Assignment-8 Apply Decision Trees on Donors Choose dataset

In [1]:

```
import warnings
warnings.filterwarnings("ignore")
import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
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
from nltk.stem.porter import PorterStemmer
import re
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle
from tqdm import tqdm
import os
from chart_studio.plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

1.1 Loading Data

In [2]:

```
data = pd.read_csv('preprocessed_data.csv', nrows=50000)
data.head(2)
```

Out[2]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL

2 rows × 29 columns

In [3]:

```
data['project_is_approved'].value_counts()
```

Out[3]:

```
1    42286
0     7714
Name: project_is_approved, dtype: int64
```

In [4]:

```
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)
X.head(2)
```

Out[4]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL

2 rows × 28 columns

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

In [5]:

```
# train 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=0.33, stratify=y)
```

1.3 Make Data Model Ready: encoding essay, and project_title

1.3.1 Vectorizing preprocessed essays & project_title using BOW

In [93]:

```
# preprocessed essays
print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)

print("="*100)


vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values)  # fit has to happen only on trai
n data

# we use the fit CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['preprocessed_essays'].values)
X_test_essay_bow = vectorizer.transform(X_test['preprocessed_essays'].values)
```

```
(33500, 28) (33500,)
(16500, 28) (16500,)
==========================================================================
==========================
```

In [95]:

```
f1=vectorizer.get_feature_names()
print("After vectorization")
print(X_train_essay_bow.shape, y_train.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 5000) (33500,)
(16500, 5000) (16500,)
==========================================================================
==========================
```

In [96]:

```
#project_title
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_titles'].values.astype('U'))

X_train_title_bow = vectorizer.transform(X_train['preprocessed_titles'].values.astype(
'U'))
X_test_title_bow = vectorizer.transform(X_test['preprocessed_titles'].values.astype('U'
))
```

In [97]:

```
f2=vectorizer.get_feature_names()
print("After vectorization")
print(X_train_title_bow.shape, y_train.shape)
print(X_test_title_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 2346) (33500,)
(16500, 2346) (16500,)
==========================================================================
==========================
```

1.3.2 Vectorizing preprocessed essays & project_title using TFIDF

In [98]:

```
#TFIDF for preprocessed_essays
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values)

X_train_essay_tfidf = vectorizer.transform(X_train['preprocessed_essays'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['preprocessed_essays'].values)
```

In [99]:

```
f3=vectorizer.get_feature_names()
print("After vectorization")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 5000) (33500,)
(16500, 5000) (16500,)
==========================================================================
==========================
```

In [100]:

```
#TFIDF for preprocessed_titles
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_titles'].values.astype('U'))

X_train_titles_tfidf = vectorizer.transform(X_train['preprocessed_titles'].values.astyp
e('U'))
X_test_titles_tfidf = vectorizer.transform(X_test['preprocessed_titles'].values.astype(
'U'))
```

In [101]:

```
f4=vectorizer.get_feature_names()
print("After vectorization")
print(X_train_titles_tfidf.shape, y_train.shape)
print(X_test_titles_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 2346) (33500,)
(16500, 2346) (16500,)
==========================================================================
==========================
```

1.3.3 Vectorizing preprocessed essays & project_title using Avg W2V

1.3.3.1 For preprocessed_titles

In [18]:

```
#Avg W2V for preprocessed_titles
#Train your own Word2Vec model using your own text corpus
import warnings
warnings.filterwarnings("ignore")
#train data
w2v_data= X_train['preprocessed_titles']
split_title_train=[]
for row in w2v_data:
    split_title_train.append([word for word in str(row).split()])     #splitting words

#train your W2v
train_w2v = Word2Vec(split_title_train,min_count=1,size=50, workers=4)
word_vectors_train = train_w2v.wv
w2v_words_train =list(word_vectors_train.vocab)
print(len(w2v_words_train ))
```

```
9605
```

In [19]:

```
# compute average word2vec for each title.
sent_vectors_train = [] # the avg-w2v for each title is stored in this list
for sent in tqdm(split_title_train):   # for each title
    sent_vec = np.zeros(50)  # as word vectors are of zero length 50
    cnt_words =0   # num of words with a valid vector in the title
    for word in sent:   # for each word in a title
        if word in w2v_words_train:
            vec = word_vectors_train[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
        sent_vectors_train.append(sent_vec)
print(len(sent_vectors_train))
print(len(sent_vectors_train[3]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████████████████████| 33500/33500 [00:04<00:00, 7374.08it/s]

33500
50
```

In [20]:

```
# For test data

# compute average word2vec for each title.
sent_vectors_test = [] # the avg-w2v for each title is stored in this list
for sent in tqdm(X_test['preprocessed_titles']):   # for each title
    sent_vec = np.zeros(50)  # as word vectors are of zero length 50
    #cnt_words =0   # num of words with a valid vector in the title
    for word in str(sent):   # for each word in a title
        if word in w2v_words_train:
            vec = word_vectors_train[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
        sent_vectors_test.append(sent_vec)
print(len(sent_vectors_test))
print(len(sent_vectors_test[3]))
```

```
100%|█████████████████████████████████████████████████████████████████████
████████████████████████████████████████████████████| 16500/16500 [00:55<0
0:00, 297.89it/s]

16500
50
```

1.3.3.2 For preprocessed_essays

Using Pretrained Models: Avg W2V

In [22]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-p
ickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('C:\\Users\\Admin\\Assignments and case studies\\Mandatory\\Assignment 7-SVM
 on donors choose\\glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
print ("Done.",len(model)," words loaded!")
```

```
Done. 51510  words loaded!
```

In [23]:

```
# Avg W2V for train data
# compute average word2vec for each review.
avg_w2v_essay_train = []   # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_train['preprocessed_essays']):   # 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
    avg_w2v_essay_train.append(vector)
print(len(avg_w2v_essay_train))
print(len(avg_w2v_essay_train[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████████| 33500/33500 [00:13<0
0:00, 2397.72it/s]
```

```
33500
300
```

In [24]:

```
# Avg W2V for test data

avg_w2v_essay_test = []   # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays']):   # 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
    avg_w2v_essay_test.append(vector)
print(len(avg_w2v_essay_test))
print(len(avg_w2v_essay_test[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████████| 16500/16500 [00:06<0
0:00, 2378.12it/s]
```

```
16500
300
```

1.3.4 Vectorizing preprocessed essays & project_title using TFIDF weighted W2V

1.3.4.1 For preprocessed essays

In [25]:

```
# For train data

tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_essays'])
#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_essays = set(tfidf_model.get_feature_names())
```

In [26]:

```
# average Word2Vec using pretrained models
# compute average word2vec for each review.
tfidf_w2v_train_essay = [] # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_train['preprocessed_essays']): # 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_essays):
            vec = model[word]  # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
        tfidf_w2v_train_essay.append(vector)
print(len(tfidf_w2v_train_essay))
print(len(tfidf_w2v_train_essay[0]))
```

```
100%|██████████████████████████████████████████████████| 33500/33500 [01:31<00:00, 366.50it/s]

33500
300
```

In [27]:

```
# For test data

tfidf_w2v_test_essay = [] # the avg-w2v for each sentence/review is stored in this list
for sentence2 in tqdm(X_test['preprocessed_essays']): # for each review/sentence
    vector2 = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight2 =0; # num of words with a valid vector in the sentence/review
    for word2 in sentence2.split(): # for each word in a review/sentence
        if (word2 in glove_words) and (word2 in tfidf_words_essays):
            vec2 = model[word2]  # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf2 = dictionary[word2]*(sentence2.count(word2)/len(sentence2.split()))
# getting the tfidf value for each word
            vector2 += (vec2 * tf_idf2) # calculating tfidf weighted w2v
            tf_idf_weight2 += tf_idf2
    if tf_idf_weight2 != 0:
        vector2 /= tf_idf_weight2
        tfidf_w2v_test_essay.append(vector2)
print(len(tfidf_w2v_test_essay))
print(len(tfidf_w2v_test_essay[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 16500/16500 [00:48<00:00, 342.12it/s]

16500
300
```

1.3.4.2 For preprocessed titles

Using pretrained models

In [28]:

```
# For train data

tfidf_model1 = TfidfVectorizer()
tfidf_model1.fit(X_train['preprocessed_titles'].values.astype('U'))
#we are converting a dictionary with word as a key, and the idf as a value
dictionary_title = dict(zip(tfidf_model1.get_feature_names(), list(tfidf_model1.idf_)))
tfidf_words_titles = set(tfidf_model1.get_feature_names())
```

In [30]:

```
# average Word2Vec using pretrained models
# compute average word2vec for each review.
tfidf_w2v_train_title = [] # the avg-w2v for each sentence/review is stored in this lis
t
for sentence_title in tqdm(X_train['preprocessed_titles']): # for each review/sentence
    vector3 = np.zeros(300) # as word vectors are of zero length
    #tf_idf_weight3=0; # num of words with a valid vector in the sentence/review
    for word3 in str(sentence_title).split(): # for each word in a review/sentence
        if (word3 in glove_words) and (word3 in tfidf_words_titles):
            vec4 = model[word3]  # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf3 = dictionary_title[word3]*(sentence_title.count(word3)/len(str(sent
ence_title).split())) # getting the tfidf value for each word
            vector3 += (vec4 * tf_idf3) # calculating tfidf weighted w2v
            tf_idf_weight3 += tf_idf3
    if tf_idf_weight3 != 0:
        vector3 /= tf_idf_weight3
        tfidf_w2v_train_title.append(vector3)
print(len(tfidf_w2v_train_title))
print(len(tfidf_w2v_train_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████| 33500/33500 [00:01<00:
00, 20163.31it/s]

33500
300
```

In [32]:

```
# For test data
tfidf_w2v_test_title = [] # the avg-w2v for each sentence/review is stored in this list
for sentence_test in tqdm(X_test['preprocessed_titles']): # for each review/sentence
    vector5 = np.zeros(300) # as word vectors are of zero length
    #tf_idf_weight5 =0; # num of words with a valid vector in the sentence/review
    for word5 in str(sentence_test).split(): # for each word in a review/sentence
        if (word5 in glove_words) and (word5 in tfidf_words_titles):
            vec6 = model[word5]  # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf5 = dictionary_title[word5]*(sentence_test.count(word5)/len(str(sente
nce_test).split())) # getting the tfidf value for each word
            vector5 += (vec6 * tf_idf5) # calculating tfidf weighted w2v
            tf_idf_weight5 += tf_idf5
    if tf_idf_weight5 != 0:
        vector5 /= tf_idf_weight5
        tfidf_w2v_test_title.append(vector5)
print(len(tfidf_w2v_test_title))
print(len(tfidf_w2v_test_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████| 16500/16500 [00:00<00:
00, 20538.88it/s]

16500
300
```

1.4 Make Data Model Ready: encoding numerical, categorical features

1.4.1 Encoding categorical features: School State

In [102]:

```
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 = vectorizer.transform(X_train['school_state'].values)
X_test_state = vectorizer.transform(X_test['school_state'].values)
f5=vectorizer.get_feature_names()
print("After vectorizations")
print(X_train_state.shape, y_train.shape)
print(X_test_state.shape, y_test.shape)
print(f5)
print("="*100)
```

```
After vectorizations
(33500, 51) (33500,)
(16500, 51) (16500,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi',
'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'm
o', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'o
k', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'w
i', 'wv', 'wy']
===========================================================================
==========================
```

1.4.2 Encoding categorical features: teacher_prefix

In [103]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)

X_train_teacher = vectorizer.transform(X_train['teacher_prefix'].values)
X_test_teacher = vectorizer.transform(X_test['teacher_prefix'].values)

f6=vectorizer.get_feature_names()
print("After vectorizations")
print(X_train_teacher.shape, y_train.shape)
print(X_test_teacher.shape, y_test.shape)
print(f6)
print("="*100)
```

```
After vectorizations
(33500, 6) (33500,)
(16500, 6) (16500,)
['dr', 'mr', 'mrs', 'ms', 'none', 'teacher']
===========================================================================
==========================
```

1.4.3 Encoding categorical features: project_grade_category

In [104]:

```
#This step is to intialize a vectorizer with vocab from train data
#Ref: https://www.kaggle.com/shashank49/donors-choose-knn#Concatinating-all-features-(T
FIDF)
from collections import Counter
my_counter = Counter()
for word in X_train['project_grade_category'].values:
    my_counter.update([word[i:i+14] for i in range(0, len(word),14)]) #https://www.geek
sforgeeks.org/python-string-split/

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
project_grade_category_dict = dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), k
ey=lambda kv: kv[1]))
```

In [105]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys
()), lowercase=False, binary=True,max_features=4)
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only on tr
ain data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade = vectorizer.transform(X_train['project_grade_category'].values)
X_test_grade = vectorizer.transform(X_test['project_grade_category'].values)

f7=vectorizer.get_feature_names()
print("After vectorizations")
print(X_train_grade.shape, y_train.shape)
print(X_test_grade.shape, y_test.shape)
print(f7)
```

```
After vectorizations
(33500, 4) (33500,)
(16500, 4) (16500,)
['Grades 9-12', 'Grades 6-8', 'Grades 3-5', 'Grades PreK-2']
```

1.4.4 Encoding categorical features: clean_categories

In [106]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat = vectorizer.transform(X_train['clean_categories'].values)
X_test_cat = vectorizer.transform(X_test['clean_categories'].values)

f8=vectorizer.get_feature_names()
print("After vectorizations")
print(X_train_cat.shape, y_train.shape)
print(X_test_cat.shape, y_test.shape)
print(f8)
print("="*100)
```

```
After vectorizations
(33500, 9) (33500,)
(16500, 9) (16500,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'lit
eracy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
==========================================================================
==========================
```

1.4.5 Encoding categorical features: clean_subcategories

In [107]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat = vectorizer.transform(X_train['clean_subcategories'].values)
X_test_subcat = vectorizer.transform(X_test['clean_subcategories'].values)

f9=vectorizer.get_feature_names()
print("After vectorizations")
print(X_train_subcat.shape, y_train.shape)
print(X_test_subcat.shape, y_test.shape)
print(f9)
print("="*100)
```

```
After vectorizations
(33500, 30) (33500,)
(16500, 30) (16500,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_governmen
t', 'college_careerprep', 'communityservice', 'earlydevelopment', 'economi
cs', 'environmentalscience', 'esl', 'extracurricular', 'financialliterac
y', 'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_welln
ess', 'history_geography', 'literacy', 'literature_writing', 'mathematic
s', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performi
ngarts', 'socialsciences', 'specialneeds', 'teamsports', 'visualarts', 'wa
rmth']
==========================================================================
==========================
```

1.4.6 Encoding numerical features: Price

In [109]:

```
from sklearn.preprocessing import Normalizer
normalizer1 = Normalizer()
# normalizer.fit(X_train['price'].values)
#this will rise an error Expected 2D array, got 1D array instead:
normalizer1.fit(X_train['price'].values.reshape(-1,1))

X_train_price_norm = normalizer1.transform(X_train['price'].values.reshape(-1,1))
X_test_price_norm = normalizer1.transform(X_test['price'].values.reshape(-1,1))

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

```
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

1.4.7 Encoding numerical features: Quantity

In [41]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['quantity'].values.reshape(1,-1))

X_train_quantity_norm = normalizer.transform(X_train['quantity'].values.reshape(1,-1))
X_test_quantity_norm = normalizer.transform(X_test['quantity'].values.reshape(1,-1))

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

1.4.8 Encoding numerical features: teacher_number_of_previously_posted_projects

In [42]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
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_post
ed_projects'].values.reshape(1,-1))
X_test_projects_norm = normalizer.transform(X_test['teacher_number_of_previously_posted
_projects'].values.reshape(1,-1))

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

```
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
===========================================================================
=========================
```

1.4.9 Encoding numerical features: sentimental_score

In [43]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['sentimental_score'].values.reshape(-1,1))

X_train_senti_norm = normalizer.transform(X_train['sentimental_score'].values.reshape(1
,-1))
X_test_senti_norm = normalizer.transform(X_test['sentimental_score'].values.reshape(1,-
1))

print("After vectorizations")
print(X_train_senti_norm.shape, y_train.shape)
print(X_test_senti_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
===========================================================================
=========================
```

1.4.10 Encoding numerical features: preprocessed_essay_word_count

In [44]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['preprocessed_essay_word_count'].values.reshape(-1,1))

X_train_ewc_norm = normalizer.transform(X_train['preprocessed_essay_word_count'].values
.reshape(1,-1))
X_test_ewc_norm = normalizer.transform(X_test['preprocessed_essay_word_count'].values.r
eshape(1,-1))

print("After vectorization")
print(X_train_ewc_norm.shape, y_train.shape)
print(X_test_ewc_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

1.4.11 Encoding numerical features: preprocessed_title_word_count

In [45]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['preprocessed_title_word_count'].values.reshape(-1,1))

X_train_twc_norm = normalizer.transform(X_train['preprocessed_title_word_count'].values
.reshape(1,-1))
X_test_twc_norm = normalizer.transform(X_test['preprocessed_title_word_count'].values.r
eshape(1,-1))

print("After vectorization")
print(X_train_twc_norm.shape, y_train.shape)
print(X_test_twc_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorization
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

1.4.5 Concatinating all the features

1.4.5.1 Set 1: Using categorical features + numerical features + preprocessed_titles(BOW) + preprocessed_essays(BOW)

In [46]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_tr_bow = hstack((X_train_essay_bow, X_train_title_bow, X_train_state, X_train_teacher
, X_train_grade, X_train_cat, X_train_subcat, X_train_price_norm, X_train_quantity_norm
, X_train_projects_norm )).tocsr()


X_test_bow = hstack((X_test_essay_bow, X_test_title_bow, X_test_state, X_test_teacher,
X_test_grade, X_test_cat, X_test_subcat, X_test_price_norm, X_test_quantity_norm, X_tes
t_projects_norm )).tocsr()

print("Final Data Matrix")
print(X_tr_bow.shape, y_train.shape)
print(X_test_bow.shape, y_train.shape)
```

```
Final Data Matrix
(33500, 7449) (33500,)
(16500, 7449) (33500,)
```

1.4.5.2 Set 2: Using categorical features + numerical features + preprocessed_titles(TFIDF) + preprocessed_essays(TFIDF)

In [47]:

```
X_tr_tfidf = hstack((X_train_essay_tfidf, X_train_titles_tfidf, X_train_state, X_train_
teacher, X_train_grade, X_train_cat, X_train_subcat, X_train_price_norm, X_train_quanti
ty_norm, X_train_projects_norm )).tocsr()


X_test_tfidf = hstack((X_test_essay_tfidf, X_test_titles_tfidf, X_test_state, X_test_te
acher, X_test_grade, X_test_cat, X_test_subcat, X_test_price_norm, X_test_quantity_norm
, X_test_projects_norm )).tocsr()

print("Final Data Matrix")
print(X_tr_tfidf.shape, y_train.shape)
print(X_test_tfidf.shape, y_train.shape)
```

```
Final Data Matrix
(33500, 7449) (33500,)
(16500, 7449) (33500,)
```

1.4.5.3 Set 3: Using categorical features + numerical features + preprocessed_titles(Avg W2V) + preprocessed_essays(Avg W2V)

In [48]:

```
X_tr_avgw2v = hstack((sent_vectors_train, avg_w2v_essay_train, X_train_state, X_train_t
eacher, X_train_grade, X_train_cat, X_train_subcat, X_train_price_norm, X_train_quantit
y_norm, X_train_projects_norm )).tocsr()


X_test_avgw2v = hstack((sent_vectors_test, avg_w2v_essay_test, X_test_state, X_test_tea
cher, X_test_grade, X_test_cat, X_test_subcat, X_test_price_norm, X_test_quantity_norm,
X_test_projects_norm )).tocsr()

print("Final Data Matrix")
print(X_tr_avgw2v.shape, y_train.shape)
print(X_test_avgw2v.shape, y_train.shape)
```

```
Final Data Matrix
(33500, 453) (33500,)
(16500, 453) (33500,)
```

1.4.5.4 Set 4: Using categorical features + numerical features + preprocessed_titles(TFIDF W2V) + preprocessed_essays(TFIDF W2V)

In [49]:

```
X_tr_tfidf_w2v = hstack((tfidf_w2v_train_essay, tfidf_w2v_train_title, X_train_state, X
_train_teacher, X_train_grade, X_train_cat, X_train_subcat, X_train_price_norm, X_train
_quantity_norm, X_train_projects_norm )).tocsr()

X_test_tfidf_w2v = hstack((tfidf_w2v_test_essay, tfidf_w2v_test_title, X_test_state, X_
test_teacher, X_test_grade, X_test_cat, X_test_subcat, X_test_price_norm, X_test_quanti
ty_norm, X_test_projects_norm )).tocsr()

print("Final Data Matrix")
print(X_tr_tfidf_w2v.shape, y_train.shape)
print(X_test_tfidf_w2v.shape, y_train.shape)
```

```
Final Data Matrix
(33500, 703) (33500,)
(16500, 703) (33500,)
```

2. Applying DT

2.1 Set 1: BOW featurization

2.1.1 Hyper parameter tuning

In [50]:

```
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier

dt_bow = DecisionTreeClassifier(criterion='gini',class_weight = 'balanced') #https://sc
ikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html
parameters = {'max_depth': [4, 6, 8, 10, 30], 'min_samples_split': [5, 20, 80, 200, 500
]}
clf1 = RandomizedSearchCV(dt_bow, parameters, cv=3, scoring='roc_auc',return_train_scor
e=True,n_jobs=-1)
rs1 = clf1.fit(X_tr_bow, y_train)
```

In [68]:

```
df=pd.DataFrame(clf1.cv_results_)
df.head(5)
```

Out[68]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_min_sample
0	1.021475	0.039561	0.038473	0.021746	500
1	1.111778	0.022664	0.020260	0.002591	200
2	0.589626	0.002974	0.033230	0.016582	500
3	5.679940	0.595381	0.025874	0.002980	500
4	1.556769	0.181293	0.024326	0.002045	500

2.1.2 3D-Plot

In [63]:

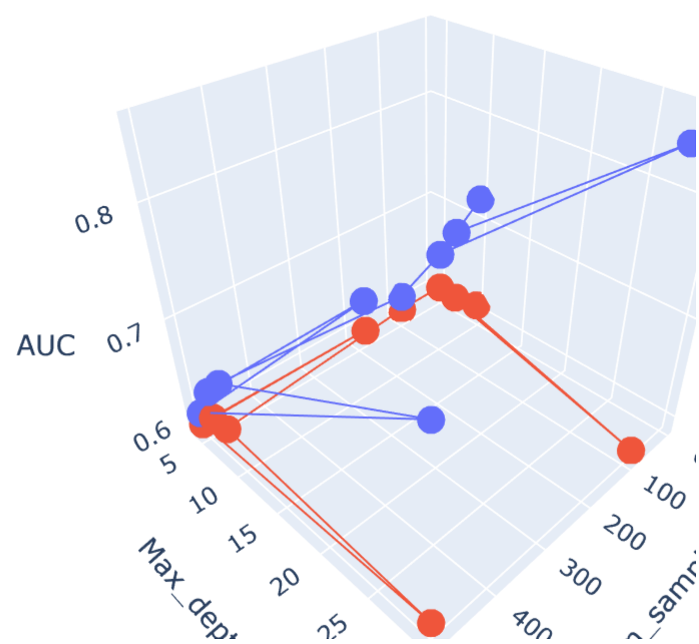
```
%matplotlib inline
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [65]:

```
def enable_plotly_in_cell():
    import IPython
    from plotly.offline import init_notebook_mode
    display(IPython.core.display.HTML('''<script src="/static/components/requirejs/requ
ire.js"></script>'''))
    init_notebook_mode(connected=False)
```

In [67]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=df['param_min_samples_split'],y=df['param_max_depth'],z=df['mea
n_train_score'], name = 'train')
trace2 = go.Scatter3d(x=df['param_min_samples_split'],y=df['param_max_depth'],z=df['mea
n_test_score'], name = 'Cross validation')
data = [trace1, trace2]
enable_plotly_in_cell()

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

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



2.1.3 Best Hyperparameters

In [310]:

```
print(clf1.best_estimator_)
print(f'CV score on train data {clf1.score(X_tr_bow,y_train)}')
print(f'Mean cross-validated score of the best_estimator : {clf1.best_score_}')
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=8,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
CV score on train data 0.6598851476183109
Mean cross-validated score of the best_estimator : 0.6144041655799374
```

In [71]:

```
best_parameters_bow = {'max_depth': [8], 'min_samples_split': [500]}
```

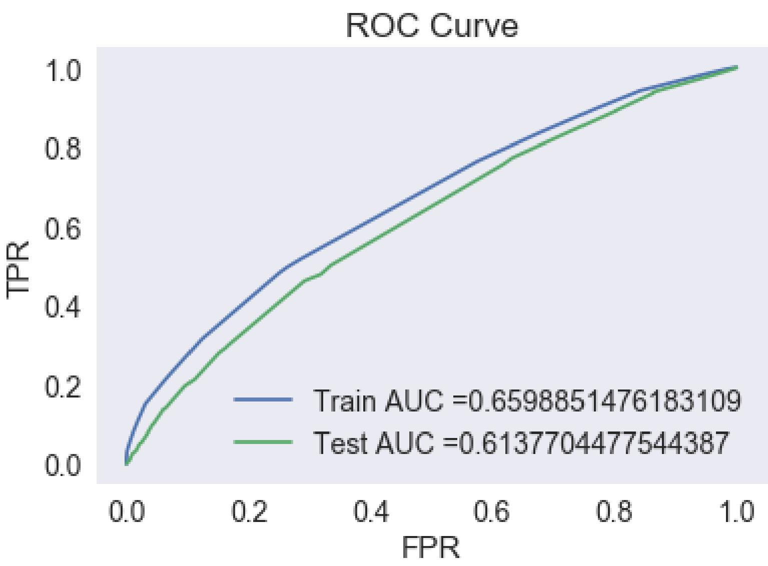
2.1.4 Applying Best Hyperparameters on train & test data & plotting ROC curve

In [89]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # not the predicted outputs
    y_data_pred = []
    pred_labels=[]
    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 =
 49000
    # in this for loop we will iterate until 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 predict
ing for the last data points
        pred_labels.extend(clf.predict(data[i:i+1000]))
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])
        pred_labels.extend(clf.predict(data[tr_loop:]))

    return y_data_pred,pred_labels
```

In [90]:

```
dt_best= DecisionTreeClassifier (class_weight = 'balanced',max_depth=8,min_samples_spli
t=500)

dt_best.fit(X_tr_bow, y_train)

y_train_pred_bow_best,pred_labels_train = batch_predict(dt_best, X_tr_bow)
y_test_pred_bow_best,pred_labels_test = batch_predict(dt_best, X_test_bow)

train_tpr_bow, train_fpr_bow, tr_thresholds_bow = roc_curve(y_train, y_train_pred_bow_b
est)
test_tpr_bow, test_fpr_bow, te_thresholds_bow = roc_curve(y_test, y_test_pred_bow_best)

plt.plot(train_tpr_bow, train_fpr_bow,label="Train AUC ="+str(auc(train_tpr_bow, train_
fpr_bow)))
plt.plot(test_tpr_bow, test_fpr_bow, label="Test AUC ="+str(auc(test_tpr_bow, test_fpr_
bow)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.grid()
plt.show()
```



2.1.5 Plot confusion matrix

In [76]:

```
## we will pick a threshold that will give the least fpr

def find_best_threshold(threshold, fpr, tpr):
    t = threshold[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.roun
d(t,3))
    return t

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

print("="*100)
```

```
==========================================================================
==========================
```

In [77]:

```
#function to get heatmap of confusion matrix
# Reference: https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-ma
trix

def cm_heatmap(cm):
    #y_pred = clf.predict(X_te)
    df_cm = pd.DataFrame(cm, range(2),range(2))
    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})
    sns.set(font_scale=1.4)#for label size
    sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='d')
```

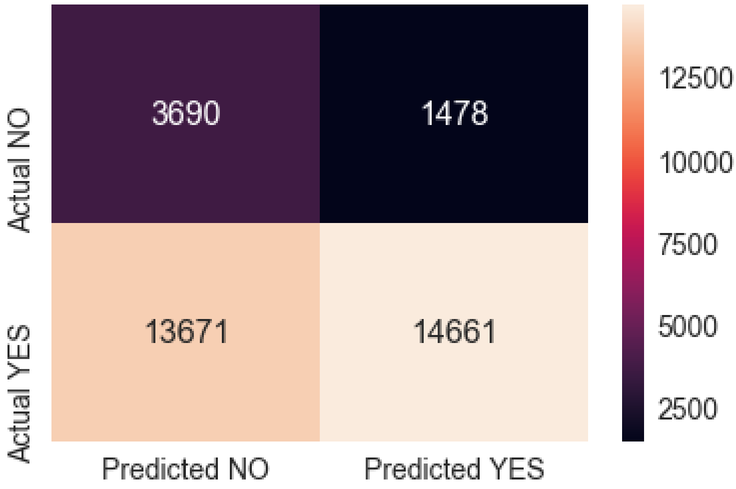
In [78]:

```
from sklearn.metrics import confusion_matrix
best_t_bow = find_best_threshold(tr_thresholds_bow, train_fpr_bow, train_tpr_bow)
print("Train confusion matrix")
cm_train_bow=confusion_matrix(y_train, predict_with_best_t(y_train_pred_bow_best, best_
t_bow))
print(cm_train_bow)
print("Test confusion matrix")
cm_test_bow=confusion_matrix(y_test, predict_with_best_t(y_test_pred_bow_best, best_t_b
ow))
print(cm_test_bow)
```

```
The maximum value of tpr*(1-fpr) 0.13799869493038974 for threshold 0.481
Train confusion matrix
[[ 3690  1478]
 [13671 14661]]
Test confusion matrix
[[1693  853]
 [6961 6993]]
```

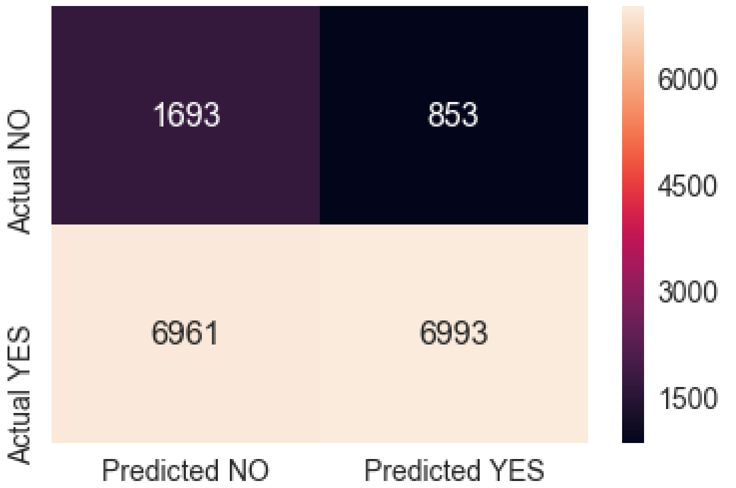
In [86]:

```
# confusion matrix heatmap for train data
cm_heatmap(cm_train_bow)
```



In [87]:

```
# confusion matrix heatmap for test data
cm_heatmap(cm_test_bow)
```



2.1.6 Visualizing Decision tree with Graphviz

In [120]:

```
# Extracting all feature names from the vectorizers of respective features

BOW_feature_names= f1+f2+f5+f6+f7+f8+f9
len(BOW_feature_names)
```

Out[120]:

7446

In [121]:

```
BOW_feature_names.append('price')        #price, quantity & previously_posted_projects
are numerical features
BOW_feature_names.append('quantity')
BOW_feature_names.append('teacher_number_of_previously_posted_projects')
len(BOW_feature_names)
```

Out[121]:

7449

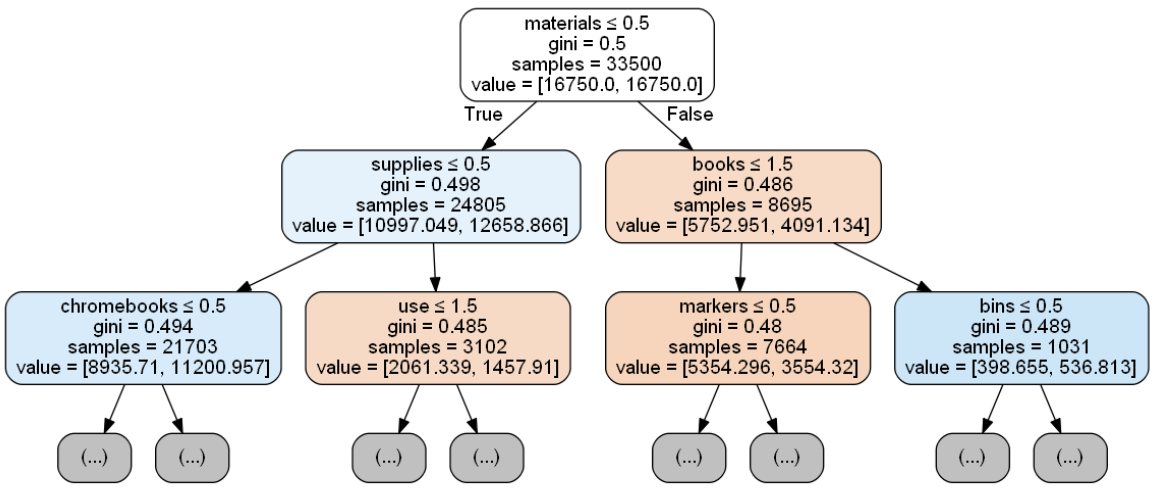
In [266]:

```
import os
os.environ["PATH"] += os.pathsep + r'D:\PGS\Applied AI course\Assignments\Mandatory\gra
phviz'
```

In [272]:

```
# Refernces:
#https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa
394176
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.export_graphviz.html


from sklearn import tree
from sklearn.tree import export_graphviz
from sklearn.externals.six import StringIO
from IPython.display import Image
import pydotplus
import collections

dot_data = StringIO()

viz1=export_graphviz(dt_best,max_depth=2, out_file=dot_data, filled=True, rounded=True,
special_characters=True,feature_names=BOW_feature_names)

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[272]:



2.1.7 Analysis of False Positives

In [237]:

```
# Extracting false postives
FP_bow = []
for i in range(len(y_test)) :
    if (y_test[i] == 0) and (pred_labels_test[i] == 1) :
        FP_bow.append(i)
FP_essay_bow = []
for i in FP_bow :
    FP_essay_bow.append(X_test['preprocessed_essays'].values[i])
```

In [238]:

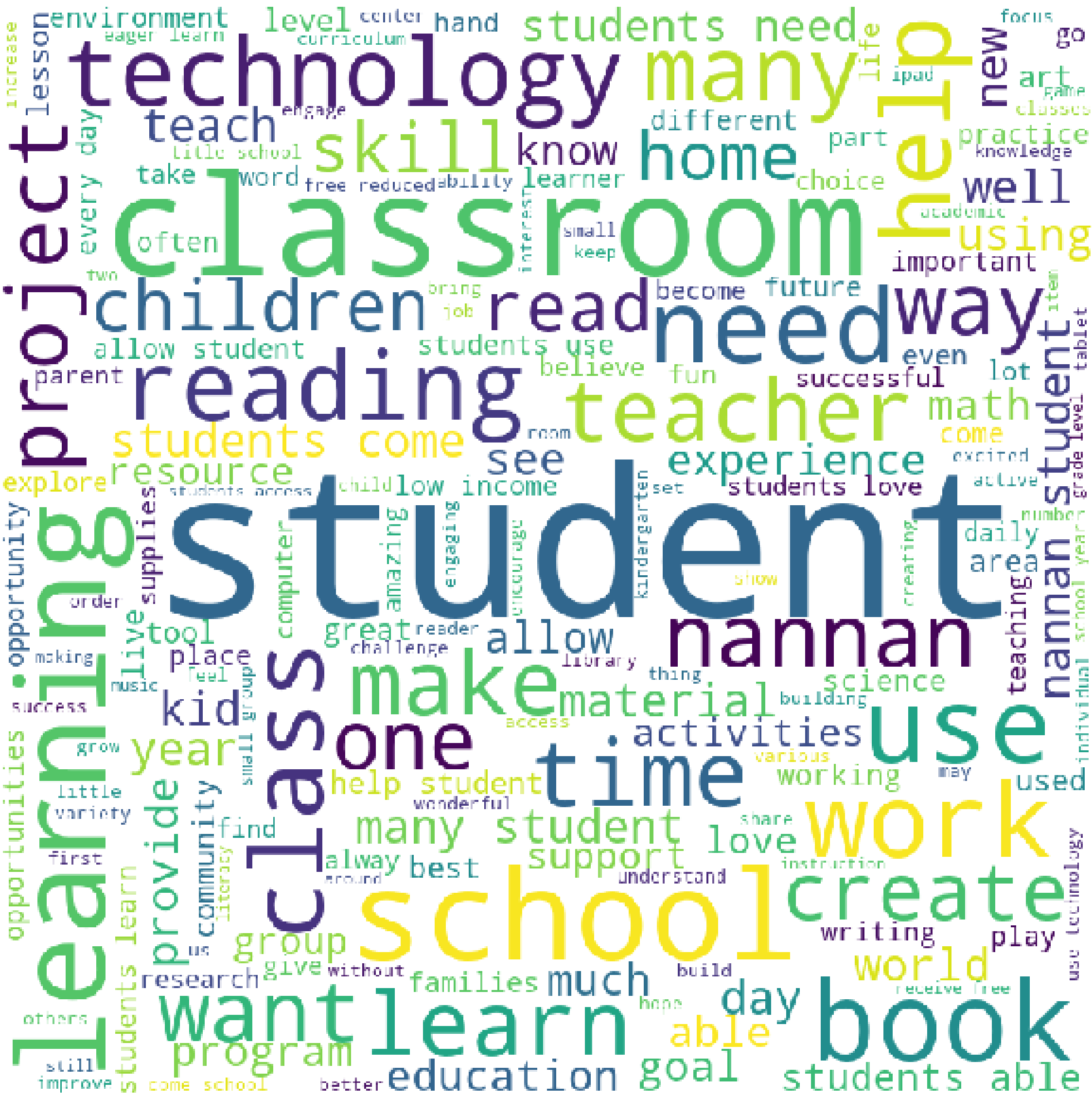
```
print(f'Total number of false positives = {len(FP_bow)}')
```

```
Total number of false positives = 810
```

Wordcloud

In [247]:

```
#plot the word cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud

words = ' '
for row in FP_essay_bow:
    tokens = row.split()
    for t in tokens:
        words += t + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_font_si
ze = 10).generate(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()
```



From the wordcloud above, it can be observed that the words " student", "classroom", "school" & "learning" had a lot of impact in predicting the class label as 1 when it was supposed to be 0.

Box plot on Price feature for false positives

In [253]:

```
FP_price_bow = []
FP_projects_bow=[]
for i in FP_bow :
    FP_price_bow.append(X_test['price'].values[i])
    FP_projects_bow.append(X_test['teacher_number_of_previously_posted_projects'].value
s[i])
```

In [256]:

```
df_bow=pd.DataFrame(columns=['Price','Projects'])
df_bow['Price']=FP_price_bow
df_bow['Projects']=FP_projects_bow
df_bow.head()
```

Out[256]:

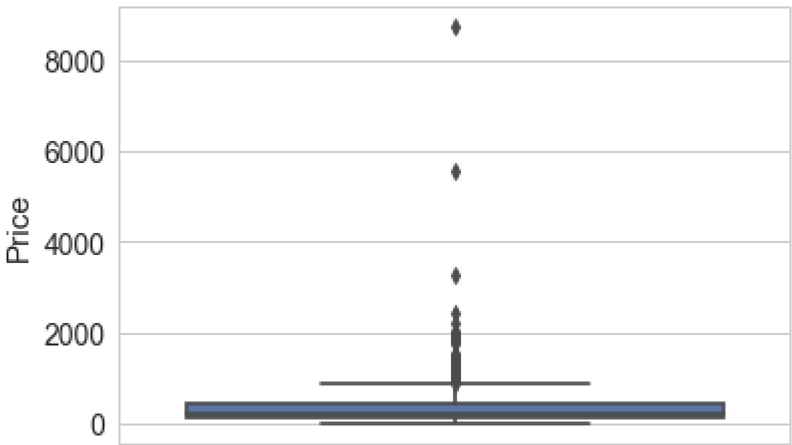
	Price	Projects
0	133.49	0
1	199.96	1
2	359.96	3
3	187.98	2
4	283.11	0

In [261]:

```
sns.set_style("whitegrid")

sns.boxplot(y = 'Price', data = df_bow)
```

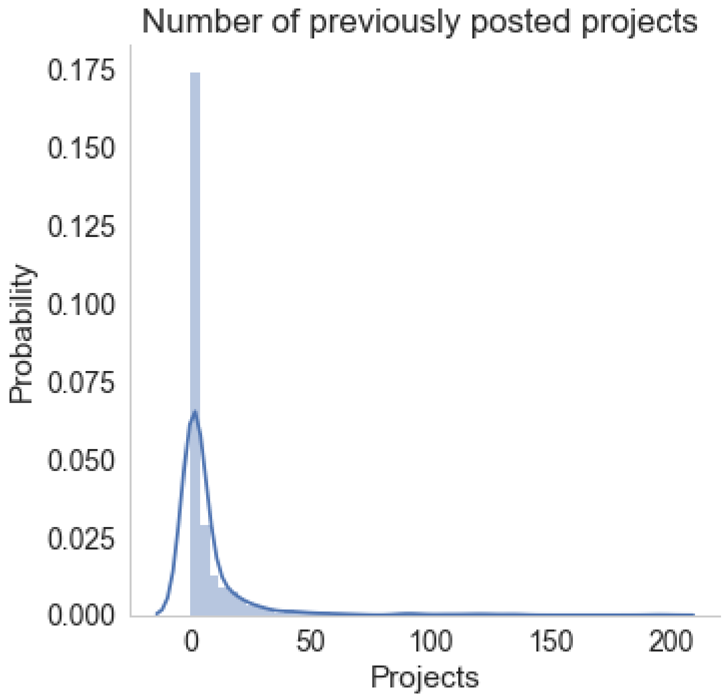
Out[261]:

<matplotlib.axes._subplots.AxesSubplot at 0x233ab084128>



In [265]:

```
#pdf
import warnings
warnings.filterwarnings("ignore")

sns.FacetGrid(df_bow,size=5) \
   .map(sns.distplot,'Projects') \
   .add_legend()
plt.ylabel('Probability')
plt.title("Number of previously posted projects ")
plt.grid()
plt.show()
```



2.2 Set 2: TFIDF featurization

2.2.1 Hyper parameter tuning

In [273]:

```
dt_tfidf = DecisionTreeClassifier(criterion='gini',class_weight = 'balanced') #https://
scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html
parameters = {'max_depth': [4, 6, 8, 10, 30,50], 'min_samples_split': [5, 20, 80, 200,
500,800]}
clf2 = RandomizedSearchCV(dt_tfidf, parameters, cv=3, scoring='roc_auc',return_train_sc
ore=True,n_jobs=-1)
rs2 = clf2.fit(X_tr_tfidf, y_train)
```

In [274]:

```
df1=pd.DataFrame(clf2.cv_results_)
df1.head(5)
```

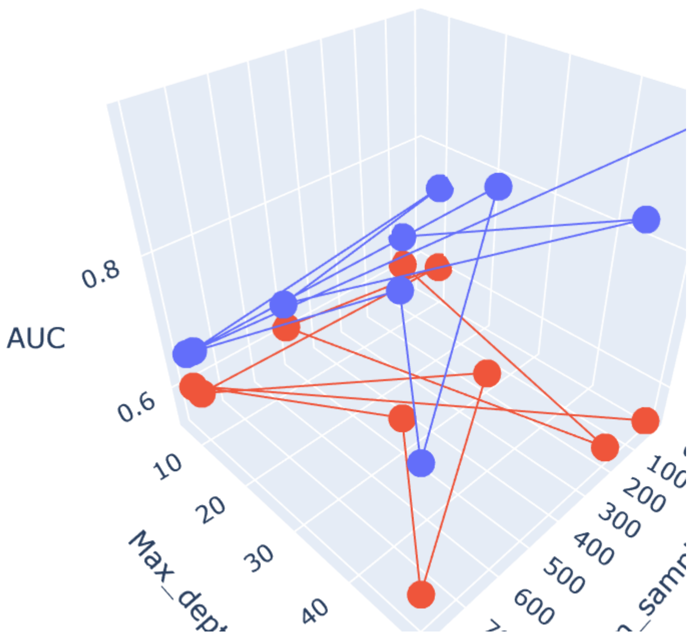
Out[274]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_min_sample
0	5.277641	0.088953	0.038977	0.002158	80
1	31.315708	1.662429	0.040311	0.000942	200
2	5.135052	0.132839	0.039645	0.003298	500
3	11.507400	0.764769	0.047307	0.012490	5
4	9.183731	0.270108	0.036313	0.001247	800

2.2.2 3D-Plot

In [275]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=df1['param_min_samples_split'],y=df1['param_max_depth'],z=df1[
'mean_train_score'], name = 'train')
trace2 = go.Scatter3d(x=df1['param_min_samples_split'],y=df1['param_max_depth'],z=df1[
'mean_test_score'], name = 'Cross validation')
data = [trace1, trace2]
enable_plotly_in_cell()

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

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



2.2.3 Best Hyperparameters

In [309]:

```
print(clf2.best_estimator_)
print(f'CV score on train data {clf2.score(X_tr_tfidf,y_train)}')
print(f'Mean cross-validated score of the best_estimator : {clf2.best_score_}')
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=800,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
CV score on train data 0.68609838946892
Mean cross-validated score of the best_estimator : 0.614976094978327
```

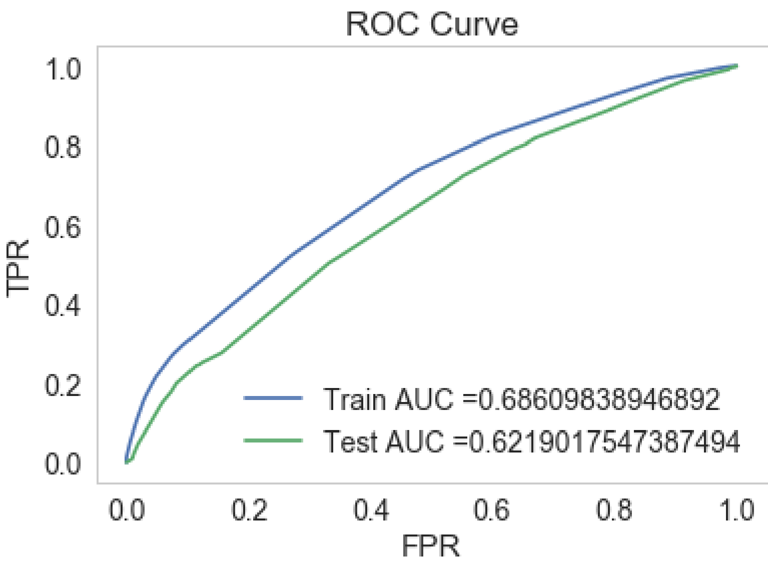
In [277]:

```
best_parameters_tfidf = {'max_depth': [10], 'min_samples_split': [800]}
```

2.2.4 Applying Best Hyperparameters on train & test data & plotting ROC curve

In [278]:

```
dt_best_tfidf= DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_sampl
es_split=800)

dt_best_tfidf.fit(X_tr_tfidf, y_train)

y_train_pred_tfidf_best,pred_labels_train = batch_predict(dt_best_tfidf, X_tr_tfidf)
y_test_pred_tfidf_best,pred_labels_test = batch_predict(dt_best_tfidf, X_test_tfidf)

train_tpr_tfidf, train_fpr_tfidf, tr_thresholds_tfidf = roc_curve(y_train, y_train_pred
_tfidf_best)
test_tpr_tfidf, test_fpr_tfidf, te_thresholds_tfidf = roc_curve(y_test, y_test_pred_tfi
df_best)

plt.plot(train_tpr_tfidf, train_fpr_tfidf,label="Train AUC ="+str(auc(train_tpr_tfidf,
train_fpr_tfidf)))
plt.plot(test_tpr_tfidf, test_fpr_tfidf, label="Test AUC ="+str(auc(test_tpr_tfidf, tes
t_fpr_tfidf)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.grid()
plt.show()
```



2.2.5 Plot confusion matrix

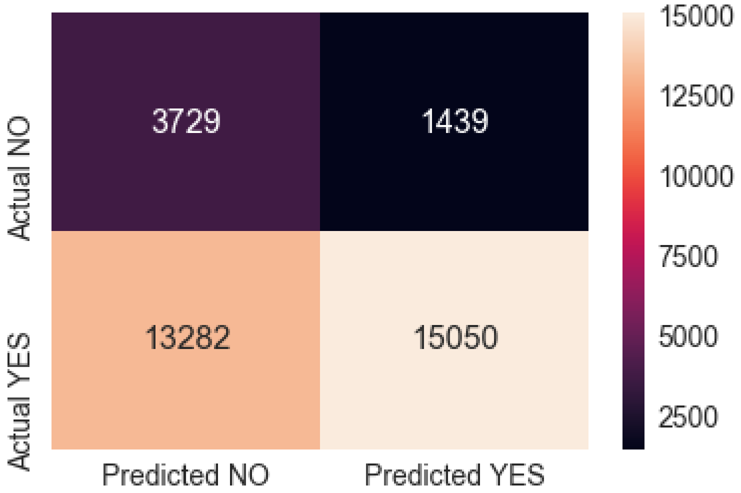
In [280]:

```
best_t_tfidf = find_best_threshold(tr_thresholds_tfidf, train_fpr_tfidf, train_tpr_tfid
f)
print("Train confusion matrix")
cm_train_tfidf=confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf_best, b
est_t_tfidf))
print(cm_train_tfidf)
print("Test confusion matrix")
cm_test_tfidf=confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf_best, best
_t_tfidf))
print(cm_test_tfidf)
```

```
The maximum value of tpr*(1-fpr) 0.1305342660816528 for threshold 0.534
Train confusion matrix
[[ 3729  1439]
 [13282 15050]]
Test confusion matrix
[[1664  882]
 [6741 7213]]
```

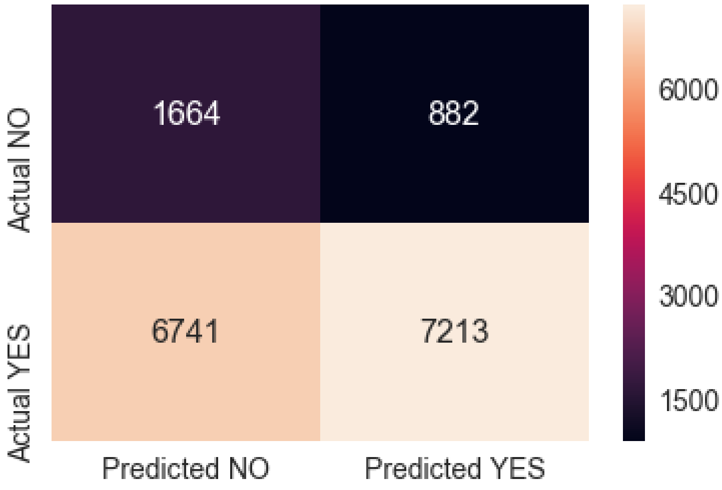
In [281]:

```
# confusion matrix heatmap for train data
cm_heatmap(cm_train_tfidf)
```



In [282]:

```
# confusion matrix heatmap for test data
cm_heatmap(cm_test_tfidf)
```



2.2.6 Visualizing Decision tree with Graphviz

In [284]:

```
# Extracting all feature names from the vectorizers of respective features

tfidf_feature_names= f3+f4+f5+f6+f7+f8+f9
len(tfidf_feature_names)
```

Out[284]:

7446

In [285]:

```
tfidf_feature_names.append('price')         #price, quantity & previously_posted_projec
ts are numerical features
tfidf_feature_names.append('quantity')
tfidf_feature_names.append('teacher_number_of_previously_posted_projects')
len(tfidf_feature_names)
```

Out[285]:

7449

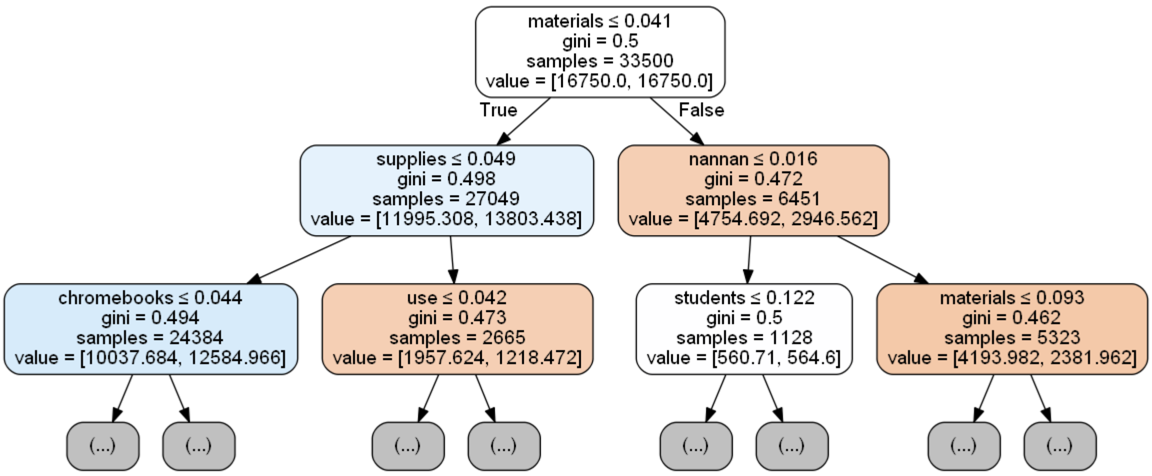
In [286]:

```
import os
os.environ["PATH"] += os.pathsep + r'D:\PGS\Applied AI course\Assignments\Mandatory\gra
phviz'
```

In [287]:

```
# Refernces:
#https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa
394176
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.export_graphviz.html


from sklearn import tree
from sklearn.tree import export_graphviz
from sklearn.externals.six import StringIO
from IPython.display import Image
import pydotplus
import collections

dot_data = StringIO()

viz2=export_graphviz(dt_best_tfidf,max_depth=2, out_file=dot_data, filled=True, rounded
=True,special_characters=True,feature_names=tfidf_feature_names)

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[287]:



2.2.7 Analysis of False Positives

In [288]:

```
# Extracting false postives
FP_tfidf = []
for i in range(len(y_test)) :
    if (y_test[i] == 0) and (pred_labels_test[i] == 1) :
        FP_tfidf.append(i)
FP_essay_tfidf = []
for i in FP_tfidf :
    FP_essay_tfidf.append(X_test['preprocessed_essays'].values[i])
```

In [289]:

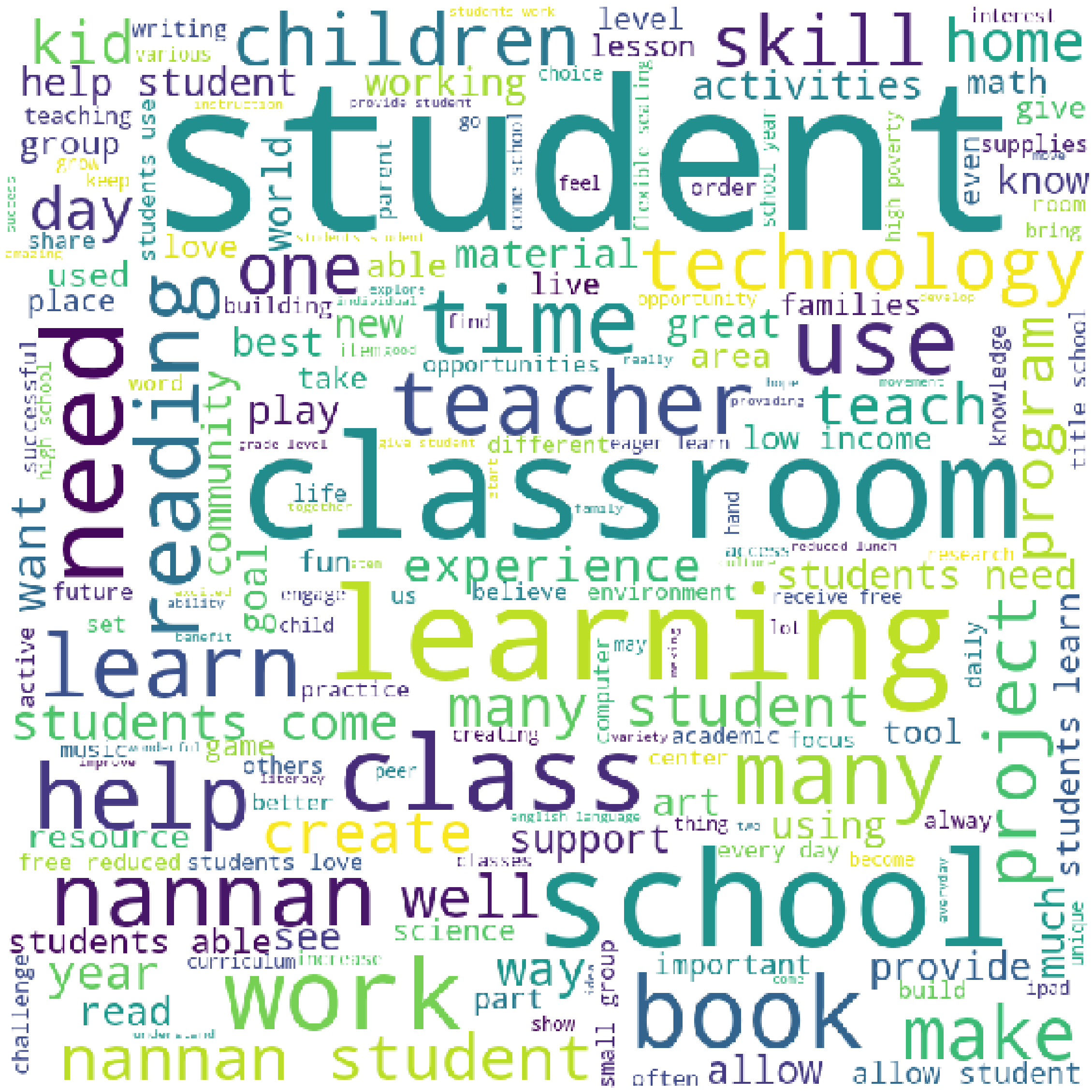
```
print(f'Total number of false positives = {len(FP_tfidf)}')
```

```
Total number of false positives = 1347
```

Wordcloud

In [290]:

```
#plot the word cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud

words = ' '
for row in FP_essay_tfidf:
    tokens = row.split()
    for t in tokens:
        words += t + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_font_si
ze = 10).generate(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()
```


student
classroom
learning
school
children
class
skill
technology
help
learn
nannan
need
reading
teacher
time
use
work
book
kid
home
help student
working
activities
math
many student
many
nannan student
make
allow student
students come
create
support
students need
experience
program
project
one
day
world
great
best
new
teach
low income
material
able
love
level
lesson
writing
various
teaching
group
share
used
place
future
want
active
students able
year
read
challenge
resource
free reduced
students love
well
science
way
part
important
provide
much
students learn
using
art
tool
academic
focus
computer
creating
game
others
better
music
practice
child
goal
community
play
take
area
families
live
opportunities
different
knowledge
title school
feel
order
parent
supplies
know
give
bring
room
see
curriculum
small group
often
allow
build
ipad
unique
daily
environment
believe
us
fun
life
word
successful
high school
engage
set
high poverty
school year
flexible seating
even
choice
interest
go
peer
center
alway
become
every day
thing
english language
classes
show
receive free
lot
hand
research
reduced lunch
students work
provide student
instruction

From the wordcloud above, it can be observed that the words " student", "classroom", "teacher" & "need" had a lot of impact in predicting the class label as 1 when it was supposed to be 0.

Box plot on Price feature for false positives

In [291]:

```
FP_price_tfidf = []
FP_projects_tfidf=[]
for i in FP_tfidf :
    FP_price_tfidf.append(X_test['price'].values[i])
    FP_projects_tfidf.append(X_test['teacher_number_of_previously_posted_projects'].val
ues[i])
```

In [292]:

```
df_tfidf=pd.DataFrame(columns=['Price','Projects'])
df_tfidf['Price']=FP_price_tfidf
df_tfidf['Projects']=FP_projects_tfidf
df_tfidf.head()
```

Out[292]:

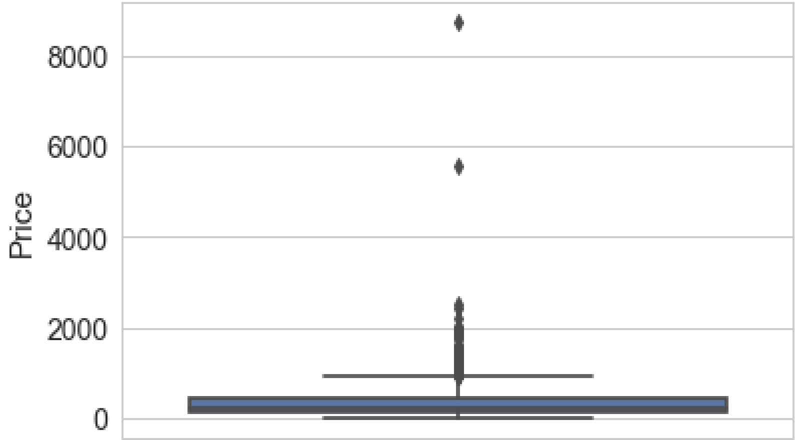
	Price	Projects
0	404.90	5
1	551.78	1
2	206.74	31
3	451.17	82
4	199.96	1

In [293]:

```
sns.set_style("whitegrid")

sns.boxplot(y = 'Price', data = df_tfidf)
```

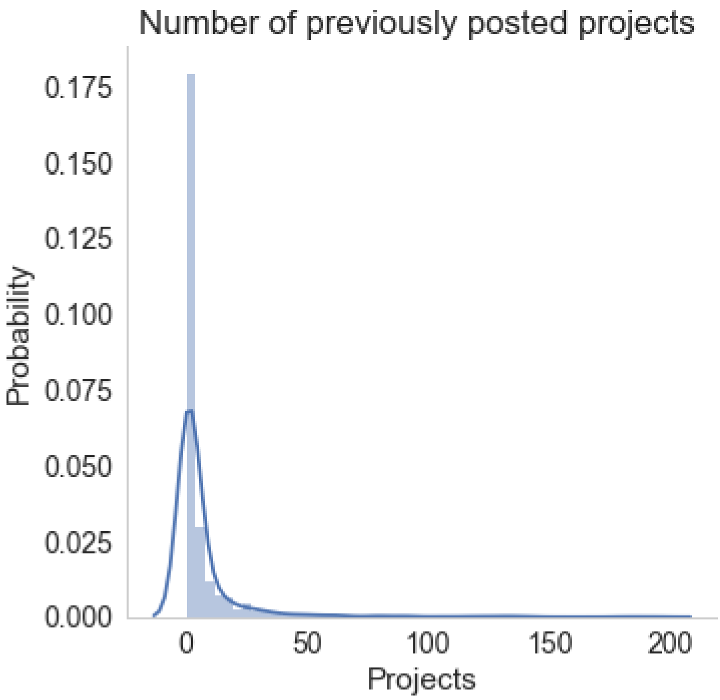
Out[293]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x233ad6b30f0>
```



In [294]:

```
#pdf
import warnings
warnings.filterwarnings("ignore")

sns.FacetGrid(df_tfidf,size=5) \
   .map(sns.distplot,'Projects') \
   .add_legend()
plt.ylabel('Probability')
plt.title("Number of previously posted projects ")
plt.grid()
plt.show()
```



2.3 Set 3: AvgW2V featurization

2.3.1 Hyper parameter tuning

In [295]:

```
dt_avg = DecisionTreeClassifier(criterion='gini',class_weight = 'balanced') #https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html
parameters = {'max_depth': [4, 6, 8, 10, 30,50], 'min_samples_split': [5, 20, 80, 200, 500, 800]}
clf3 = RandomizedSearchCV(dt_avg, parameters, cv=3, scoring='roc_auc',return_train_score=True,n_jobs=-1)
rs3 = clf3.fit(X_tr_avgw2v, y_train)
```

In [296]:

```
df2=pd.DataFrame(clf3.cv_results_)
df2.head(5)
```

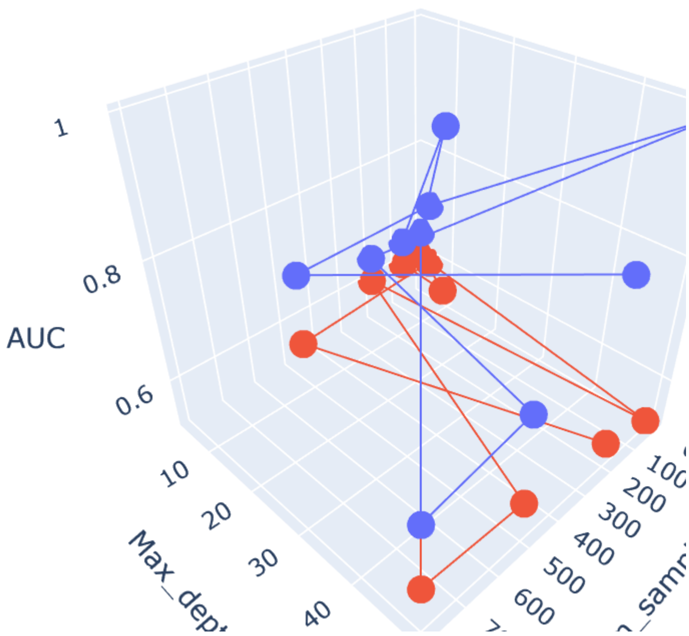
Out[296]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_min_sample
0	11.961802	2.504694	0.069294	0.002054	80
1	38.023394	2.278792	0.092281	0.014258	20
2	10.855789	0.277335	0.072292	0.002493	5
3	19.719419	0.630861	0.085631	0.011540	800
4	25.071697	0.289909	0.088951	0.011218	500

2.3.2 3D-Plot

In [297]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=df2['param_min_samples_split'],y=df2['param_max_depth'],z=df2[
'mean_train_score'], name = 'train')
trace2 = go.Scatter3d(x=df2['param_min_samples_split'],y=df2['param_max_depth'],z=df2[
'mean_test_score'], name = 'Cross validation')
data = [trace1, trace2]
enable_plotly_in_cell()

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

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



2.3.3 Best Hyperparameters

In [308]:

```
print(clf3.best_estimator_)
print(f'Score on train data : {clf3.score(X_tr_avgw2v,y_train)}')
print(f'Mean cross-validated score of the best_estimator : {clf3.best_score_}')
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=80,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
Score on train data : 0.633075862648499
Mean cross-validated score of the best_estimator : 0.5969475086213375
```

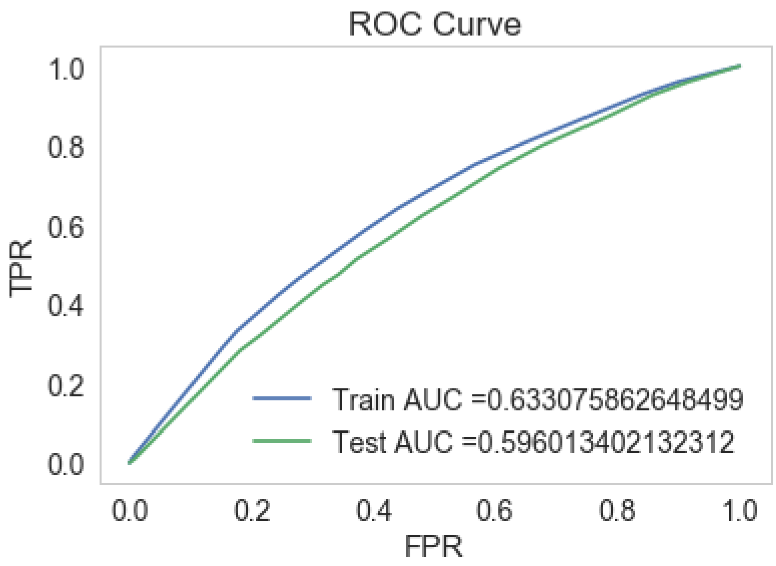
In [305]:

```
best_parameters_tfidf = {'max_depth': [4], 'min_samples_split': [80]}
```

2.3.4 Applying Best Hyperparameters on train & test data & plotting ROC curve

In [311]:

```
dt_best_avg= DecisionTreeClassifier (class_weight = 'balanced',max_depth=4,min_samples_
split=80)

dt_best_avg.fit(X_tr_avgw2v, y_train)

y_train_pred_avg_best,pred_labels_train = batch_predict(dt_best_avg, X_tr_avgw2v)
y_test_pred_avg_best,pred_labels_test = batch_predict(dt_best_avg, X_test_avgw2v)

train_tpr_avg, train_fpr_avg, tr_thresholds_avg = roc_curve(y_train, y_train_pred_avg_b
est)
test_tpr_avg, test_fpr_avg, te_thresholds_avg = roc_curve(y_test, y_test_pred_avg_best)

plt.plot(train_tpr_avg, train_fpr_avg,label="Train AUC ="+str(auc(train_tpr_avg, train_
fpr_avg)))
plt.plot(test_tpr_avg, test_fpr_avg, label="Test AUC ="+str(auc(test_tpr_avg, test_fpr_
avg)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.grid()
plt.show()
```



2.3.5 Plot confusion matrix

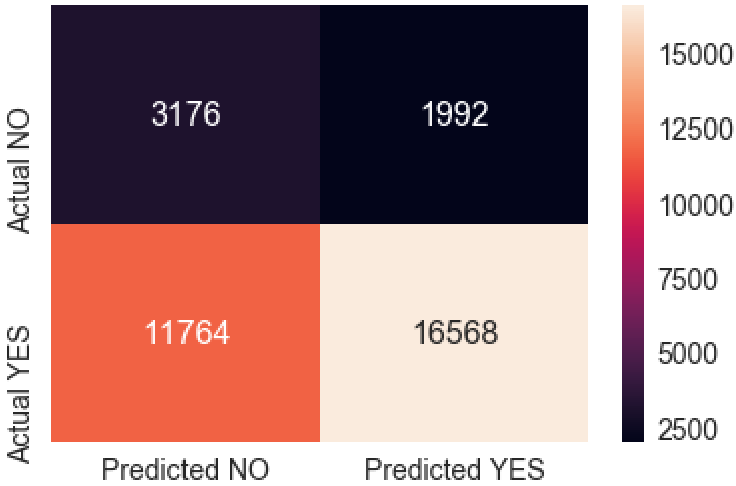
In [312]:

```
from sklearn.metrics import confusion_matrix
best_t_avg = find_best_threshold(tr_thresholds_avg, train_fpr_avg, train_tpr_avg)
print("Train confusion matrix")
cm_train_avg=confusion_matrix(y_train, predict_with_best_t(y_train_pred_avg_best, best_
t_avg))
print(cm_train_avg)
print("Test confusion matrix")
cm_test_avg=confusion_matrix(y_test, predict_with_best_t(y_test_pred_avg_best, best_t_a
vg))
print(cm_test_avg)
```

```
The maximum value of tpr*(1-fpr) 0.1600459216656635 for threshold 0.528
Train confusion matrix
[[ 3176  1992]
 [11764 16568]]
Test confusion matrix
[[1463 1083]
 [6068 7886]]
```

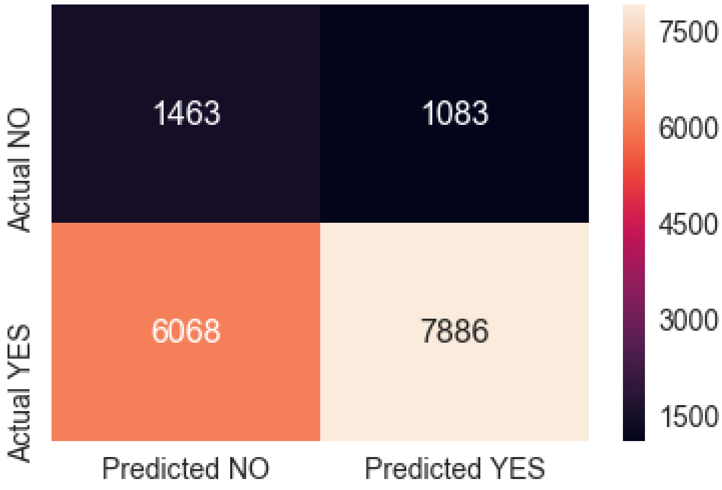
In [313]:

```
# confusion matrix heatmap for train data
cm_heatmap(cm_train_avg)
```



In [314]:

```
# confusion matrix heatmap for test data
cm_heatmap(cm_test_avg)
```



2.3.7 Analysis of False Positives

In [315]:

```
# Extracting false postives
FP_avg = []
for i in range(len(y_test)) :
    if (y_test[i] == 0) and (pred_labels_test[i] == 1) :
        FP_avg.append(i)
FP_essay_avg = []
for i in FP_avg :
    FP_essay_avg.append(X_test['preprocessed_essays'].values[i])
```

In [316]:

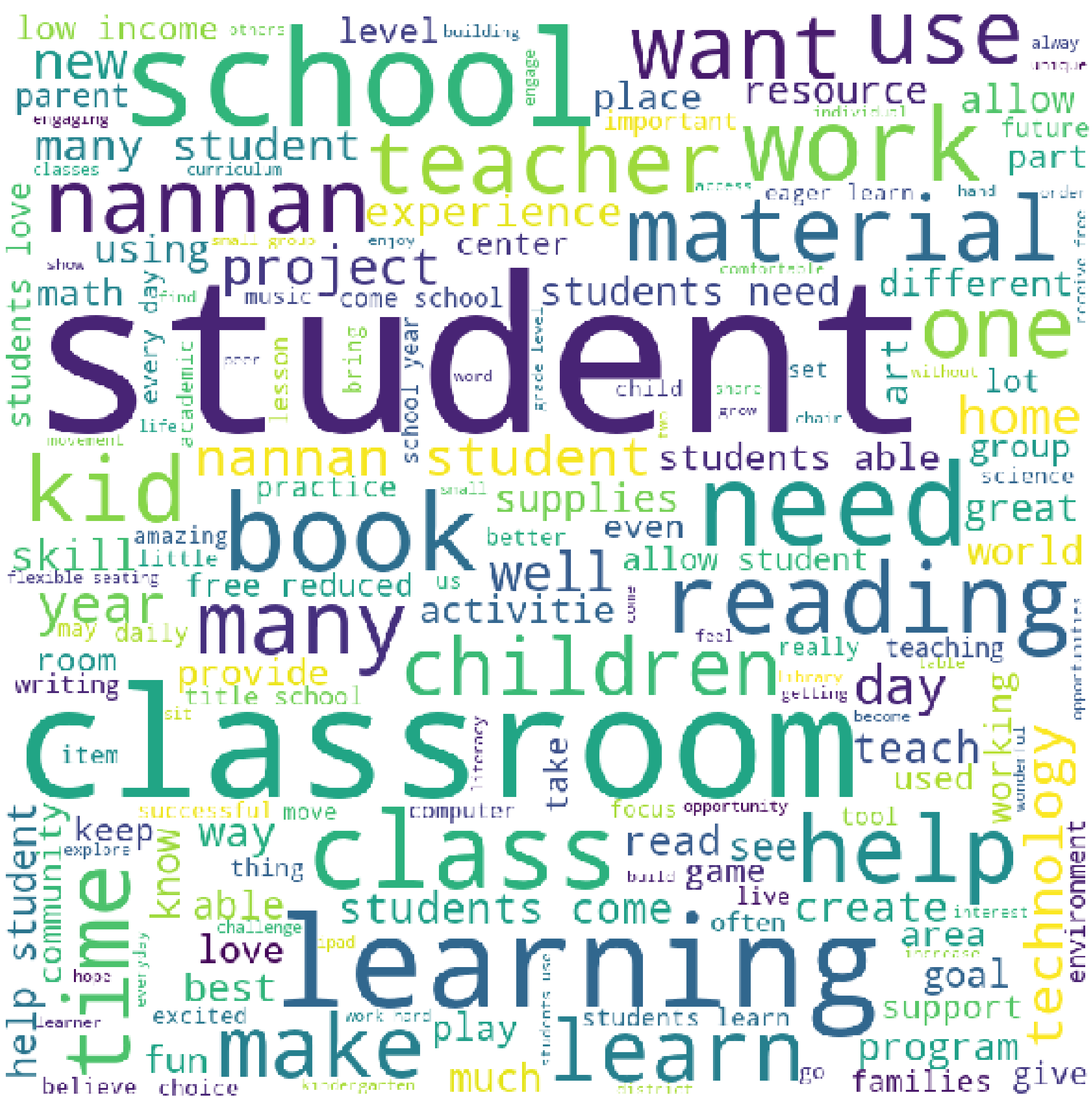
```
print(f'Total number of false positives = {len(FP_avg)}')
```

```
Total number of false positives = 1220
```

Wordcloud

In [317]:

```
#plot the word cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud

words = ' '
for row in FP_essay_avg:
    tokens = row.split()
    for t in tokens:
        words += t + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_font_si
ze = 10).generate(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()
```



From the wordcloud above, it can be observed that the words " student", "school", "book" & "need" had a lot of impact in predicting the class label as 1 when it was supposed to be 0.

Box plot on Price feature for false positives

In [318]:

```
FP_price_avg = []
FP_projects_avg=[]
for i in FP_avg :
    FP_price_avg.append(X_test['price'].values[i])
    FP_projects_avg.append(X_test['teacher_number_of_previously_posted_projects'].value
s[i])
```

In [319]:

```
df_avg=pd.DataFrame(columns=['Price','Projects'])
df_avg['Price']=FP_price_avg
df_avg['Projects']=FP_projects_avg
df_avg.head()
```

Out[319]:

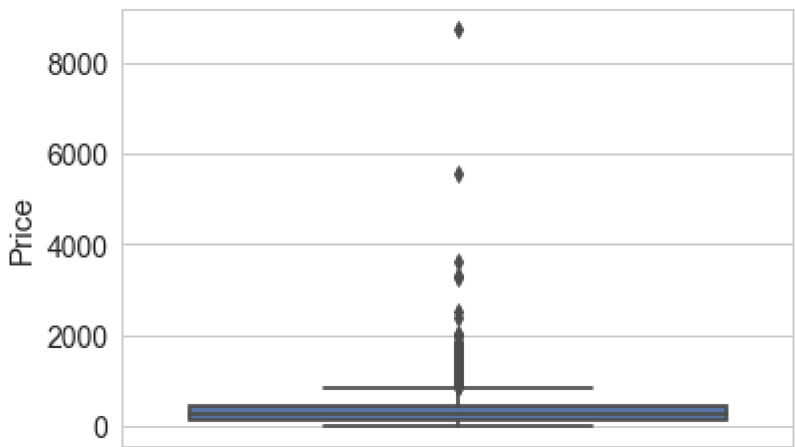
	Price	Projects
0	2020.93	27
1	315.37	0
2	133.49	0
3	199.96	1
4	359.96	3

In [320]:

```
sns.set_style("whitegrid")

sns.boxplot(y = 'Price', data = df_avg)
```

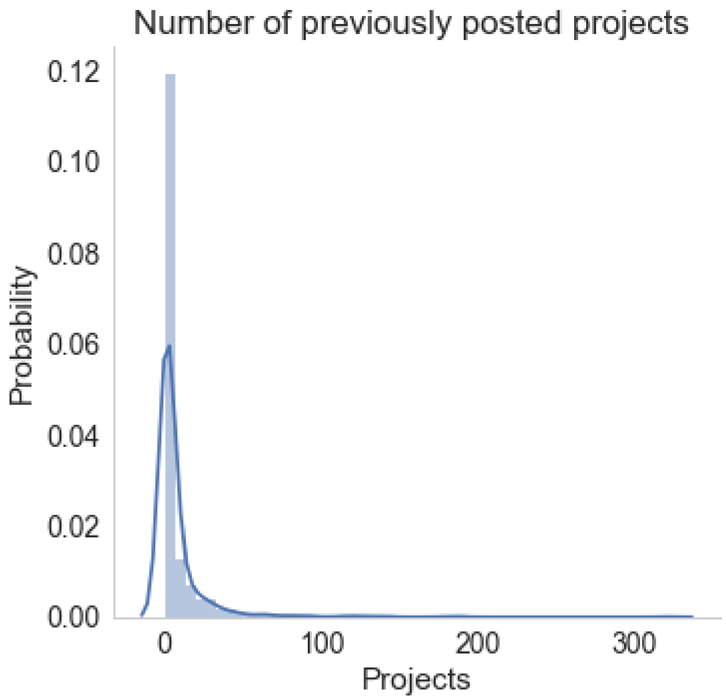
Out[320]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x233ab9bb160>
```



In [321]:

```
#pdf
import warnings
warnings.filterwarnings("ignore")

sns.FacetGrid(df_avg,size=5) \
   .map(sns.distplot,'Projects') \
   .add_legend()
plt.ylabel('Probability')
plt.title("Number of previously posted projects ")
plt.grid()
plt.show()
```



2.4 Set 4: TFIDFW2V featurization

2.4.1 Hyper parameter tuning

In [322]:

```
dt_tw = DecisionTreeClassifier(criterion='gini',class_weight = 'balanced') #https://sci
kit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html
parameters = {'max_depth': [4, 6, 8, 10, 30, 50], 'min_samples_split': [5, 20, 80, 200,
500, 800]}
clf4 = RandomizedSearchCV(dt_tw, parameters, cv=3, scoring='roc_auc',return_train_score
=True,n_jobs=-1)
rs4 = clf4.fit(X_tr_tfidf_w2v, y_train)
```

In [323]:

```
df3=pd.DataFrame(clf4.cv_results_)
df3.head(5)
```

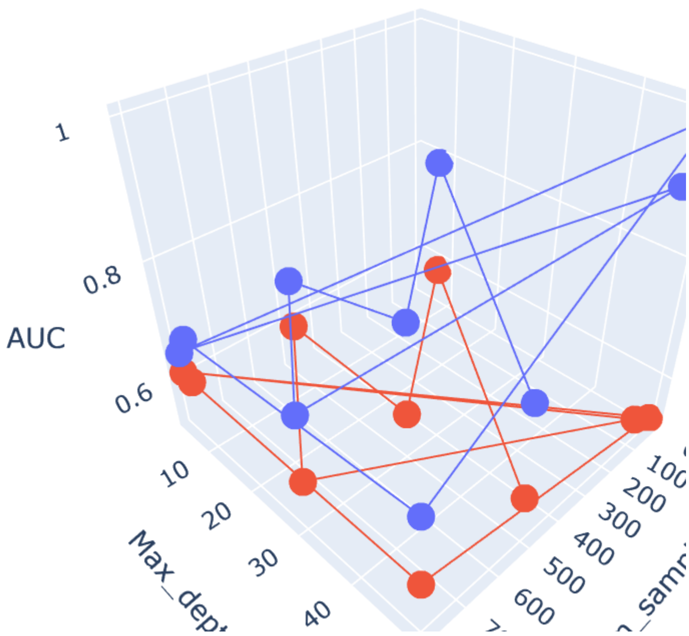
Out[323]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_min_sample
0	43.771447	7.377569	2.570922	1.769419	500
1	43.209565	0.497868	0.357273	0.366711	5
2	35.242696	2.280972	0.092892	0.011800	500
3	24.975228	4.094482	0.115971	0.011310	500
4	28.721339	2.797737	0.125303	0.003770	800

2.4.2 3D-Plot

In [324]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=df3['param_min_samples_split'],y=df3['param_max_depth'],z=df3[
'mean_train_score'], name = 'train')
trace2 = go.Scatter3d(x=df3['param_min_samples_split'],y=df3['param_max_depth'],z=df3[
'mean_test_score'], name = 'Cross validation')
data = [trace1, trace2]
enable_plotly_in_cell()

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

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



2.4.3 Best Hyperparameters

In [326]:

```
print(clf4.best_estimator_)
print(f'Score on train data : {clf4.score(X_tr_tfidf_w2v,y_train)}')
print(f'Mean cross-validated score of the best_estimator : {clf4.best_score_}')
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=800,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
Score on train data : 0.6405634919151906
Mean cross-validated score of the best_estimator : 0.612679772013652
```

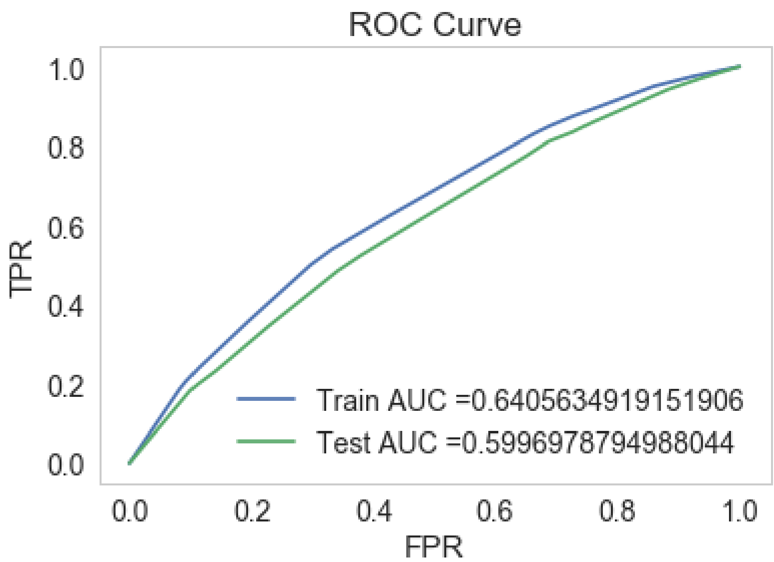
In [327]:

```
best_parameters_tfidf = {'max_depth': [4], 'min_samples_split': [800]}
```

2.4.4 Applying Best Hyperparameters on train & test data & plotting ROC curve

In [328]:

```
dt_best_tw= DecisionTreeClassifier (class_weight = 'balanced',max_depth=4,min_samples_s
plit=800)

dt_best_tw.fit(X_tr_tfidf_w2v, y_train)

y_train_pred_tw_best,pred_labels_train = batch_predict(dt_best_tw, X_tr_tfidf_w2v)
y_test_pred_tw_best,pred_labels_test = batch_predict(dt_best_tw, X_test_tfidf_w2v)

train_tpr_tw, train_fpr_tw, tr_thresholds_tw = roc_curve(y_train, y_train_pred_tw_best)
test_tpr_tw, test_fpr_tw, te_thresholds_tw = roc_curve(y_test, y_test_pred_tw_best)

plt.plot(train_tpr_tw, train_fpr_tw,label="Train AUC ="+str(auc(train_tpr_tw, train_fpr
_tw)))
plt.plot(test_tpr_tw, test_fpr_tw, label="Test AUC ="+str(auc(test_tpr_tw, test_fpr_tw
)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.grid()
plt.show()
```



2.4.5 Plot confusion matrix

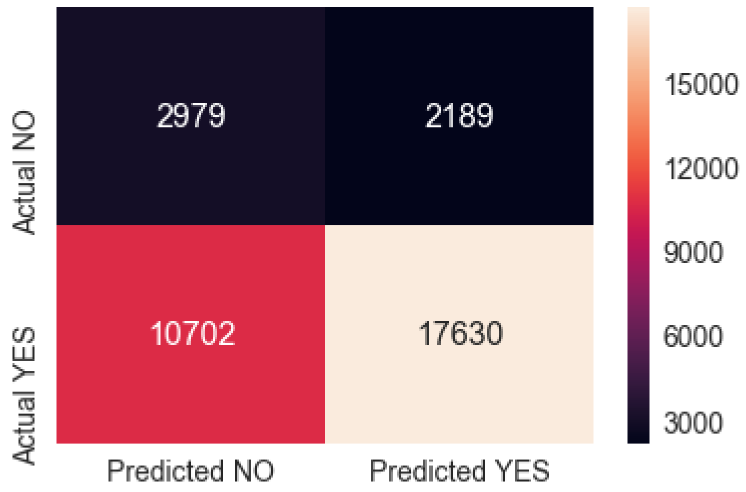
In [329]:

```
from sklearn.metrics import confusion_matrix
best_t_tw = find_best_threshold(tr_thresholds_tw, train_fpr_tw, train_tpr_tw)
print("Train confusion matrix")
cm_train_tw=confusion_matrix(y_train, predict_with_best_t(y_train_pred_tw_best, best_t_
tw))
print(cm_train_tw)
print("Test confusion matrix")
cm_test_tw=confusion_matrix(y_test, predict_with_best_t(y_test_pred_tw_best, best_t_tw
))
print(cm_test_tw)
```

```
The maximum value of tpr*(1-fpr) 0.1599966796834876 for threshold 0.474
Train confusion matrix
[[ 2979  2189]
 [10702 17630]]
Test confusion matrix
[[1348 1198]
 [5454 8500]]
```

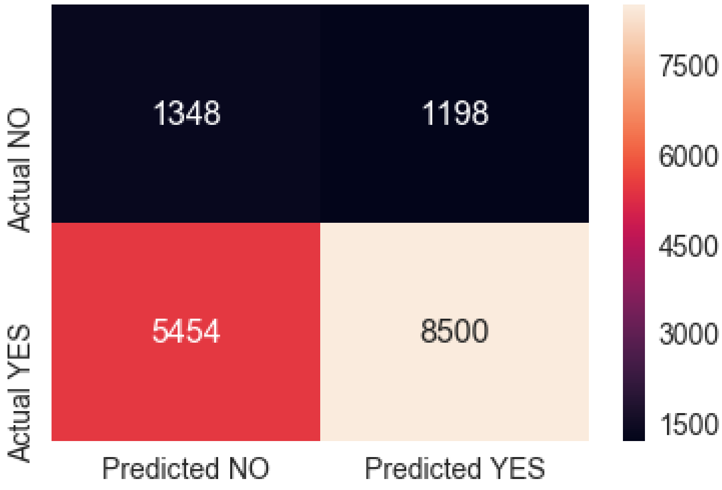
In [330]:

```
# confusion matrix heatmap for train data
cm_heatmap(cm_train_tw)
```



In [331]:

```
# confusion matrix heatmap for test data
cm_heatmap(cm_test_tw)
```



2.4.6 Analysis of False Positives

In [332]:

```
# Extracting false postives
FP_tw = []
for i in range(len(y_test)) :
    if (y_test[i] == 0) and (pred_labels_test[i] == 1) :
        FP_tw.append(i)
FP_essay_tw = []
for i in FP_tw :
    FP_essay_tw.append(X_test['preprocessed_essays'].values[i])
```

In [333]:

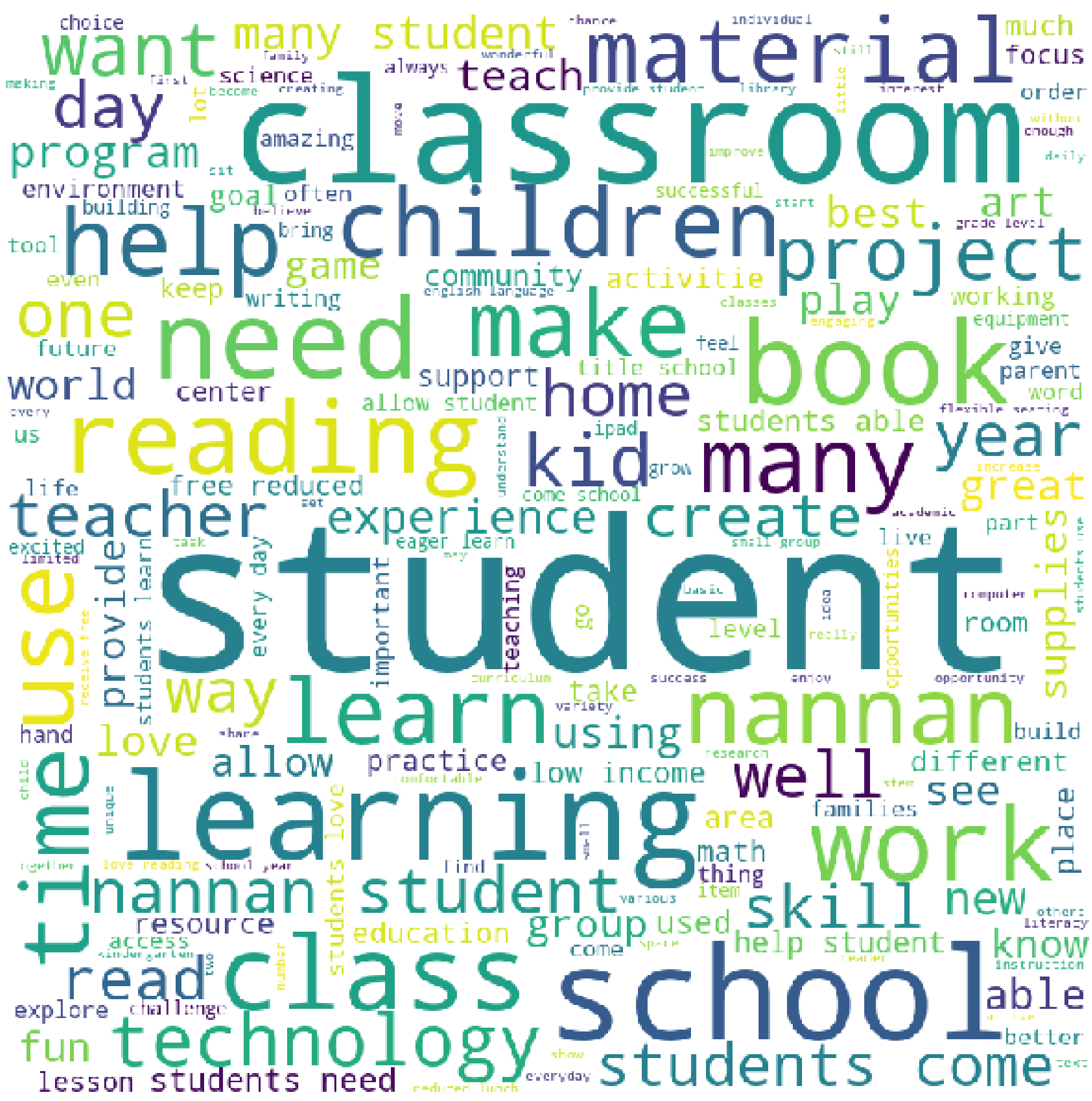
```
print(f'Total number of false positives = {len(FP_tw)}')
```

```
Total number of false positives = 964
```

Wordcloud

In [334]:

```
#plot the word cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud

words = ' '
for row in FP_essay_tw:
    tokens = row.split()
    for t in tokens:
        words += t + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_font_si
ze = 10).generate(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()
```



From the wordcloud above, it can be observed that the words " student", "school", "learning" & "classroom" had a lot of impact in predicting the class label as 1 when it was supposed to be 0.

Box plot on Price feature for false positives

In [337]:

```
FP_price_tw = []
FP_projects_tw=[]
for i in FP_tw :
    FP_price_tw.append(X_test['price'].values[i])
    FP_projects_tw.append(X_test['teacher_number_of_previously_posted_projects'].values
[i])
```

In [338]:

```
df_tw=pd.DataFrame(columns=['Price','Projects'])
df_tw['Price']=FP_price_tw
df_tw['Projects']=FP_projects_tw
df_tw.head()
```

Out[338]:

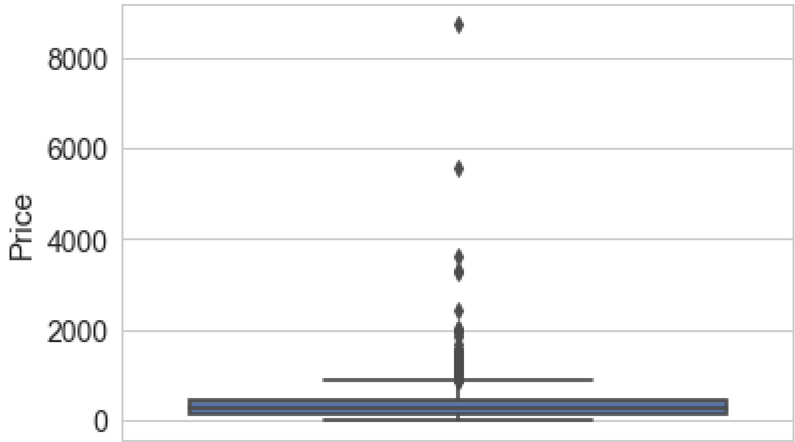
	Price	Projects
0	2020.93	27
1	133.49	0
2	359.96	3
3	233.71	0
4	219.73	1

In [339]:

```
sns.set_style("whitegrid")

sns.boxplot(y = 'Price', data = df_tw)
```

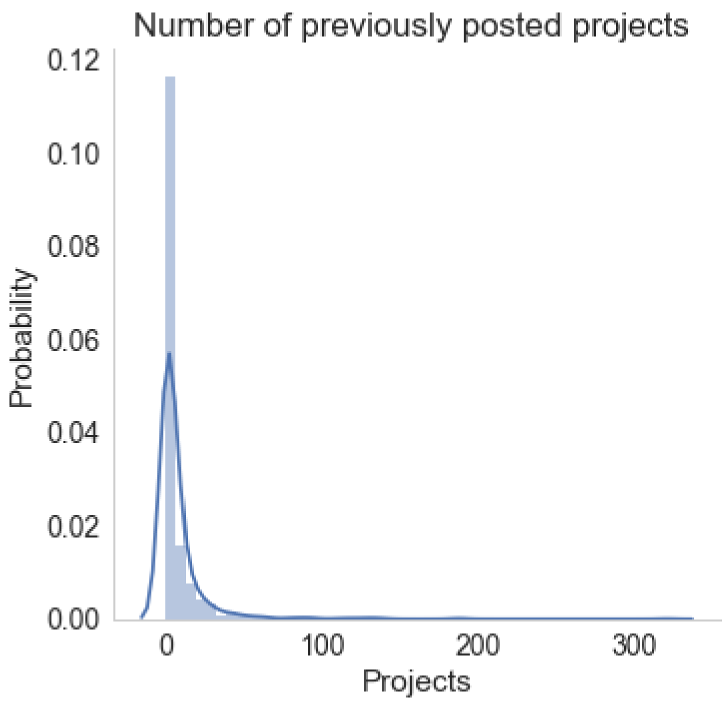
Out[339]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x233ab267400>
```



In [340]:

```
#pdf
import warnings
warnings.filterwarnings("ignore")

sns.FacetGrid(df_tw,size=5) \
   .map(sns.distplot,'Projects') \
   .add_legend()
plt.ylabel('Probability')
plt.title("Number of previously posted projects ")
plt.grid()
plt.show()
```



2.5 Set 5: 5k best features from from features of Set 2.

In [366]:

```
# Using tfidf train & test to find top 5000 features
#clf2 corresponds to the randomsearchCV classifier that was used in set-2
X_train_5k = X_tr_tfidf[:,clf2.best_estimator_.feature_importances_.argsort()[::-1][:50
00]]
X_test_5k = X_test_tfidf[:,clf2.best_estimator_.feature_importances_.argsort()[::-1][:5
000]]

print(X_train_5k.shape)
print(X_test_5k.shape)
```

```
(33500, 5000)
(16500, 5000)
```

2.5.1 Hyper parameter tuning

In [368]:

```
dt_5k = DecisionTreeClassifier(criterion='gini',class_weight = 'balanced') #https://sci
kit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html
parameters = {'max_depth': [4, 6, 8, 10, 30, 50], 'min_samples_split': [5, 20, 80, 200,
500, 800]}
clf5 = RandomizedSearchCV(dt_5k, parameters, cv=3, scoring='roc_auc',return_train_score
=True,n_jobs=-1)
rs5 = clf5.fit(X_train_5k, y_train)
```

In [369]:

```
df4=pd.DataFrame(clf5.cv_results_)
df4.head(5)
```

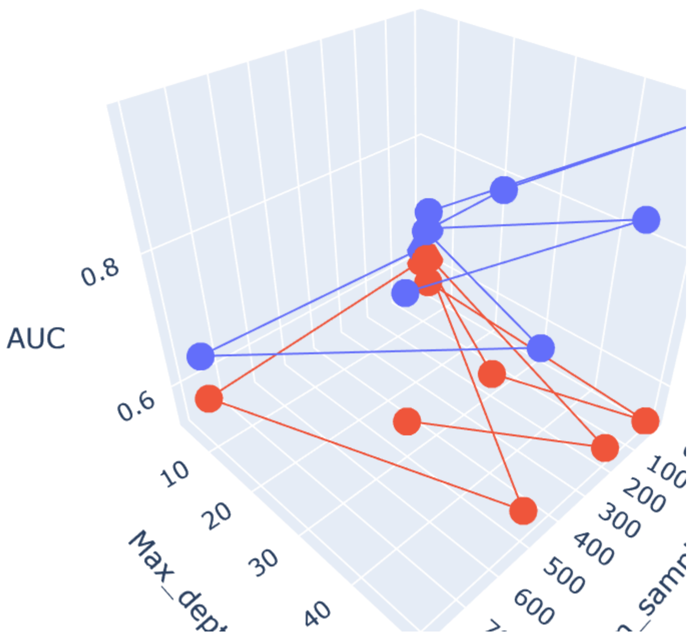
Out[369]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_min_sample
0	14.257821	0.458145	0.136588	0.023572	500
1	24.248760	1.046582	0.133592	0.012030	200
2	4.420130	0.068286	0.141919	0.008160	5
3	2.697118	0.022941	0.130926	0.014344	5
4	5.961580	0.079456	0.140254	0.015789	800

2.5.2 3D-Plot

In [370]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=df4['param_min_samples_split'],y=df4['param_max_depth'],z=df4[
'mean_train_score'], name = 'train')
trace2 = go.Scatter3d(x=df4['param_min_samples_split'],y=df4['param_max_depth'],z=df4[
'mean_test_score'], name = 'Cross validation')
data = [trace1, trace2]
enable_plotly_in_cell()

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

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



2.5.3 Best Hyperparameters

In [371]:

```
print(clf5.best_estimator_)
print(f'Score on train data : {clf5.score(X_train_5k,y_train)}')
print(f'Mean cross-validated score of the best_estimator : {clf5.best_score_}')
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=800,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
Score on train data : 0.68609838946892
Mean cross-validated score of the best_estimator : 0.6158844294289313
```

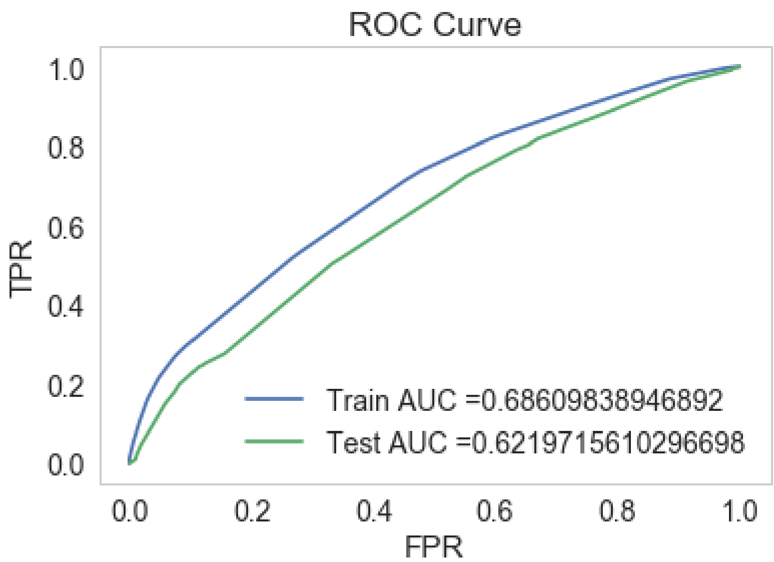
In [372]:

```
best_parameters_tfidf = {'max_depth': [10], 'min_samples_split': [800]}
```

2.5.4 Applying Best Hyperparameters on train & test data & plotting ROC curve

In [373]:

```
dt_best_5k= DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_
split=800)

dt_best_5k.fit(X_train_5k, y_train)

y_train_pred_5k_best,pred_labels_train = batch_predict(dt_best_5k, X_train_5k)
y_test_pred_5k_best,pred_labels_test = batch_predict(dt_best_5k, X_test_5k)

train_tpr_5k, train_fpr_5k, tr_thresholds_5k = roc_curve(y_train, y_train_pred_5k_best)
test_tpr_5k, test_fpr_5k, te_thresholds_5k = roc_curve(y_test, y_test_pred_5k_best)

plt.plot(train_tpr_5k, train_fpr_5k,label="Train AUC ="+str(auc(train_tpr_5k, train_fpr
_5k)))
plt.plot(test_tpr_5k, test_fpr_5k, label="Test AUC ="+str(auc(test_tpr_5k, test_fpr_5k
)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.grid()
plt.show()
```



2.5.5 Plot confusion matrix

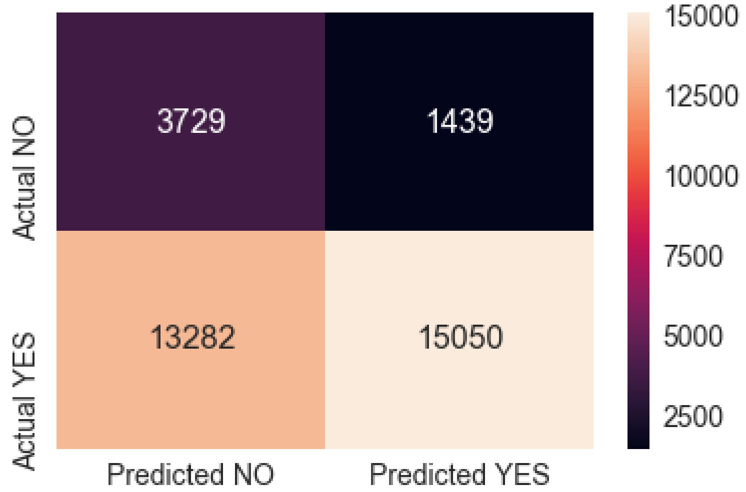
In [374]:

```
from sklearn.metrics import confusion_matrix
best_t_5k = find_best_threshold(tr_thresholds_5k, train_fpr_5k, train_tpr_5k)
print("Train confusion matrix")
cm_train_5k=confusion_matrix(y_train, predict_with_best_t(y_train_pred_5k_best, best_t_
5k))
print(cm_train_5k)
print("Test confusion matrix")
cm_test_5k=confusion_matrix(y_test, predict_with_best_t(y_test_pred_5k_best, best_t_5k
))
print(cm_test_5k)
```

```
The maximum value of tpr*(1-fpr) 0.1305342660816528 for threshold 0.534
Train confusion matrix
[[ 3729  1439]
 [13282 15050]]
Test confusion matrix
[[1664  882]
 [6740 7214]]
```

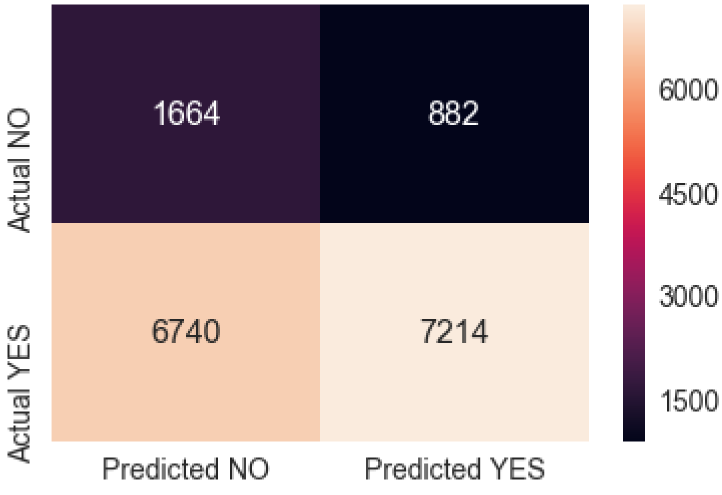
In [375]:

```
# confusion matrix heatmap for train data
cm_heatmap(cm_train_5k)
```



In [376]:

```
# confusion matrix heatmap for test data
cm_heatmap(cm_test_5k)
```



2.5.6 Analysis of False Positives

In [377]:

```
# Extracting false postives
FP_5k = []
for i in range(len(y_test)) :
    if (y_test[i] == 0) and (pred_labels_test[i] == 1) :
        FP_5k.append(i)
FP_essay_5k = []
for i in FP_5k :
    FP_essay_5k.append(X_test['preprocessed_essays'].values[i])
```

In [378]:

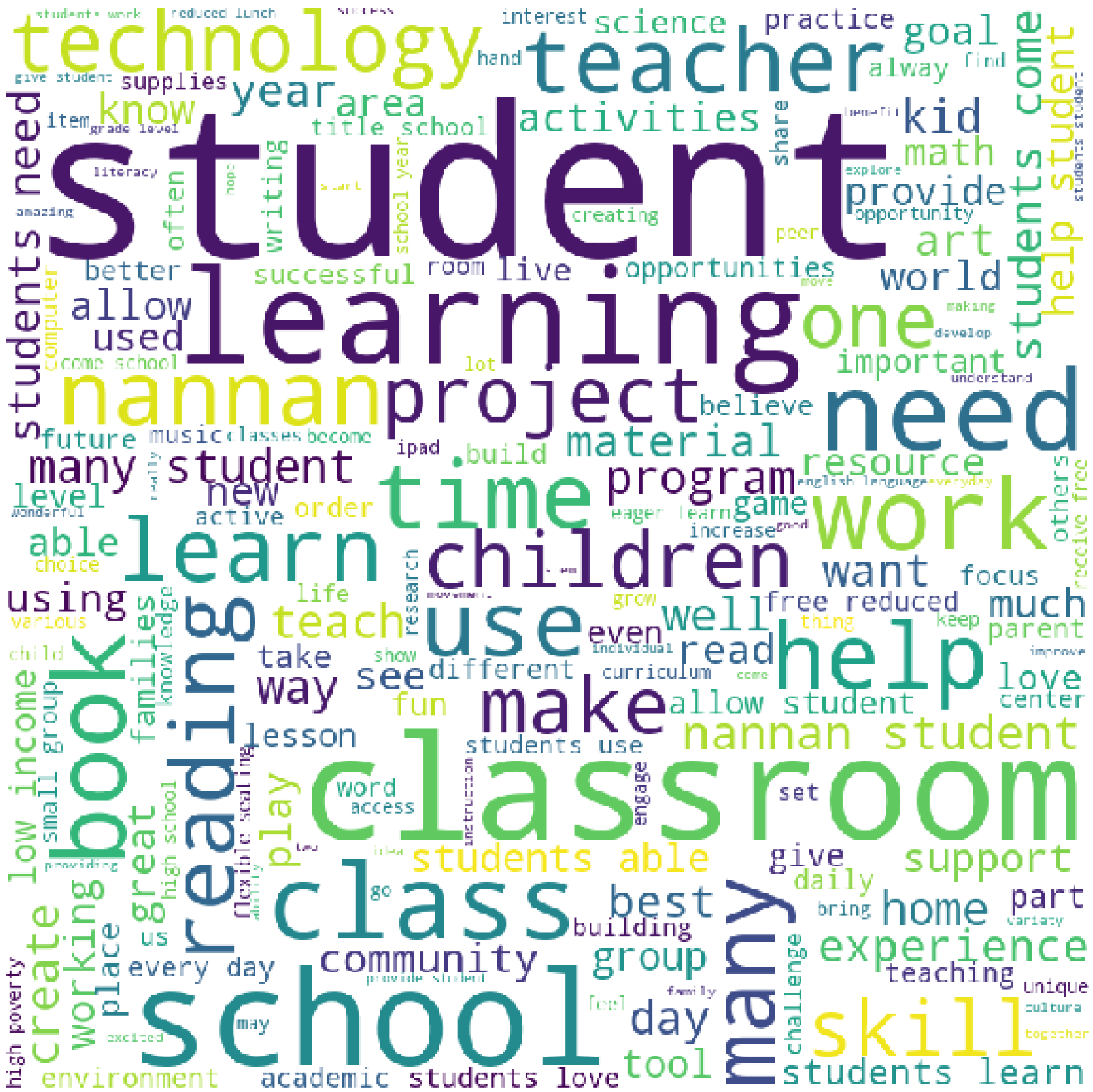
```
print(f'Total number of false positives = {len(FP_5k)}')
```

```
Total number of false positives = 1347
```

Wordcloud

In [379]:

```
#plot the word cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud

words = ' '
for row in FP_essay_5k:
    tokens = row.split()
    for t in tokens:
        words += t + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_font_si
ze = 10).generate(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()
```



From the wordcloud above, it can be observed that the words " student", "school", "learning" & "classroom" had a lot of impact in predicting the class label as 1 when it was supposed to be 0.

Box plot on Price feature for false positives

In [380]:

```
FP_price_5k = []
FP_projects_5k=[]
for i in FP_5k :
    FP_price_5k.append(X_test['price'].values[i])
    FP_projects_5k.append(X_test['teacher_number_of_previously_posted_projects'].values
[i])
```

In [381]:

```
df_5k=pd.DataFrame(columns=['Price','Projects'])
df_5k['Price']=FP_price_5k
df_5k['Projects']=FP_projects_5k
df_5k.head()
```

Out[381]:

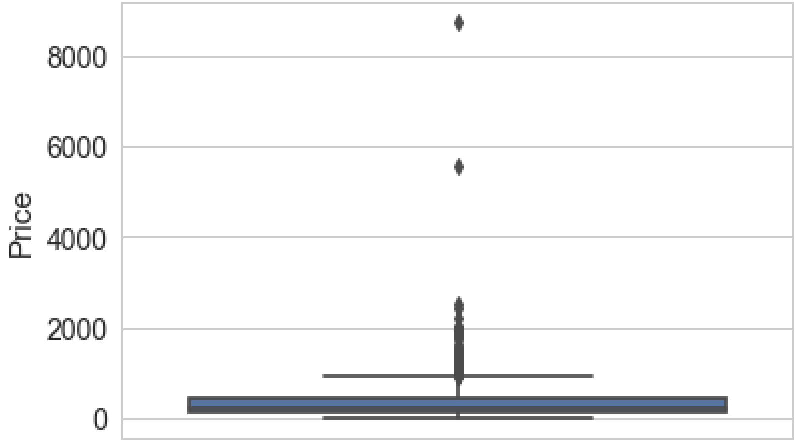
	Price	Projects
0	404.90	5
1	551.78	1
2	206.74	31
3	451.17	82
4	199.96	1

In [382]:

```
sns.set_style("whitegrid")

sns.boxplot(y = 'Price', data = df_5k)
```

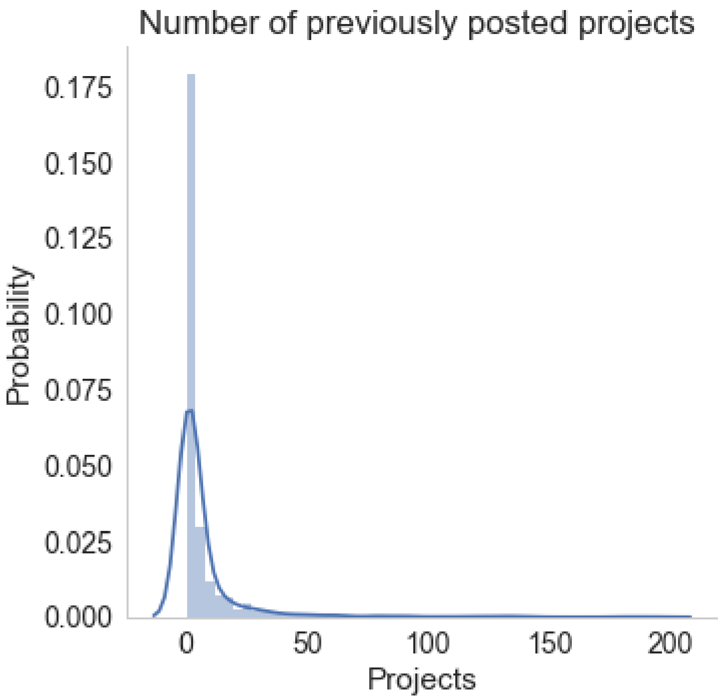
Out[382]:

<matplotlib.axes._subplots.AxesSubplot at 0x233ad8b3a20>



In [383]:

```
#pdf
import warnings
warnings.filterwarnings("ignore")

sns.FacetGrid(df_5k,size=5) \
   .map(sns.distplot,'Projects') \
   .add_legend()
plt.ylabel('Probability')
plt.title("Number of previously posted projects ")
plt.grid()
plt.show()
```



3.0 Summary

In [385]:

```
#Ref: http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer","max_depth","min_samples_split" ,"Test AUC"]
x.add_row(["BOW", 8, 500, 0.61])
x.add_row(["TFIDF", 10, 800, 0.62])
x.add_row(["Avg W2V", 4, 80, 0.60])
x.add_row(["TFIDF W2V", 4, 800, 0.60])
x.add_row(["TFIDF using 5K features", 10, 800, 0.62])

print(x)
```

Vectorizer	max_depth	min_samples_split	Test AUC
BOW	8	500	0.61
TFIDF	10	800	0.62
Avg W2V	4	80	0.6
TFIDF W2V	4	800	0.6
TFIDF using 5K features	10	800	0.62

- There was no change in performance when TFIDF with 5K features were used instead of all features. However, the time taken to fit the data with 5K features to a DT calssifier was marginally less compared to using all 7K features i.e. there was a difference of 15 seconds.