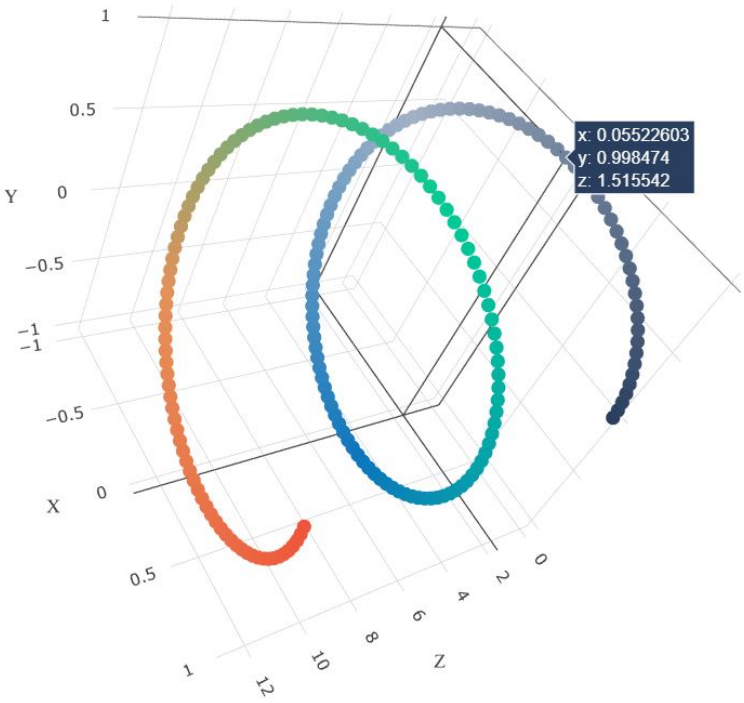
Assignment : DT

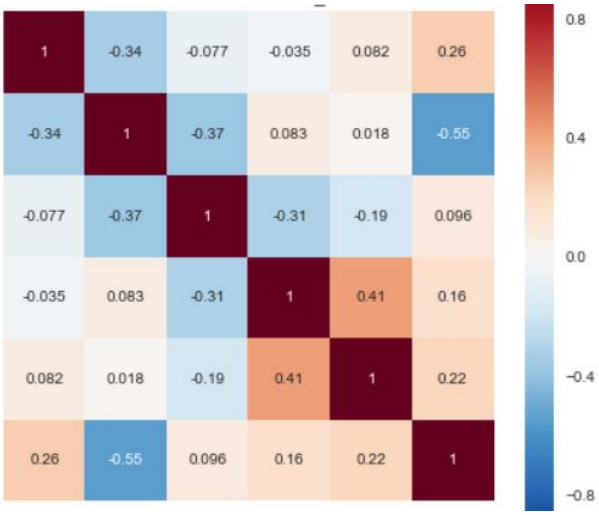
1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
    - Set 1: categorical, numerical features + preprocessed_eassay (TFIDF)
    - Set 2: categorical, numerical features + preprocessed_eassay (TFIDF W2V)
2. **The hyper paramter tuning (best `depth` in range [1, 5, 10, 50], and the best `min_samples_split` in range [5, 10, 100, 500])**
    - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
    - find the best hyper paramter using k-fold cross validation(use gridsearch cv or randomsearch cv)/simple cross validation data(you can write your own for loops refer sample solution)
3. **Representation of results**
    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



with X-axis as **min_sample_split**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

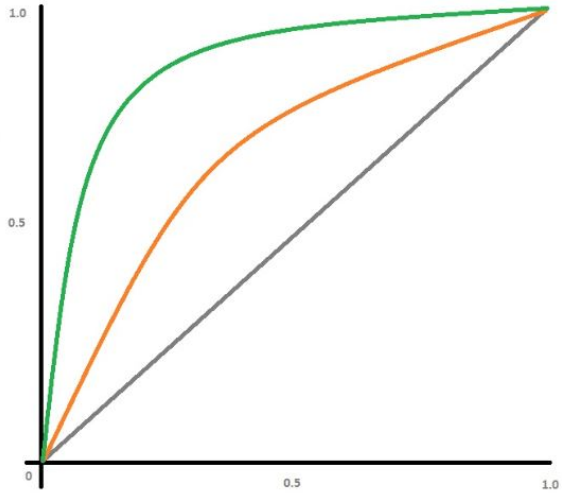
or

- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**

- You choose either of the plotting techniques out of 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.



- Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points

	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

- Once after you plot the confusion matrix with the test data, get all the `false positive data points`
  - Plot the WordCloud(https://www.geeksforgeeks.org/generating-word-cloud-python/) with the words of essay text of these `false positive data points`
  - Plot the box plot with the `price` of these `false positive data points`
  - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

4. **Task 2:** For this task consider set-1 features. Select all the features which are having non-zero feature importance.You can get the feature importance using 'feature_importances_` (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard the all other

remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3
Note: when you want to find the feature importance make sure you don't use max_depth parameter keep it None.

5. You need to summarize the results at the end of the notebook, summarize it in the table format

Vectorizer	Model	Hyper parameter	AUC
BOW	Brute	7	0.78
TFIDF	Brute	12	0.79
W2V	Brute	10	0.78
TFIDFW2V	Brute	6	0.78

1. Decision Tree

Task1

1.1 Loading Data

In [1]:

```
#Importing libraries

import pandas as pd
import numpy as np
import nltk
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/

import pickle
from tqdm import tqdm
import os

#from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

In [2]:

```
data  = pd.read_csv('preprocessed_data.csv',nrows=60000)
data.head(5)
```

Out[2]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pr
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

In [3]:

```
data.columns
```

Out[3]:

```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'price'],
      dtype='object')
```

In [4]:

```
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)
X.head(1)
```

Out[4]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pr
0	ca	mrs	grades_prek_2	

1.2 Splitting data into Train and cross validation(or test): Stratified Sampling

In [5]:

```
# train, CV, test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.30, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.30, stratify=
```

1.3 Make Data Model Ready: encoding Text Feature eassay

1.3.1 TFIDF featurization of eassy feature

In [6]:

```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)

from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,4),max_features=5000)
text_tfidf = vectorizer.fit(X_train['essay'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf= vectorizer.transform(X_train['essay'].values)
X_cv_essay_tfidf = vectorizer.transform(X_cv['essay'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['essay'].values)

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
essay_features_tfidf = vectorizer.get_feature_names()
```

```
(29400, 8) (29400,)
(12600, 8) (12600,)
(18000, 8) (18000,)
============================================================================
========================
After vectorizations
(29400, 5000) (29400,)
(12600, 5000) (12600,)
(18000, 5000) (18000,)
============================================================================
========================
```

1.3.2 TFIDF W2V featurization of eassy feature

In [7]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickl
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

tfidf_w2v_vectors for Train data

In [8]:

```
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=50000)
tfidf_model.fit(X_train['essay'])
tfidf_model.transform(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 [9]:

```
tfidf_w2v_vectors_X_train_essay = []; # the avg-w2v for each sentence/review is stored in t
for sentence in tqdm(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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_X_train_essay.append(vector)

print(len(tfidf_w2v_vectors_X_train_essay))
print(len(tfidf_w2v_vectors_X_train_essay[0]))
```

```
100%|██████████| 29400/29400 [01:46<00:00, 275.68it/s]

29400
300
```

tfidf_w2v_vectors for CV data

In [10]:

```
#tfidf_model = TfidfVectorizer()
tfidf_model.transform(X_cv['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 [11]:

```
tfidf_w2v_vectors_X_cv_essay = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm(X_cv['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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_X_cv_essay.append(vector)

print(len(tfidf_w2v_vectors_X_cv_essay))
print(len(tfidf_w2v_vectors_X_cv_essay[0]))
```

```
100%|██████████| 12600/12600 [00:46<00:00, 269.56it/s]

12600
300
```

tfidf_w2v_vectors For Test data

In [12]:

```
#tfidf_model = TfidfVectorizer()
tfidf_model.transform(X_test['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 [13]:

```
tfidf_w2v_vectors_X_test_essay = []; # the avg-w2v for each sentence/review is stored in th
for sentence in tqdm(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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_X_test_essay.append(vector)

print(len(tfidf_w2v_vectors_X_test_essay))
print(len(tfidf_w2v_vectors_X_test_essay[0]))
```

```
100%|██████████| 18000/18000 [01:04<00:00, 278.26it/s]

18000
300
```

1.4 Make Data Model Ready: encoding numerical, categorical features

1.4.1 encoding categorical features: School State

In [14]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
school_state_features = vectorizer.get_feature_names()
```

```
After vectorizations
(29400, 51) (29400,)
(12600, 51) (12600,)
(18000, 51) (18000,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'i
a', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo',
'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'o
r', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv',
'wy']
====================================================================================
========================
```

1.4.2 encoding categorical features: teacher_prefix

In [15]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
teacher_prefix_features = vectorizer.get_feature_names()
```

```
After vectorizations
(29400, 5) (29400,)
(12600, 5) (12600,)
(18000, 5) (18000,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================
========================
```

1.4.3 encoding categorical features: project_grade_category

In [16]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only on train

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
project_grade_features = vectorizer.get_feature_names()
```

```
After vectorizations
(29400, 4) (29400,)
(12600, 4) (12600,)
(18000, 4) (18000,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
====================================================================================
========================
```

1.4.4 encoding categorical features: clean_categories

In [17]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_categories_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_categories_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_categories_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_categories_ohe.shape, y_train.shape)
print(X_cv_categories_ohe.shape, y_cv.shape)
print(X_test_categories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
categories_features = vectorizer.get_feature_names()
```

```
After vectorizations
(29400, 9) (29400,)
(12600, 9) (12600,)
(18000, 9) (18000,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'liter
acy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
====================================================================================
========================
```

1.4.5 encoding categorical features: clean_subcategories

In [18]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only on train dat

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcategories_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_subcategories_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_subcategories_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcategories_ohe.shape, y_train.shape)
print(X_cv_subcategories_ohe.shape, y_cv.shape)
print(X_test_subcategories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
subcategories_features = vectorizer.get_feature_names()
```

```
After vectorizations
(29400, 30) (29400,)
(12600, 30) (12600,)
(18000, 30) (18000,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_governmen
t', 'college_careerprep', 'communityservice', 'earlydevelopment', 'economic
s', 'environmentalscience', 'esl', 'extracurricular', 'financialliteracy',
'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_wellness',
'history_geography', 'literacy', 'literature_writing', 'mathematics', 'musi
c', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 's
ocialsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
====================================================================================
========================
```

1.4.6 encoding numerical features: Price

In [19]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(1,-1))

X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(1,-1))#Normalize(
X_train_price_norm = X_train_price_norm.reshape(-1,1)
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(1,-1))
X_cv_price_norm = X_cv_price_norm.reshape(-1,1)
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(1,-1))
X_test_price_norm = X_test_price_norm.reshape(-1,1)



print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(29400, 1) (29400,)
(12600, 1) (12600,)
(18000, 1) (18000,)
====================================================================================================
========================
```

1.4.7 encoding numerical features: teacher_number_of_previously_posted_projects

In [20]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1)

X_train_projects_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_p
X_train_projects_norm = X_train_projects_norm.reshape(-1,1)
X_cv_projects_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_project
X_cv_projects_norm = X_cv_projects_norm.reshape(-1,1)
X_test_projects_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_pro
X_test_projects_norm = X_test_projects_norm.reshape(-1,1)



print("After vectorizations")
print(X_train_projects_norm.shape, y_train.shape)
print(X_cv_projects_norm.shape, y_cv.shape)
print(X_test_projects_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(29400, 1) (29400,)
(12600, 1) (12600,)
(18000, 1) (18000,)
====================================================================================
========================
```

1.4.8 Concatinating all the features

Set1: Features:categorical, numerical features + eassay (tfidf vec)

In [21]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf = hstack((X_train_essay_tfidf, X_train_state_ohe, X_train_teacher_ohe, X_train_g
X_cr_tfidf = hstack((X_cv_essay_tfidf, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, X_
X_te_tfidf = hstack((X_test_essay_tfidf, X_test_state_ohe, X_test_teacher_ohe, X_test_grade

print("Final Data matrix")
print(X_tr_tfidf.shape, y_train.shape)
print(X_cr_tfidf.shape, y_cv.shape)
print(X_te_tfidf.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(29400, 5101) (29400,)
(12600, 5101) (12600,)
(18000, 5101) (18000,)
====================================================================================
========================
```

Set2 : Features:categorical, numerical features + eassay (TFIDF W2V)

In [22]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf_W2V = hstack((tfidf_w2v_vectors_X_train_essay, X_train_state_ohe, X_train_teache
X_cr_tfidf_W2V = hstack((tfidf_w2v_vectors_X_cv_essay, X_cv_state_ohe, X_cv_teacher_ohe, X_
X_te_tfidf_W2V = hstack((tfidf_w2v_vectors_X_test_essay, X_test_state_ohe, X_test_teacher_o

print("Final Data matrix")
print(X_tr_tfidf_W2V.shape, y_train.shape)
print(X_cr_tfidf_W2V.shape, y_cv.shape)
print(X_te_tfidf_W2V.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(29400, 401) (29400,)
(12600, 401) (12600,)
(18000, 401) (18000,)
====================================================================================
========================
```

1.5 Appling Decision Tree on different kind of featurization as mentioned in the instructions

Apply Decision Tree on different kind of featurization as mentioned in the instructions
For Every model that you work on make sure you do the step 2 and step 3 of instrucations

1.5.1 Modeling of set1 features

Hyperparameter Tuning

In [23]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 4900
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [24]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values
decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
max_depth_plot = []
min_samples_split_plot =[]
min_samples_split=[5, 10, 100, 500]
max_depth=[1, 5, 10, 50]
for i in tqdm(min_samples_split):
    for j in max_depth:
        min_samples_split_plot.append(i)
        max_depth_plot.append(j)
        clf=DecisionTreeClassifier(random_state=0,min_samples_split=i,max_depth=j)
        clf.fit(X_tr_tfidf, y_train)

        y_train_pred = batch_predict(clf, X_tr_tfidf)
        y_cv_pred = batch_predict(clf, X_cr_tfidf)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
100%|██████████| 4/4 [04:22<00:00, 65.64s/it]
```

In [25]:

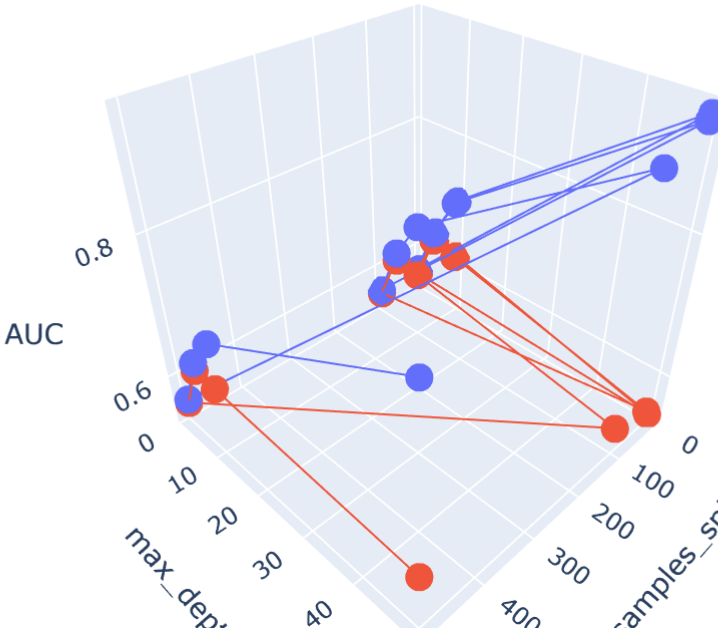
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [26]:

```
x1 = min_samples_split_plot
y1 = max_depth_plot
z1 = train_auc

x2 = min_samples_split_plot
y2 = max_depth_plot
z2 = cv_auc
```

In [27]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'train')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Cross validation')
data = [trace1, trace2]

layout = go.Layout(scene = dict(
        xaxis = dict(title='min_samples_split'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data=data, layout=layout)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

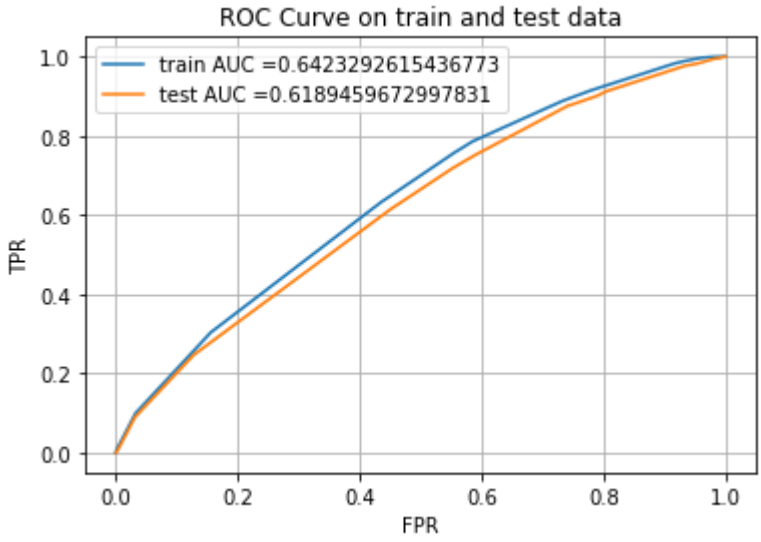


In [28]:

```
# from the error plot we choose best Hyperparameters such that, we will have maximum AUC on


#here we are choosing the best Hyperparameters based on forloop results
min_samples_split_best = 10
max_depth_best = 5
```

In [29]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

clf=DecisionTreeClassifier(random_state=0,min_samples_split=min_samples_split_best,max_dept
clf.fit(X_tr_tfidf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_tfidf)
y_test_pred = batch_predict(clf, X_te_tfidf)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve on train and test data")
plt.grid()
plt.show()
```



1.5.2 Ploting confusion matrix for set1 features

In [30]:

```
# 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.round(t
    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 [31]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

```
====================================================================================
========================
the maximum value of tpr*(1-fpr) 0.35714394530297855 for threshold 0.862
Train confusion matrix
[[ 2640  2032]
 [ 9099 15629]]
Test confusion matrix
[[1569 1292]
 [5823 9316]]
```

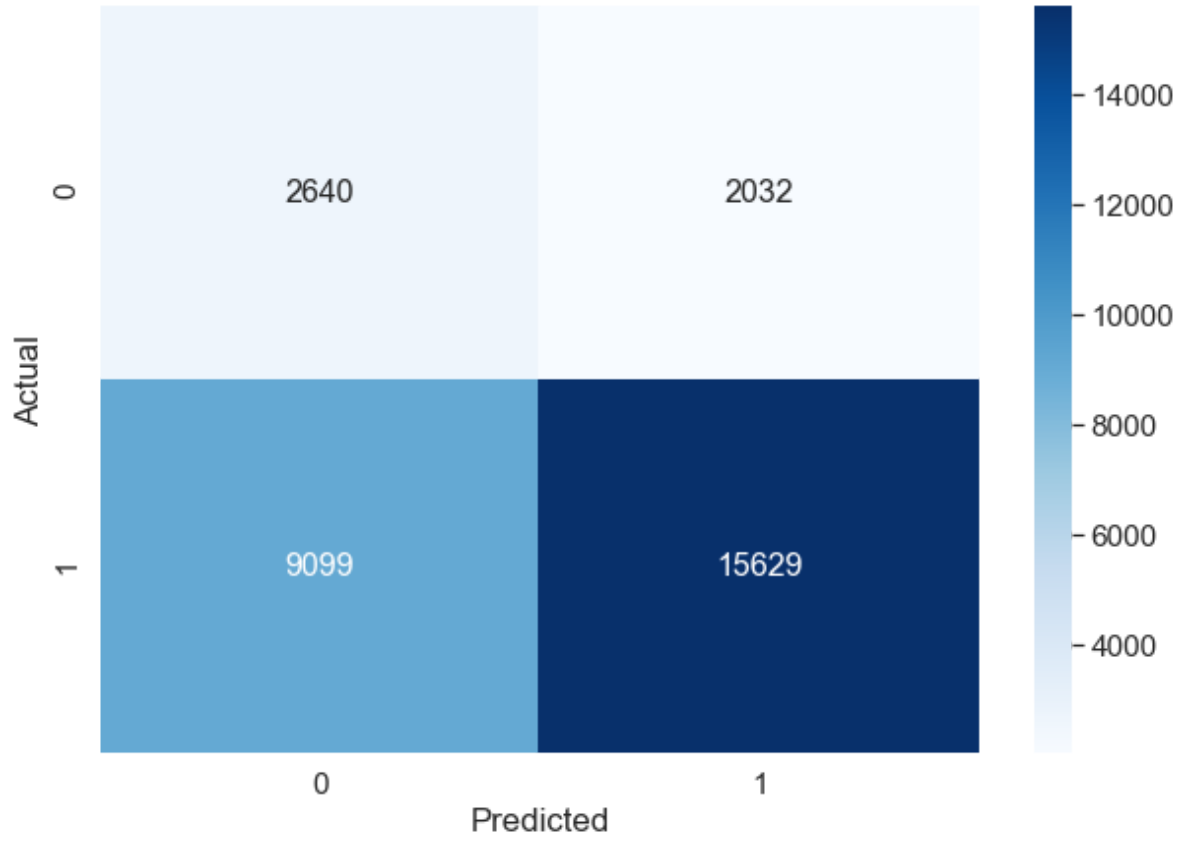
In [32]:

```
from sklearn.metrics import confusion_matrix
import pandas as pd
import seaborn as sn
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np

print("Train confusion matrix")
data = confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Train confusion matrix
```

Out[32]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d52d6bef88>
```



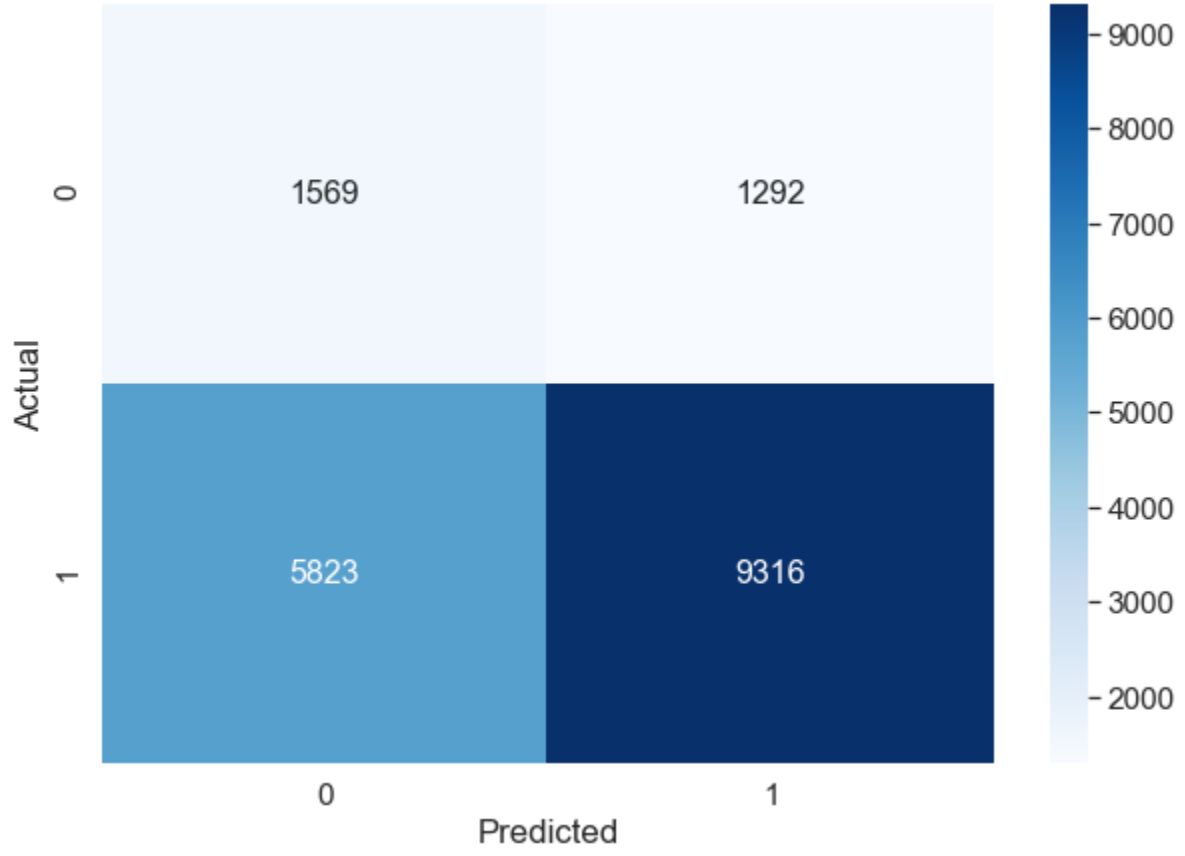
In [33]:

```
print("Test confusion matrix")
data = confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
y_pred_test = predict_with_best_t(y_test_pred, best_t)
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Test confusion matrix
```

Out[33]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d52d3ed148>
```



1.5.3 Ploting word cloud of essay feature

In [34]:

```
y_pred_test_t = np.transpose(y_pred_test)
```

In [35]:

```
# Getting eassy feature of false positive data points from test data
X_test_fp = X_test[(y_test == 0) & (y_pred_test_t == 1)]
essay_fp = X_test_fp['essay']

len(essay_fp)
```

Out[35]:

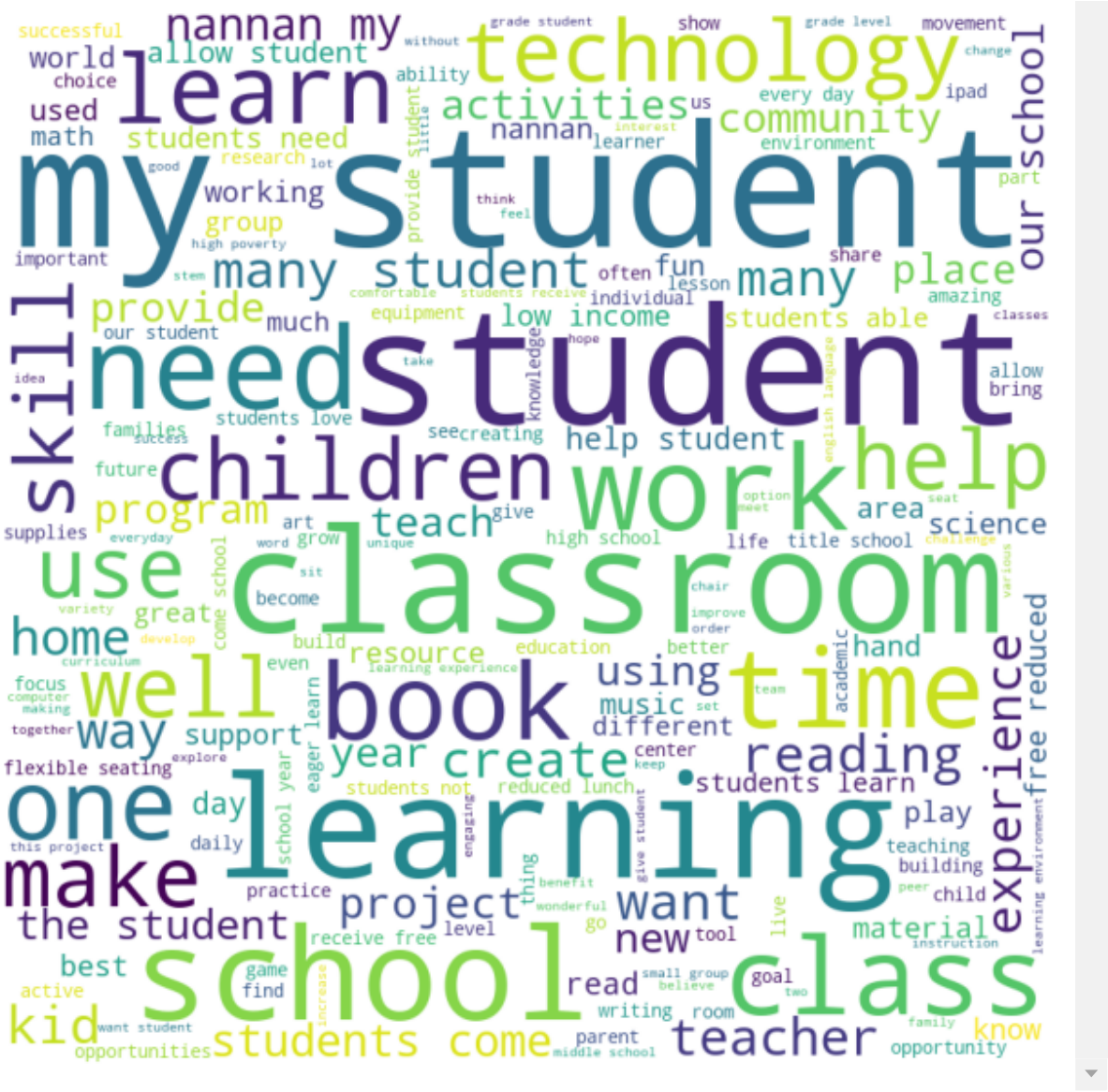
```
1292
```

In [36]:

```
from wordcloud import WordCloud, STOPWORDS
```

In [37]:

```
df = essay_fp

comment_words = ''
stopwords = set(STOPWORDS)

# iterate through the csv file
for val in df:

    # typecaste each val to string
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    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 = (8, 8), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



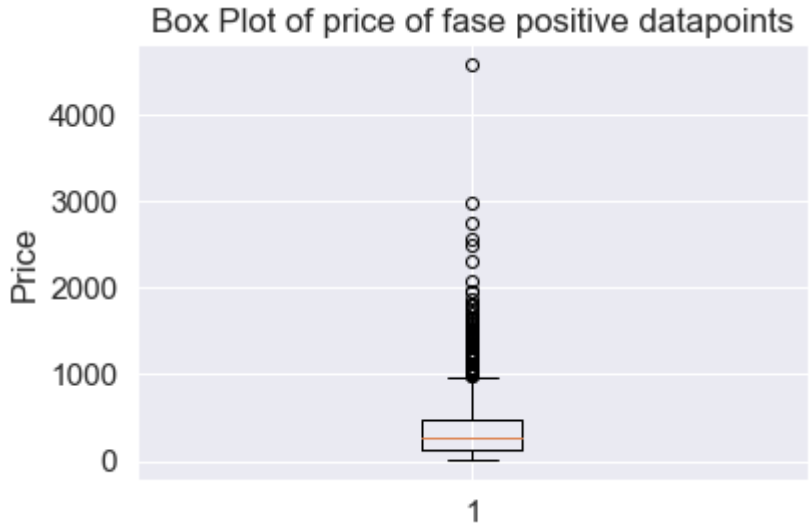
1.5.4 Ploting Box plot of Price Feature

In [38]:

```
price_fp = X_test_fp['price'] # Considering price feature of False positive data points
```

In [39]:

```
plt.boxplot(price_fp)
plt.ylabel('Price')
plt.title("Box Plot of price of fase positive datapoints")
plt.show()
```



In [ ]:

```

```

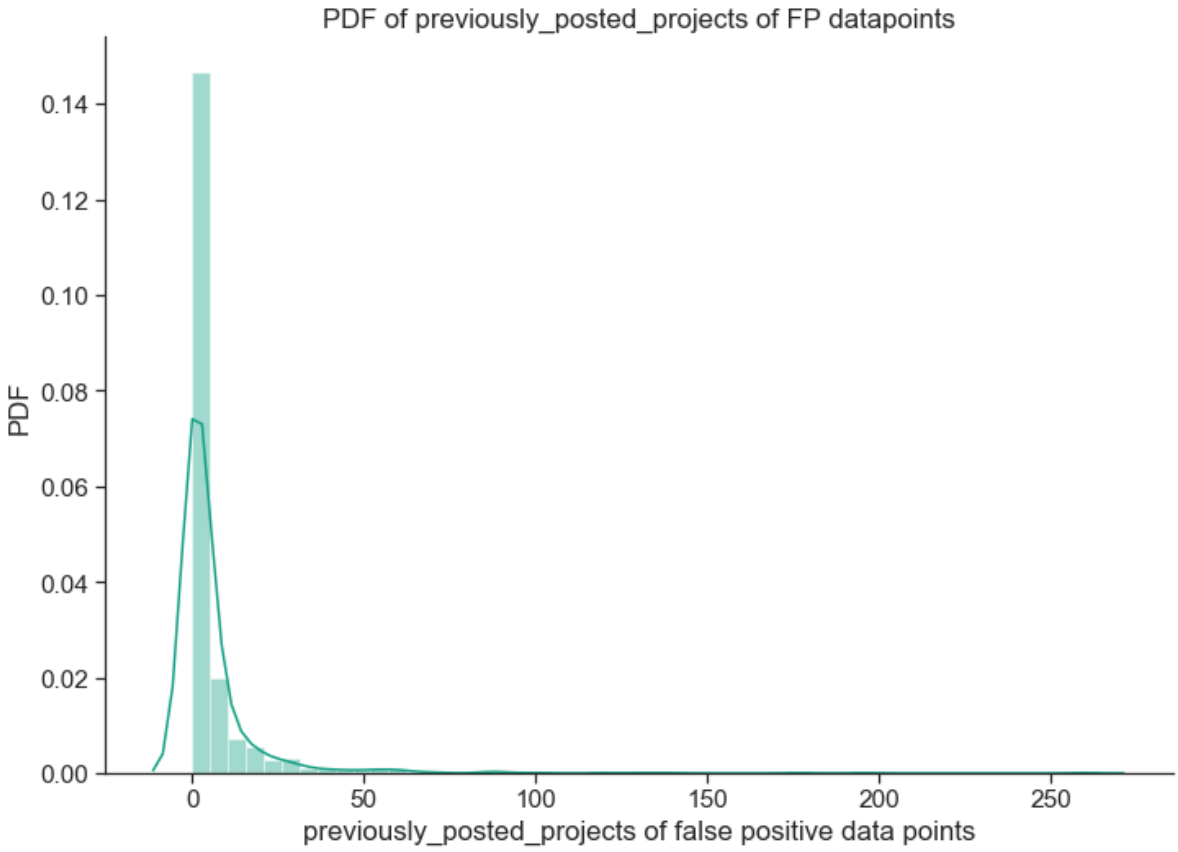
1.5.5 Ploting PDF teacher_number_of_previously_posted_projects

In [40]:

```
previously_posted_projects=X_test_fp['teacher_number_of_previously_posted_projects'] #Consi
```

In [41]:

```
sns.set_style('ticks')
fig, ax = plt.subplots()
fig.set_size_inches(11.7, 8.27)
sns.distplot(previously_posted_projects, color='#16A085')
plt.xlabel('previously_posted_projects of false positive data points')
plt.ylabel('PDF')
plt.title('PDF of previously_posted_projects of FP datapoints')
sns.despine()
```



In [ ]:

```
```

1.5.6 Modeling of set2 features

In [42]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 4900
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [43]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values
decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
max_depth_plot = []
min_samples_split_plot =[]
min_samples_split=[5, 10, 100, 500]
max_depth=[1, 5, 10, 50]
for i in tqdm(min_samples_split):
    for j in max_depth:
        min_samples_split_plot.append(i)
        max_depth_plot.append(j)
        clf=DecisionTreeClassifier(random_state=0,min_samples_split=i,max_depth=j)
        clf.fit(X_tr_tfidf_W2V, y_train)

        y_train_pred = batch_predict(clf, X_tr_tfidf_W2V)
        y_cv_pred = batch_predict(clf, X_cr_tfidf_W2V)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
100%|██████████| 4/4 [08:23<00:00, 125.92s/it]
```

In [44]:

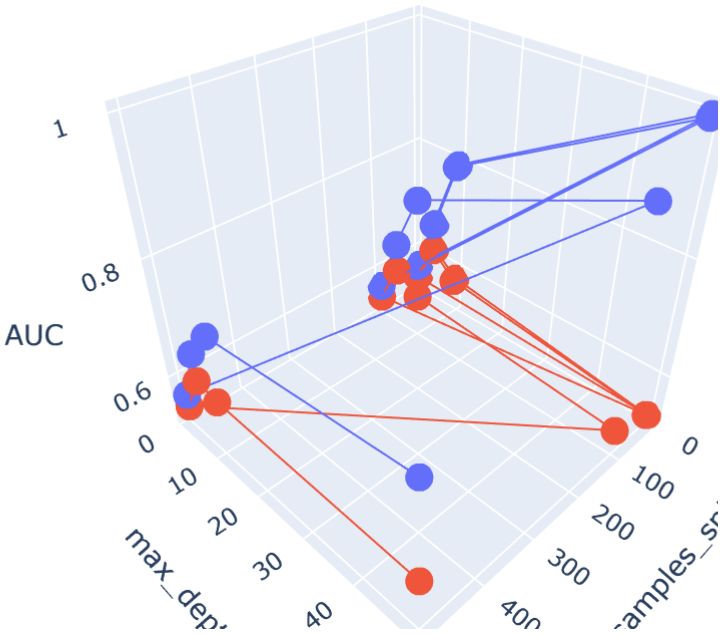
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [45]:

```
x1 = min_samples_split_plot
y1 = max_depth_plot
z1 = train_auc

x2 = min_samples_split_plot
y2 = max_depth_plot
z2 = cv_auc
```

In [46]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'train')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Cross validation')
data = [trace1, trace2]

layout = go.Layout(scene = dict(
        xaxis = dict(title='min_samples_split'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data=data, layout=layout)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

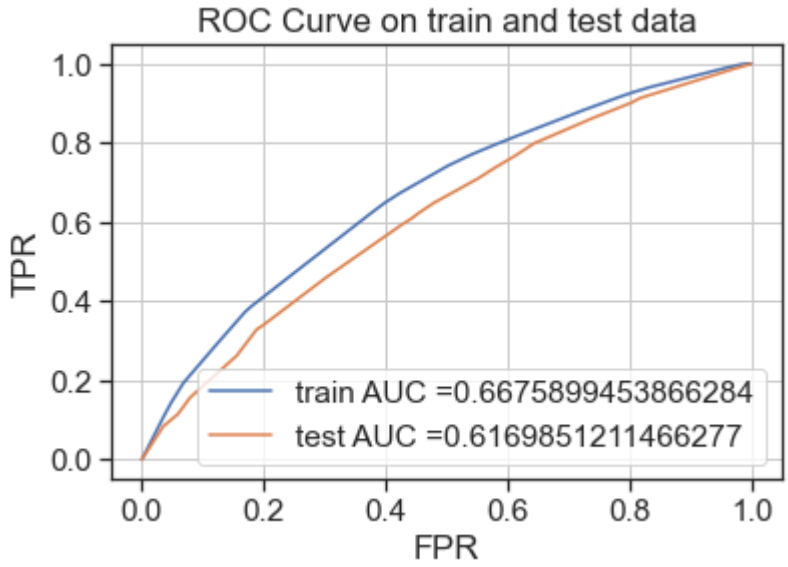


In [96]:

```
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap be
# Note: based on the method you use you might get different hyperparameter values as best o
# so, you choose according to the method you choose, you use gridsearch if you are having m
# if you increase the cv values in the GridSearchCV you will get more rebust results.

#here we are choosing the best_k based on forloop results
min_samples_split_best = 10
max_depth_best = 5
```

In [97]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

clf=DecisionTreeClassifier(random_state=0,min_samples_split=min_samples_split_best,max_dept
clf.fit(X_tr_tfidf_W2V, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_tfidf_W2V)
y_test_pred = batch_predict(clf, X_te_tfidf_W2V)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve on train and test data")
plt.grid()
plt.show()
```



1.5.7 Ploting confusion matrix for set2 features

In [49]:

```
# 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.round(t
    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 [50]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

```
====================================================================================
========================
the maximum value of tpr*(1-fpr) 0.3898538184488329 for threshold 0.858
Train confusion matrix
[[ 2809  1863]
 [ 8694 16034]]
Test confusion matrix
[[1563 1298]
 [5723 9416]]
```

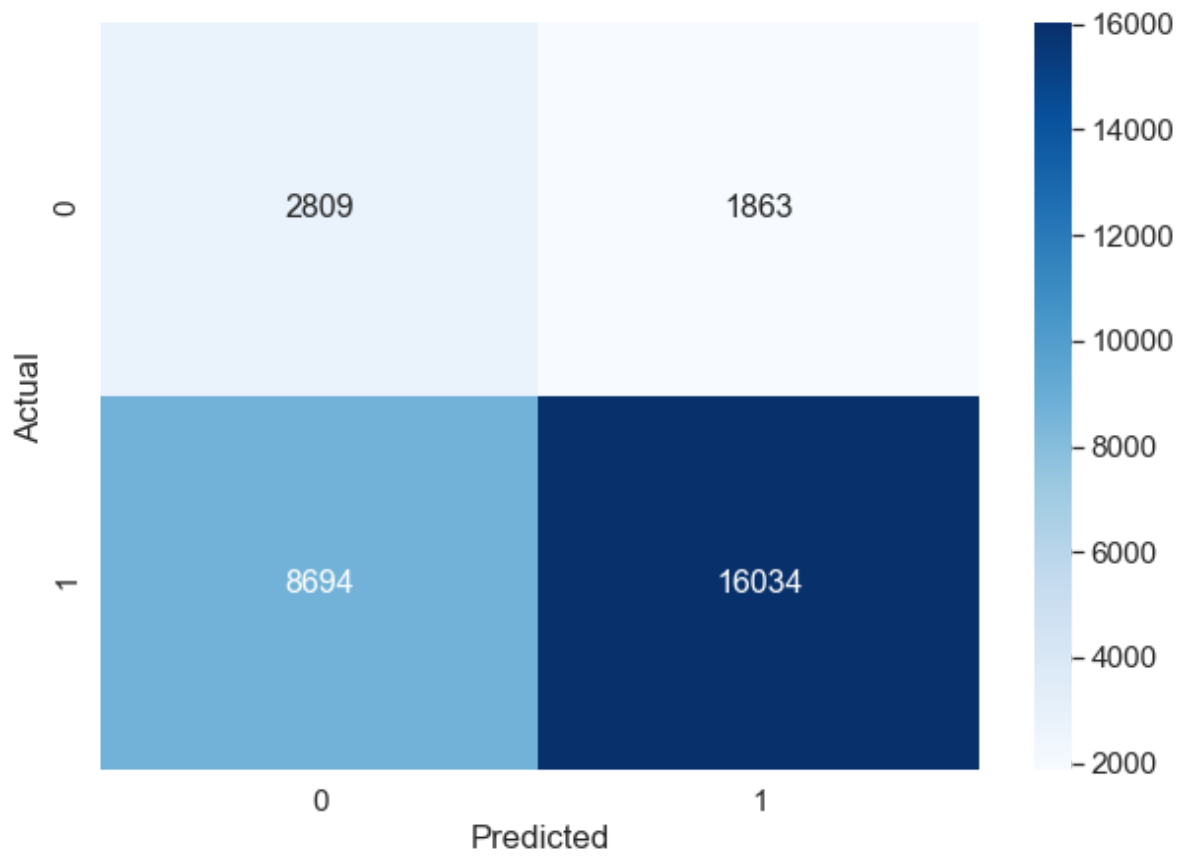
In [51]:

```
from sklearn.metrics import confusion_matrix
import pandas as pd
import seaborn as sn
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np

print("Train confusion matrix")
data = confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Train confusion matrix
```

Out[51]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d523e7aa48>
```



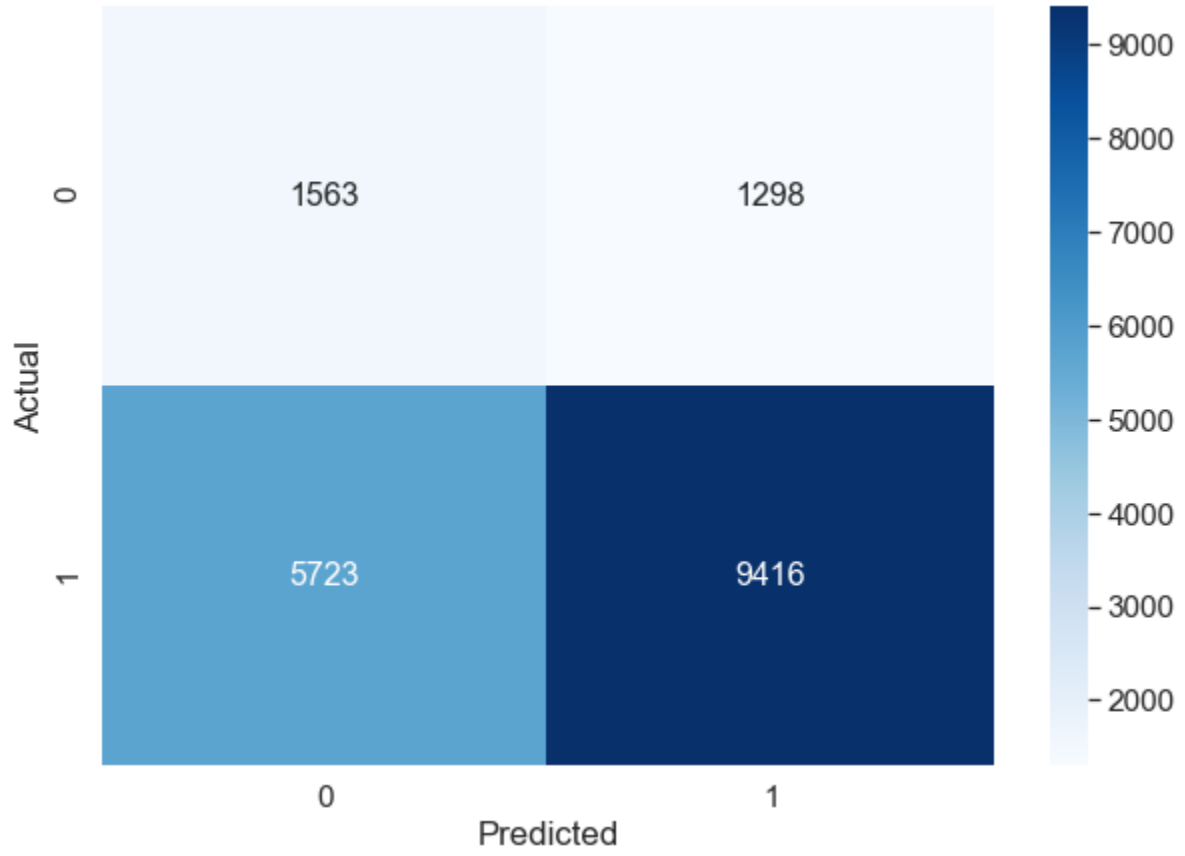
In [52]:

```
print("Test confusion matrix")
data = confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
y_pred_test = predict_with_best_t(y_test_pred, best_t)
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Test confusion matrix
```

Out[52]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d53801d988>
```



1.5.8 Ploting word cloud of essay feature

In [53]:

```
y_pred_test_t = np.transpose(y_pred_test)
```

In [54]:

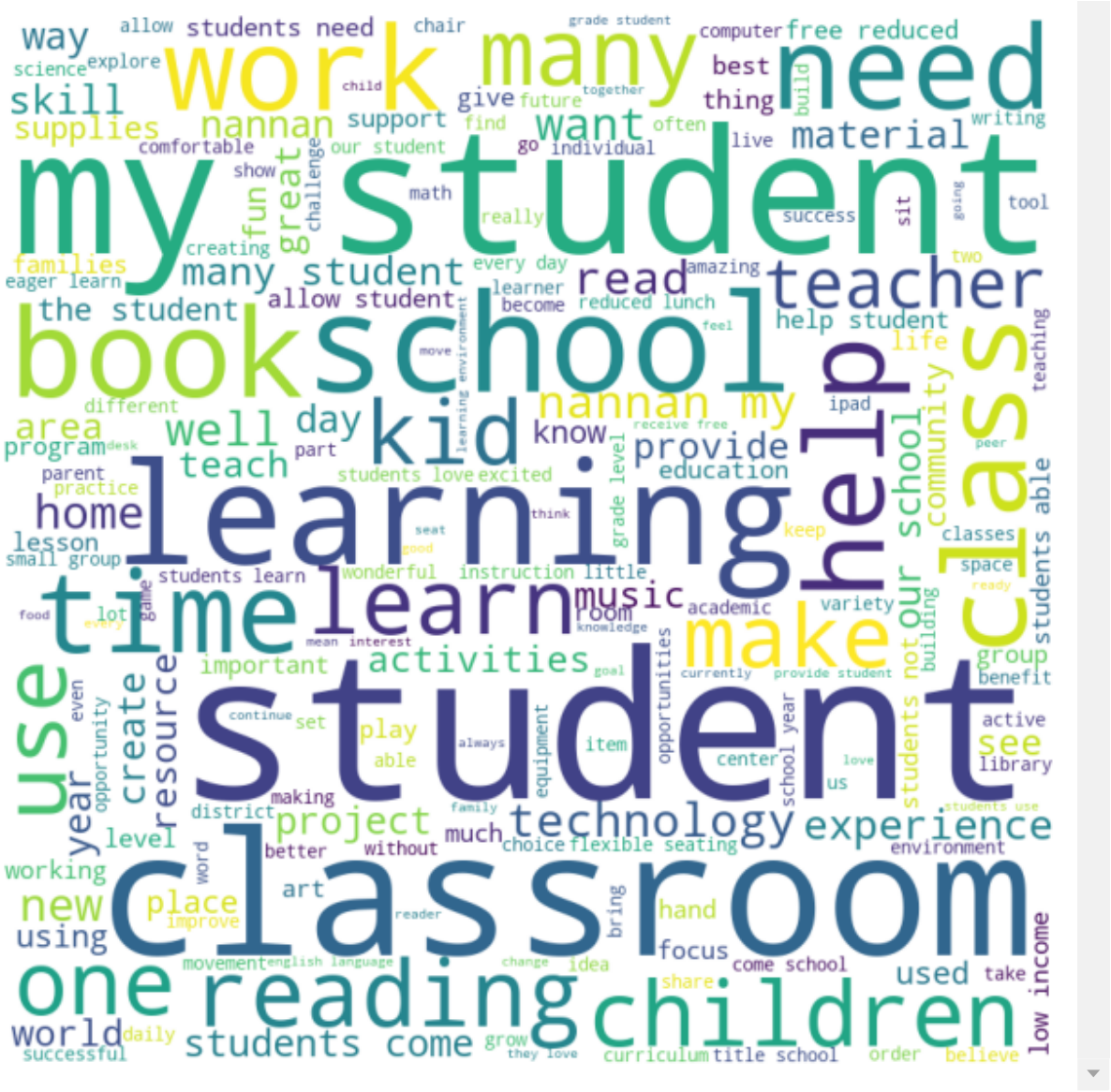
```
# Getting eassy feature of false positive data points from test data
X_test_fp = X_test[(y_test == 0) & (y_pred_test_t == 1)]
essay_fp = X_test_fp['essay']
len(essay_fp)
```

Out[54]:

```
1298
```

In [55]:

```
df = essay_fp

comment_words = ''
stopwords = set(STOPWORDS)

# iterate through the csv file
for val in df:

    # typecaste each val to string
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    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 = (8, 8), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



1.5.9 Ploting Box plot Price

In [56]:

```
price_fp = X_test_fp['price'] # Getting "Price " feature of false positive data points
```

In [57]:

```
plt.boxplot(price_fp)
plt.ylabel('Price')
plt.title("Box Plot of price of fase positive datapoints")
plt.show()
```

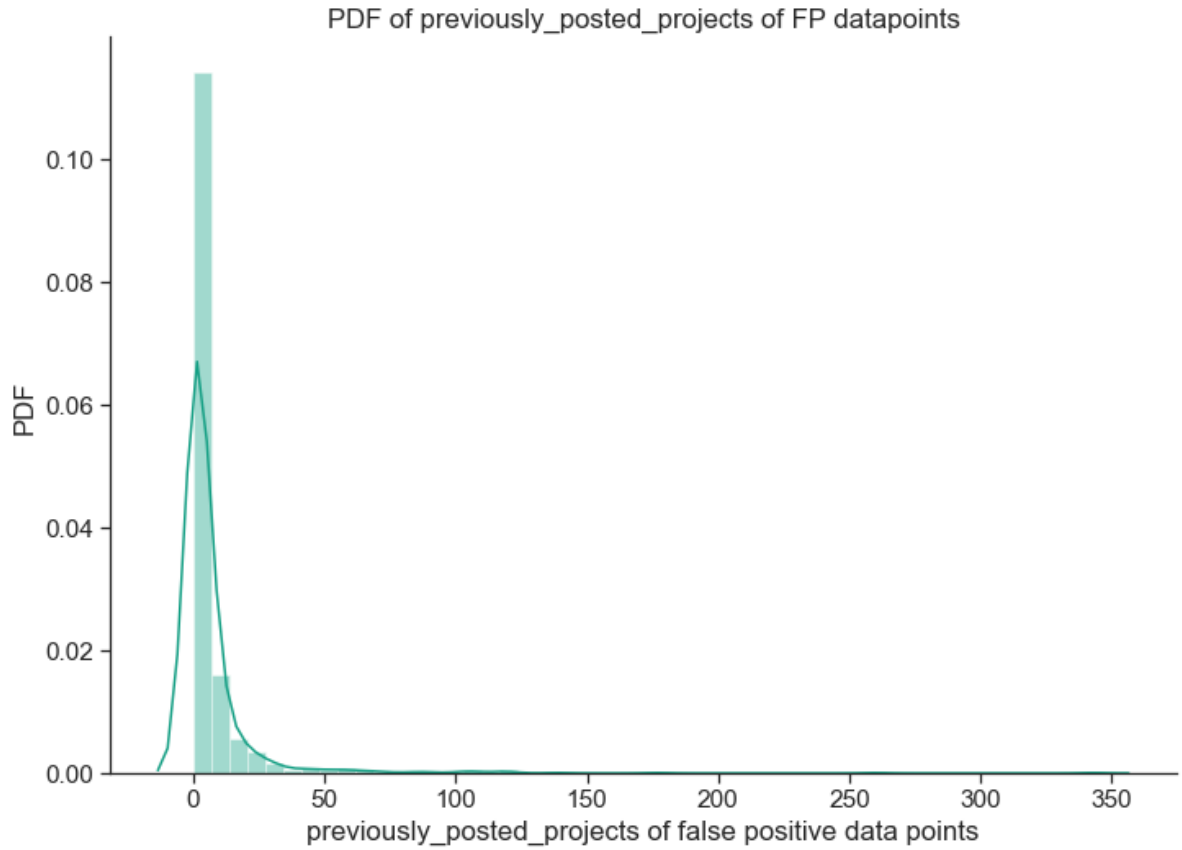
1.5.10 Ploting PDF teacher_number_of_previously_posted_projects

In [58]:

```
previously_posted_projects=X_test_fp['teacher_number_of_previously_posted_projects']  # Get
```

In [59]:

```
sns.set_style('ticks')
fig, ax = plt.subplots()
fig.set_size_inches(11.7, 8.27)
sns.distplot(previously_posted_projects, color='#16A085')
plt.xlabel('previously_posted_projects of false positive data points')
plt.ylabel('PDF')
plt.title('PDF of previously_posted_projects of FP datapoints')
sns.despine()
```



In [ ]:

```
```

Task2

1.6 Getting top features using `feature_importances_`

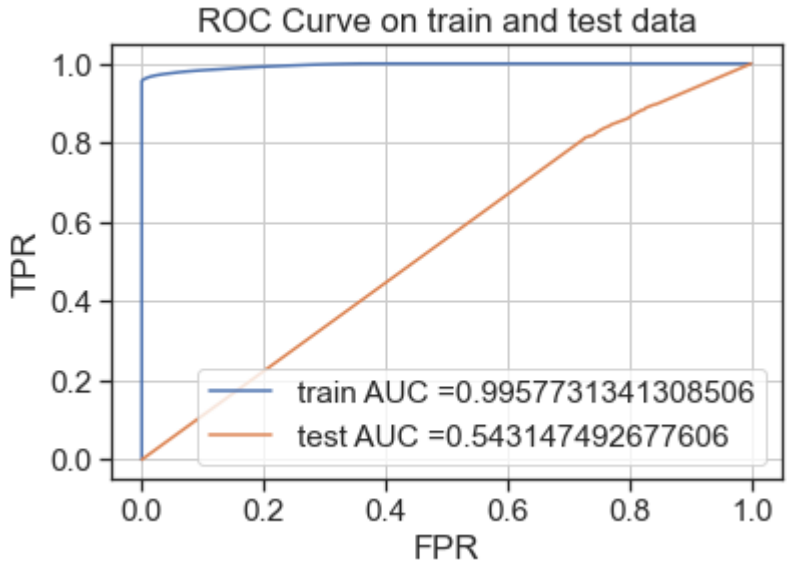
In [60]:

```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

1.6.1 Getting Feature Importance for set1 features

In [61]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

clf=DecisionTreeClassifier(random_state=0,min_samples_split=10,max_depth=None)
clf.fit(X_tr_tfidf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_tfidf)
y_test_pred = batch_predict(clf, X_te_tfidf)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve on train and test data")
plt.grid()
plt.show()
```



In [62]:

```
featureImportance_values=clf.feature_importances_
featureImportance_values
```

Out[62]:

```
array([0.        , 0.00067905, 0.00160961, ..., 0.        , 0.01738841,
       0.00620896])
```

In [63]:

```
# Getting non-zero feature importance values and there corresponding indices

import numpy as np
featureImportance_values

print(featureImportance_values)

print ('Indices of featureImportance_values !=0')

feature_indices = np.where(featureImportance_values != 0)
print(feature_indices)
print("featureImportance_values which are != 0")
print(featureImportance_values[feature_indices])
feature_indices= list(feature_indices[0])
```

```
[0.         0.00067905 0.00160961 ... 0.         0.01738841 0.00620896]
Indices of featureImportance_values !=0
(array([   1,    2,    4, ..., 5095, 5099, 5100], dtype=int64),)
featureImportance_values which are != 0
[0.00067905 0.00160961 0.00027877 ... 0.00042845 0.01738841 0.00620896]
```

In [64]:

```
# New train, CV, Test data set corresponding to non_zero feature indices
X_tr_tfidf_FI = X_tr_tfidf[:,feature_indices]
X_cr_tfidf_FI =X_cr_tfidf[:,feature_indices]
X_te_tfidf_FI = X_te_tfidf[:,feature_indices]
(X_tr_tfidf_FI).shape
```

Out[64]:

```
(29400, 1456)
```

1.6.2 Modeling

Hyperparameter Tuning

In [65]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 4900
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [66]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
max_depth_plot = []
min_samples_split_plot =[]
min_samples_split=[5, 10, 100, 500]
max_depth=[1, 5, 10, 50]
for i in tqdm(min_samples_split):
    for j in max_depth:
        min_samples_split_plot.append(i)
        max_depth_plot.append(j)
        clf=DecisionTreeClassifier(random_state=0,min_samples_split=i,max_depth=j)
        clf.fit(X_tr_tfidf_FI, y_train)

        y_train_pred = batch_predict(clf, X_tr_tfidf_FI)
        y_cv_pred = batch_predict(clf, X_cr_tfidf_FI)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
100%|██████████| 4/4 [02:20<00:00, 35.07s/it]
```

In [67]:

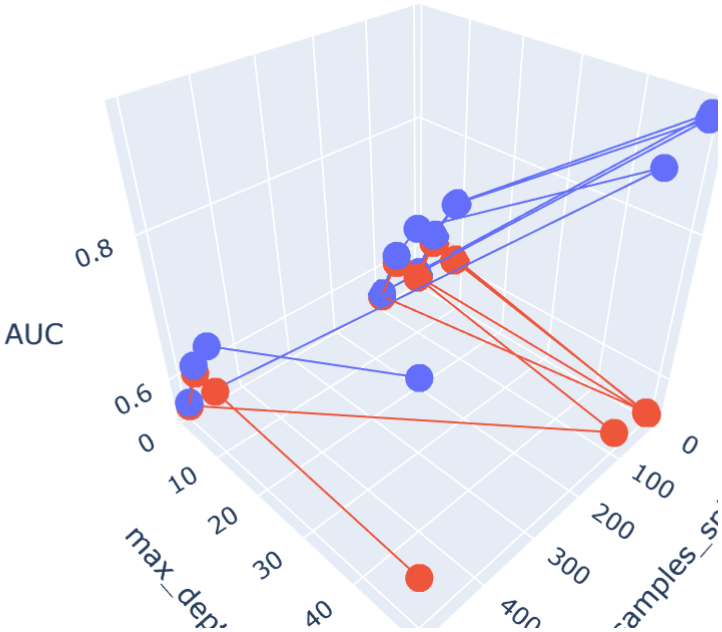
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [68]:

```
x1 = min_samples_split_plot
y1 = max_depth_plot
z1 = train_auc

x2 = min_samples_split_plot
y2 = max_depth_plot
z2 = cv_auc
```

In [69]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'train')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Cross validation')
data = [trace1, trace2]

layout = go.Layout(scene = dict(
        xaxis = dict(title='min_samples_split'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data=data, layout=layout)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

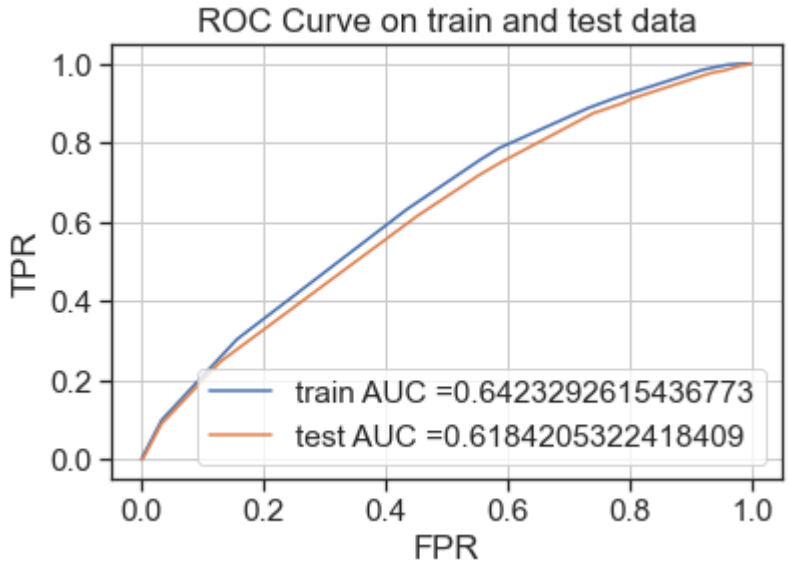


In [70]:

```
#  we choose best hyperparameterssuch that, we will have maximum AUC on cv data and gap bet

#here we are choosing the best hyperparameters based on forloop results
min_samples_split_best = 10
max_depth_best = 5
```

In [71]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

clf=DecisionTreeClassifier(random_state=0,min_samples_split=min_samples_split_best,max_dept
clf.fit(X_tr_tfidf_FI, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_tfidf_FI)
y_test_pred = batch_predict(clf, X_te_tfidf_FI)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve on train and test data")
plt.grid()
plt.show()
```



1.6.3 Ploting confusion matrix for set1 features

In [72]:

```
# 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.round(t
    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 [73]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

```
====================================================================================
========================
the maximum value of tpr*(1-fpr) 0.35714394530297855 for threshold 0.862
Train confusion matrix
[[ 2640  2032]
 [ 9099 15629]]
Test confusion matrix
[[1568 1293]
 [5826 9313]]
```

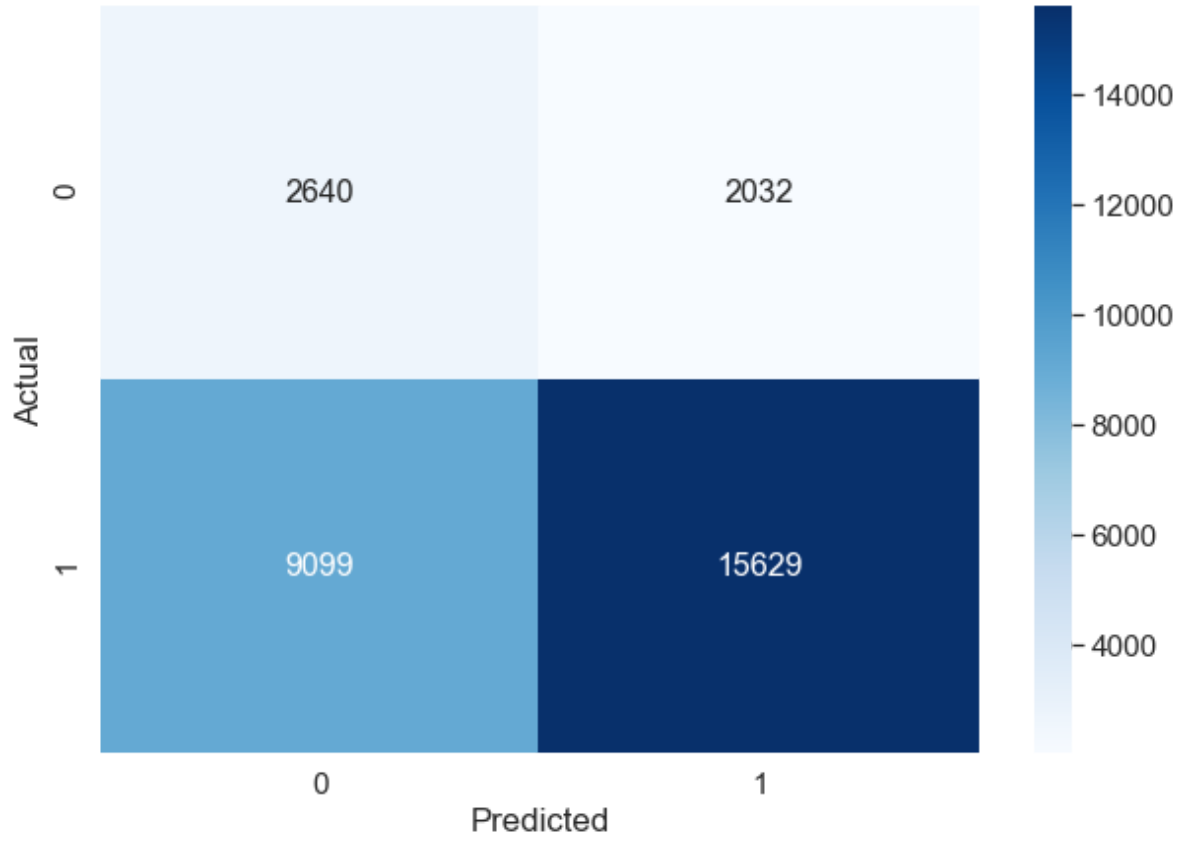
In [74]:

```
from sklearn.metrics import confusion_matrix
import pandas as pd
import seaborn as sn
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np

print("Train confusion matrix")
data = confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Train confusion matrix
```

Out[74]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d523e828c8>
```



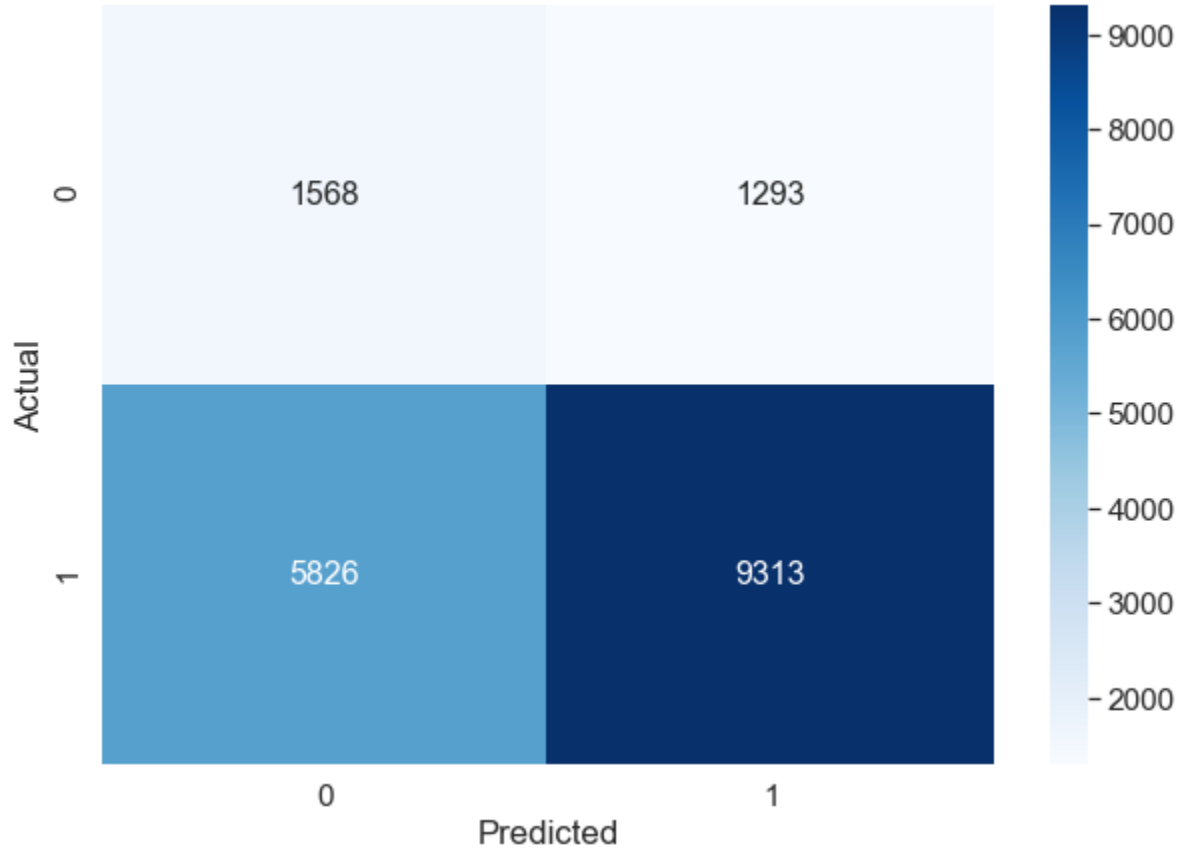
In [75]:

```
print("Test confusion matrix")
data = confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t))
df_cm = pd.DataFrame(data, columns=np.unique(y_test), index = np.unique(y_test))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
y_pred_test = predict_with_best_t(y_test_pred, best_t)
plt.figure(figsize = (10,7))
sn.set(font_scale=1.4)#for label size
sn.heatmap(df_cm, cmap="Blues", annot=True,annot_kws={"size": 16},fmt='g')# font size
```

```
Test confusion matrix
```

Out[75]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1d54d3512c8>
```



1.6.4 Ploting word cloud of essay feature

In [76]:

```
y_pred_test_t = np.transpose(y_pred_test)
```

In [77]:

```
# Getting eassy feature of false positive data points from test data
X_test_fp = X_test[(y_test == 0) & (y_pred_test_t == 1)]
essay_fp = X_test_fp['essay']

len(essay_fp)
```

Out[77]:

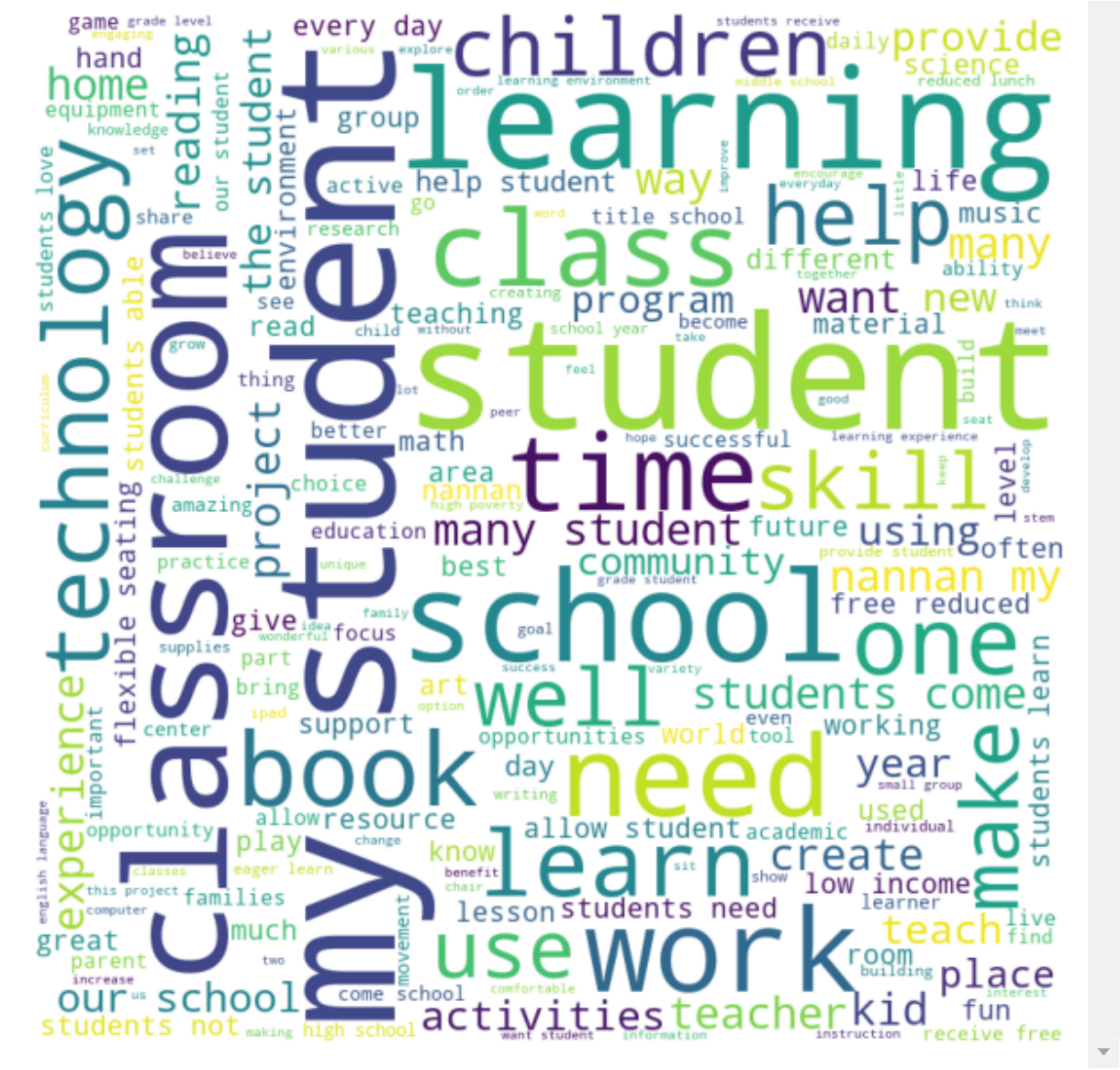
```
1293
```

In [78]:

```
from wordcloud import WordCloud, STOPWORDS
```

In [79]:

```
df = essay_fp

comment_words = ''
stopwords = set(STOPWORDS)

# iterate through the csv file
for val in df:

    # typecaste each val to string
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    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 = (8, 8), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



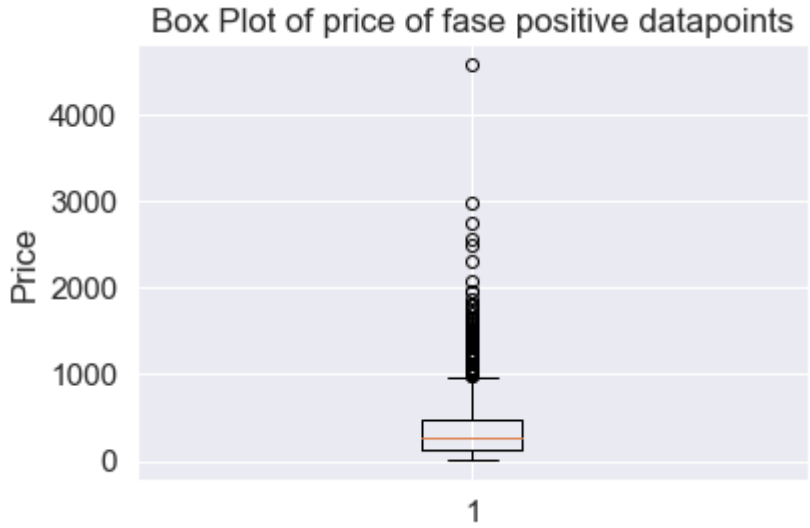
1.6.5 Ploting Box plot Price

In [80]:

```
price_fp = X_test_fp['price']
```

In [81]:

```
plt.boxplot(price_fp)
plt.ylabel('Price')
plt.title("Box Plot of price of fase positive datapoints")
plt.show()
```



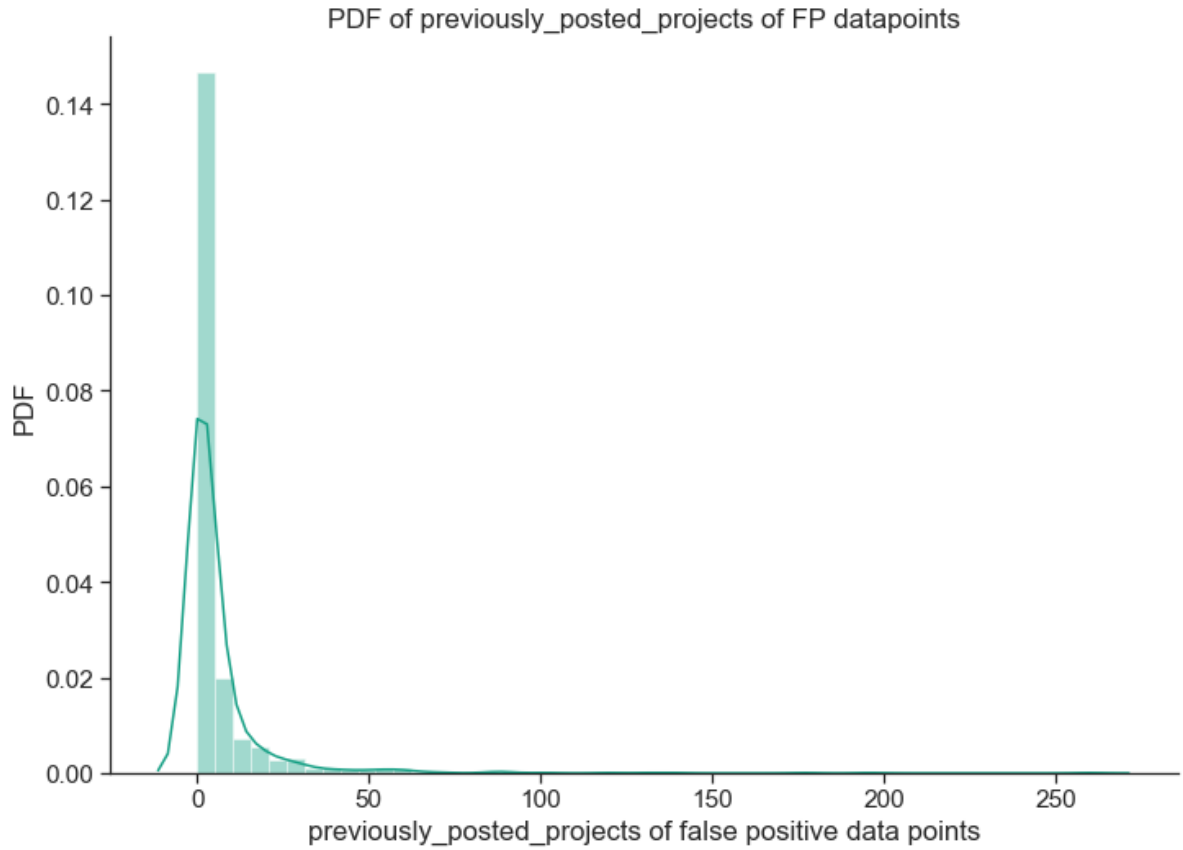
1.6.6 Ploting PDF teacher_number_of_previously_posted_projects

In [82]:

```
previously_posted_projects=X_test_fp['teacher_number_of_previously_posted_projects']
```

In [83]:

```
sns.set_style('ticks')
fig, ax = plt.subplots()
fig.set_size_inches(11.7, 8.27)
sns.distplot(previously_posted_projects, color='#16A085')
plt.xlabel('previously_posted_projects of false positive data points')
plt.ylabel('PDF')
plt.title('PDF of previously_posted_projects of FP datapoints')
sns.despine()
```



In [ ]:

```

```

2. Summary

In [95]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyperparameter min_samples_split","Hyperparameter

x.add_row(["TFIDF","DecisionTreeClassifier", '10','5', '0.64','0.61'])
x.add_row(["TFIDF_W2V", "DecisionTreeClassifier", '10','5', '0.66','0.61'])
x.add_row(["TFIDF(Fe_Imp)", "DecisionTreeClassifier", '10','5', '0.64','0.61'])# Considerin
print(x)
```

```
+---------------+-----------------------+---------------------------------
+--------------------------+-----------+----------+
|   Vectorizer  |         Model         | Hyperparameter min_samples_split
| Hyperparameter Max_Depth | Train_AUC | Test_AUC |
+---------------+-----------------------+---------------------------------
+--------------------------+-----------+----------+
|     TFIDF     | DecisionTreeClassifier |                10
|            5             |    0.64   |   0.61   |
|   TFIDF_W2V   | DecisionTreeClassifier |                10
|            5             |    0.66   |   0.61   |
| TFIDF(Fe_Imp) | DecisionTreeClassifier |                10
|            5             |    0.64   |   0.61   |
+---------------+-----------------------+---------------------------------
+--------------------------+-----------+----------+
```

In [ ]:

In [ ]: