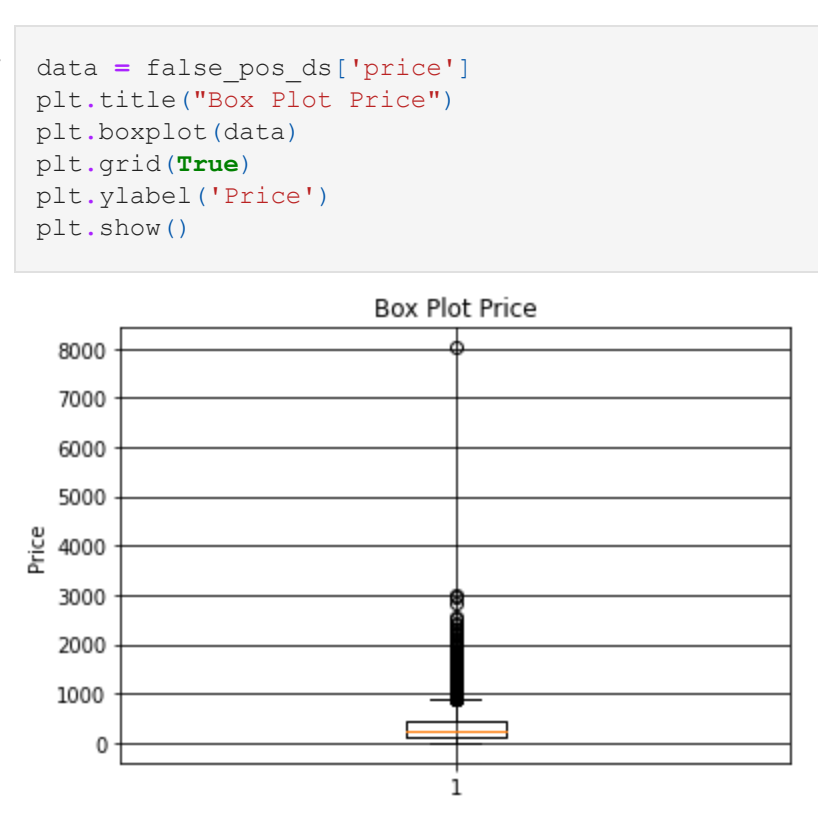
In [138]:

```
# https://www.geeksforgeeks.org/generating-word-cloud-python/
comment_words = ''
stopwords = set(STOPWORDS)
for val in false_pos_ds['essay']:
    val = str(val)
    tokens = val.split()
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()
    comment_words += " ".join(tokens)+" "
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='white',
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (12, 12), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [139]:

```
data = false_pos_ds['price']
plt.title("Box Plot Price")
plt.boxplot(data)
plt.grid(True)
plt.ylabel('Price')
plt.show()
```

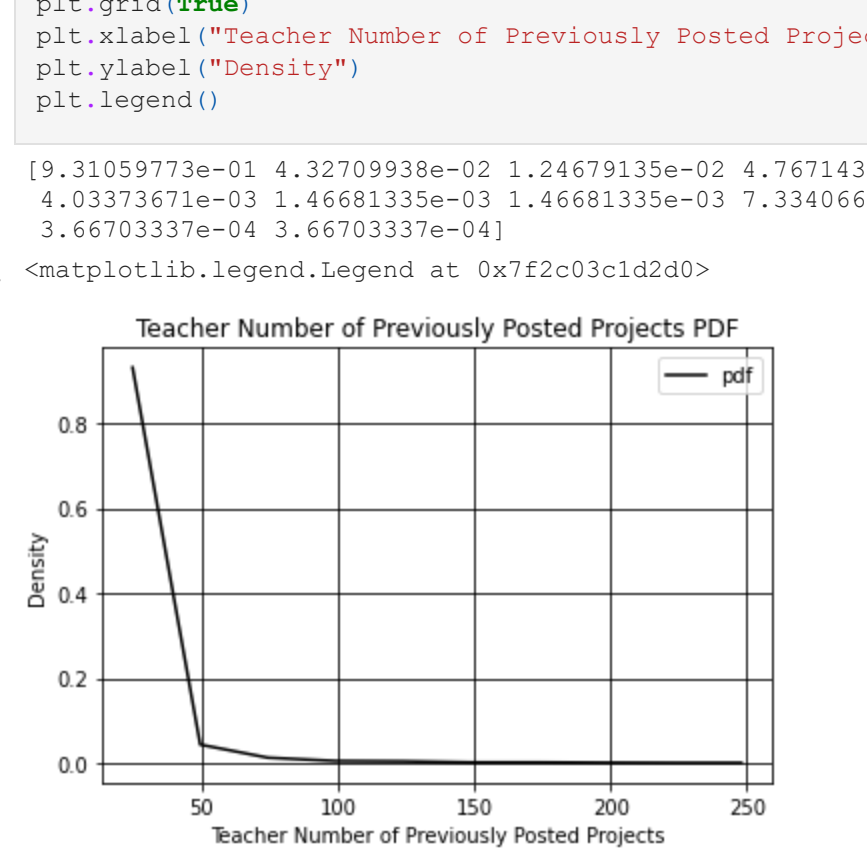


In [140]:

```
counts, bin_edges = np.histogram(false_pos_ds['teacher_number_of_previously_posted_pro
pdf = counts/(sum(counts))
print(pdf)
plt.plot(bin_edges[1:],pdf,label = "pdf",color="black")
plt.title("Teacher Number of Previously Posted Projects PDF")
plt.ylabel("Density")
plt.xlabel("Teacher Number of Previously Posted Projects")
plt.legend()
```

```
[9.31059773e-01 4.32709398e-02 1.24679179e-02 4.76714338e-03
 4.03373671e-03 1.46681335e-03 1.46681335e-03 7.33406674e-04
 3.66703337e-04 3.66703337e-04]
```

Out[140]: <matplotlib.legend.Legend at 0x7f2c03c1d2d0>



In [144]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["S.NO","Model","Hyper_Parameter","Vectorizer","Train_AUC","Test_AUC
x.add_row(["1", "Decision Tree", "max_depth=10, min_samples_split=500", "TFIDF",0.690
x.add_row(["2", "Decision Tree", "max_depth=10, min_samples_split=500", "TFIDF Weight
x.add_row(["3", "Decision Tree", "max_depth=30, min_samples_split=10 ", "Non Zero TFID
print(x)
```

```
+------+---------------+---------------------------------------+--------------------------
-------+
| S.NO |     Model     |            Hyper_Parameter            |        Vectorizer
     Train_AUC      |      Test_AUC      |
+------+---------------+---------------------------------------+--------------------------
-------+
|  1   | Decision Tree | max_depth=10, min_samples_split=500 |          TFIDF
| 0.6906169866546935 | 0.6523688468568721 |
|  2   | Decision Tree | max_depth=10, min_samples_split=500 |     TFIDF Weight W2V
| 0.7205814263237997 | 0.6340109302027459 |
|  3   | Decision Tree | max_depth=30, min_samples_split=10  |  Non Zero TFIDF Feature
| 0.5018072070799903 | 0.4996731068825199 |
+------+---------------+---------------------------------------+--------------------------
-------+
```