In [1]:

```
%matplotlib inline
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
# Tutorial about Python regular expressions: https://pymotw.com/2/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 plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

READING DATA

In [2]:

```
dft = pd.read_csv('train_data.csv',nrows=60000)
dfr = pd.read_csv('resources.csv')
```

In [3]:

```
print("Number of data points in train data", dft.shape)
print('-'*50)
print("The attributes of data :", dft.columns.values)
```

```
Number of data points in train data (60000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix'
'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

```
print("Number of data points in train data", dfr.shape)
print(dfr.columns.values)
dfr.head(2)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
```

Out[4]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

In [5]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(dft.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/40840
39
dft['Date'] = pd.to_datetime(dft['project_submitted_datetime'])
dft.drop('project_submitted_datetime', axis=1, inplace=True)
dft.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
dft = dft[cols]


dft.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	(
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	(

TEXT PROCESSING

In [6]:

```
# merge two column text dataframe:
dft["essay"] = dft["project_essay_1"].map(str) +\
                        dft["project_essay_2"].map(str) + \
                        dft["project_essay_3"].map(str) + \
                        dft["project_essay_4"].map(str)
```

In [7]:

```
dft.head(2)
```

Out[7]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	(
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	(

In [8]:

```
# https://stackoverflow.com/a/47091490/4084039
import re
def decontracted(phrase):
# specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
# general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [9]:

```
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing of project_subject_categories

In [10]:

```
catogories = list(dft['project_subject_categories'].values)

cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace
 it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placing all the ' '(space) with ''(empty) ex:"Ma
th & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

dft['clean_categories'] = cat_list
dft.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in dft['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

Preprocessing of project_subject_subcategories

In [11]:

```
sub_catogories = list(dft['project_subject_subcategories'].values)
# remove special characters from list of strings python:
#https://stackoverflow.com/a/47301924/4084039

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace
 it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placing all the ' '(space) with ''(empty) ex:"Ma
th & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

dft['clean_subcategories'] = sub_cat_list
dft.drop(['project_subject_subcategories'], axis=1, inplace=True)

# count of all the words in corpus python:
#https://stackoverflow.com/a/22898595/4084039
my_counter = Counter()
for word in dft['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [12]:

```
# we have to remove the grades from every row
print(dft['project_grade_category'][:20])
```

```
55660    Grades PreK-2
51140    Grades PreK-2
473      Grades PreK-2
41558       Grades 3-5
29891       Grades 3-5
23374    Grades PreK-2
49228    Grades PreK-2
7176     Grades PreK-2
35006       Grades 3-5
5145        Grades 3-5
48237      Grades 9-12
52282      Grades 9-12
46375       Grades 3-5
36468    Grades PreK-2
36358    Grades PreK-2
39438    Grades PreK-2
2521     Grades PreK-2
58794    Grades PreK-2
40180    Grades PreK-2
53562      Grades 9-12
Name: project_grade_category, dtype: object
```

In [13]:

```
d= list(dft['project_grade_category'].values)
# remove special characters from list of strings python:
# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/

grade_cat_list = []
for i in d:
# consider we have text like this:
    for j in i.split(' '): # # split by space
        j=j.replace('Grades','')# clean grades from the row
    grade_cat_list.append(j.strip())

dft['clean_grade'] = grade_cat_list
dft.drop(['project_grade_category'], axis=1, inplace=True)

my_counter = Counter()
for word in dft['clean_grade'].values:
     my_counter.update(word.split())
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]))
```

Preparing data for the models

Test - Train Split

In [14]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(dft, dft['project_is_approved'],str
atify = dft['project_is_approved'], test_size=0.33)
X_train,X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, strati
fy=y_train)
```

In [15]:

```
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, stratify= y_train,tes
t_size = 0.33)
```

In [16]:

```
print(y_train.value_counts())
print(y_test.value_counts())
print(y_cv.value_counts())
```

```
1    15295
0     2750
Name: project_is_approved, dtype: int64
1    16782
0     3018
Name: project_is_approved, dtype: int64
1    7535
0    1354
Name: project_is_approved, dtype: int64
```

In [17]:

```
#droping the y labels
#https://stackoverflow.com/questions/13411544/delete-column-from-pandas-dataframe-by-co
lumn-name

X_train.drop(["project_is_approved"], axis = 1, inplace = True)

X_test.drop(["project_is_approved"], axis = 1, inplace = True)

X_cv.drop(["project_is_approved"], axis = 1, inplace = True)
```

Text preprocessing

In [18]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_train = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_train.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████████
██████| 18045/18045 [00:20<00:00, 760.92it/s]
```

In [19]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_test = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_test.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████████
██████| 19800/19800 [00:26<00:00, 749.84it/s]
```

In [20]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_cv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_cv.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████████
████████| 8889/8889 [00:12<00:00, 736.00it/s]
```

In [21]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_cv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_cv.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████
█████| 8889/8889 [00:00<00:00, 16760.57it/s]
```

In [22]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_train = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_train.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████
████| 18045/18045 [00:01<00:00, 16870.17it/s]
```

In [23]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_test = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_test.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████
████| 19800/19800 [00:01<00:00, 16517.69it/s]
```

Encoding numerical, Categorical features

vectorize categorical data

In [24]:

```
#project_subject_categories convert categorical to vectors

# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer1 = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False,
binary=True)
vectorizer1.fit(X_train['clean_categories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_cat = vectorizer1.transform(X_train['clean_categories'].values)
X_cv_cat = vectorizer1.transform(X_cv['clean_categories'].values)
X_test_cat = vectorizer1.transform(X_test['clean_categories'].values)
print(vectorizer1.get_feature_names())
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearnin
g', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
```

In [25]:

```
f1=vectorizer1.get_feature_names()
print("After vectorizations")
print(X_train_cat.shape, y_train.shape)
print(X_cv_cat.shape, y_cv.shape)
print(X_test_cat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 9) (18045,)
(8889, 9) (8889,)
(19800, 9) (19800,)
==========================================================================
==========================
```

In [26]:

```
##project_subject_subcategories convert categorical to vectors
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer2 = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
vectorizer2.fit(X_train['clean_subcategories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat = vectorizer2.transform(X_train['clean_subcategories'].values)
X_cv_subcat = vectorizer2.transform(X_cv['clean_subcategories'].values)
X_test_subcat = vectorizer2.transform(X_test['clean_subcategories'].values)
print(vectorizer2.get_feature_names())
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvemen
t', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'Nutrition
Education', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts',
'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Histor
y_Geography', 'Music', 'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'G
ym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'App
liedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Liter
acy']
```

In [27]:

```
print("After vectorizations")
print(X_train_subcat.shape, y_train.shape)
print(X_cv_subcat.shape, y_cv.shape)
print(X_test_subcat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 30) (18045,)
(8889, 30) (8889,)
(19800, 30) (19800,)
==========================================================================
==========================
```

In [28]:

```
# school_state convert categorical to vectors
# now time to cont the each words
from collections import Counter
my_counter = Counter()
for word in dft['school_state'].values:
    my_counter.update(word.split())# count the words
school_state_dict = dict(my_counter)# store in dicionary
sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1
]))
print(sorted_school_state_dict)
```

```
{'VT': 40, 'WY': 58, 'ND': 78, 'MT': 120, 'RI': 148, 'NH': 175, 'NE': 176,
'SD': 177, 'DE': 181, 'AK': 188, 'WV': 252, 'HI': 270, 'ME': 277, 'DC': 29
4, 'NM': 295, 'KS': 340, 'IA': 363, 'ID': 371, 'AR': 534, 'CO': 638, 'MN':
671, 'OR': 676, 'MS': 710, 'KY': 725, 'NV': 774, 'MD': 801, 'CT': 923, 'T
N': 935, 'AL': 944, 'UT': 958, 'WI': 994, 'VA': 1124, 'AZ': 1172, 'NJ': 12
35, 'OK': 1283, 'LA': 1308, 'WA': 1309, 'MA': 1312, 'OH': 1399, 'MO': 142
1, 'IN': 1431, 'PA': 1699, 'MI': 1760, 'SC': 2186, 'GA': 2203, 'IL': 2371,
'NC': 2831, 'FL': 3444, 'TX': 4010, 'NY': 4039, 'CA': 8377}
```

In [29]:

```
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer3 = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowerca
se=False, binary=True)
vectorizer3.fit(dft['school_state'].values)
# firstly convert fit the train data into the vector then it learn the vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer3.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer3.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer3.transform(X_test['school_state'].values)
print(vectorizer3.get_feature_names())
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'NE', 'SD', 'DE', 'AK', 'WV', 'HI',
'ME', 'DC', 'NM', 'KS', 'IA', 'ID', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'N
V', 'MD', 'CT', 'TN', 'AL', 'UT', 'WI', 'VA', 'AZ', 'NJ', 'OK', 'LA', 'W
A', 'MA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'T
X', 'NY', 'CA']
```

In [30]:

```
print("After vectorizations")
print(X_train_school_state .shape, y_train.shape)
print(X_cv_school_state .shape, y_cv.shape)
print(X_test_school_state .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 51) (18045,)
(8889, 51) (8889,)
(19800, 51) (19800,)
==========================================================================
==========================
```

In [31]:

```
#project_grade_category categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attrib
ute-split
dft['clean_grade']=dft['clean_grade'].fillna("")# fill the null values with space
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer4 = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys
()),lowercase=False, binary=True)
vectorizer4.fit(dft['clean_grade'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade_category = vectorizer4.transform(X_train['clean_grade'].values)
X_cv_project_grade_category = vectorizer4.transform(X_cv['clean_grade'].values)
X_test_project_grade_category = vectorizer4.transform(X_test['clean_grade'].values)
print(vectorizer4.get_feature_names())
```

```
['9-12', '6-8', '3-5', 'PreK-2']
```

In [32]:

```
print("After vectorizations")
print(X_train_project_grade_category .shape, y_train.shape)
print(X_cv_project_grade_category .shape, y_cv.shape)
print(X_test_project_grade_category .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 4) (18045,)
(8889, 4) (8889,)
(19800, 4) (19800,)
==========================================================================
==========================
```

In [33]:

```
#teacher_prefix categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attrib
ute-split
dft['teacher_prefix']=dft['teacher_prefix'].fillna(" ")# filll the null valueswith spac
e
my_counter = Counter()
for word in dft['teacher_prefix'].values:
    my_counter.update(word.split())
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
teacher_cat_dict = dict(my_counter)
sorted_teacher_prefix_dict = dict(sorted(teacher_cat_dict.items(), key=lambda kv: kv[1
]))
```

In [34]:

```
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer5 = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lower
case=False,binary=True)
vectorizer5.fit(dft['teacher_prefix'].values.astype('U'))
# firstly convert fit the train data into the vectorizer
# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer5.transform(X_train['teacher_prefix'].values.astype(
'U'))
X_cv_teacher_prefix= vectorizer5.transform(X_cv['teacher_prefix'].values.astype('U'))
X_test_teacher_prefix = vectorizer5.transform(X_test['teacher_prefix'].values.astype(
'U'))
print(vectorizer5.get_feature_names())
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
```

In [35]:

```
print("After vectorizations")
print(X_train_teacher_prefix .shape, y_train.shape)
print(X_cv_teacher_prefix .shape, y_cv.shape)
print(X_test_teacher_prefix .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 5) (18045,)
(8889, 5) (8889,)
(19800, 5) (19800,)
==========================================================================
==========================
```

Encoding essay, and Project_title

In [36]:

```
#bow featurization essay

X_train_essay=preprocessed_essays_train
X_cv_essay=preprocessed_essays_cv
X_test_essay=preprocessed_essays_test

X_train_title=preprocessed_titles_train
X_cv_title=preprocessed_titles_cv
X_test_title=preprocessed_titles_test
# We are considering only the words which appeared in at least 10 documents(rows or pro
jects).
vectorizer6 = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer6.fit(X_train_essay)# that is learned from trained data

# we use the fitted CountVectorizer to convert the text to vector
X_train_bow = vectorizer6.transform(X_train_essay)
X_cv_bow = vectorizer6.transform(X_cv_essay)
X_test_bow = vectorizer6.transform(X_test_essay)
```

In [37]:

```
#bow featurization title
vectorizer7 = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer7.fit(X_train_title)# that is learned from trainned data
# we use the fitted CountVectorizer to convert the text to vector
X_train_bow_title = vectorizer7.transform(X_train_title)
X_cv_bow_title= vectorizer7.transform(X_cv_title)
X_test_bow_title = vectorizer7.transform(X_test_title)
print("After vectorizations")
print(X_train_bow_title.shape, y_train.shape)
print(X_cv_bow_title.shape, y_cv.shape)
print(X_test_bow_title.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 1327) (18045,)
(8889, 1327) (8889,)
(19800, 1327) (19800,)
==========================================================================
==========================
```

Tfidf featurization

In [38]:

```
#for titles
from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or pro
jects).
vectorizer8 = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer8.fit(X_train_title)# that is learned from trained data

# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_title = vectorizer8.transform(X_train_title)
X_cv_tf_title= vectorizer8.transform(X_cv_title)
X_test_tf_title = vectorizer8.transform(X_test_title)
print("After vectorizations")
print(X_train_tf_title.shape, y_train.shape)
print(X_cv_tf_title.shape, y_cv.shape)
print(X_test_tf_title.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 1327) (18045,)
(8889, 1327) (8889,)
(19800, 1327) (19800,)
==========================================================================
==========================
```

In [39]:

```
#for essay
from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or pro
jects).
vectorizer9 = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer9.fit(X_train_essay)# that is learned from trained data
# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_essay = vectorizer9.transform(X_train_essay)
X_cv_tf_essay= vectorizer9.transform(X_cv_essay)
X_test_tf_essay = vectorizer9.transform(X_test_essay)
print("After vectorizations")
print(X_train_tf_essay.shape, y_train.shape)
print(X_cv_tf_essay.shape, y_cv.shape)
print(X_test_tf_essay.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 5000) (18045,)
(8889, 5000) (8889,)
(19800, 5000) (19800,)
===========================================================================
=========================
```

Using Pretrained Models : AVG W2V

In [40]:

```
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039

def loadGloveModel(gloveFile):

    print ("Loading Glove Model")

    f = open(gloveFile,'r', encoding = 'utf8')

    model = {}

    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding

    print ("Done.",len(model)," words loaded!")

    return model
```

In [41]:

```
model = loadGloveModel('glove.42B.300d.txt')
```

```
Loading Glove Model

1917495it [09:14, 3459.20it/s]

Done. 1917495  words loaded!
```

In [42]:

```
glove_words = set(model.keys())
```

In [43]:

```
#for essay
# average Word2Vec
# compute average word2vec for each review.
def func(wordlist):

  train_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
 list
  for sentence in tqdm(wordlist): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length # we are taking the 300
dimensions very large
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_avg_w2v_vectors.append(vector)

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

In [44]:

```
train_avg_w2v_vectors=func(preprocessed_essays_train)
test_avg_w2v_vectors=func(preprocessed_essays_test)
cv_avg_w2v_vectors=func(preprocessed_essays_cv)
#for titles
cv_avg_w2v_vectors_title=func(preprocessed_titles_cv)
test_avg_w2v_vectors_title=func(preprocessed_titles_test)
train_avg_w2v_vectors_title=func(preprocessed_titles_train)
```

```
100%|████████████████████████████████████████████████████████████████████
█████| 18045/18045 [00:09<00:00, 1805.19it/s]

18045
300

100%|████████████████████████████████████████████████████████████████████
█████| 19800/19800 [00:10<00:00, 1884.12it/s]

19800
300

100%|████████████████████████████████████████████████████████████████████
███████| 8889/8889 [00:04<00:00, 1841.96it/s]

8889
300

100%|████████████████████████████████████████████████████████████████████
██████| 8889/8889 [00:00<00:00, 41983.19it/s]

8889
300

100%|████████████████████████████████████████████████████████████████████
████| 19800/19800 [00:00<00:00, 46198.56it/s]

19800
300

100%|████████████████████████████████████████████████████████████████████
████| 18045/18045 [00:00<00:00, 41310.19it/s]

18045
300
```

Using Pretrained Models: TFIDF weighted W2V

In [45]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_train)
# 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 [46]:

```
# average Word2Vec
# compute average word2vec for each review.
def tf_idf_done(word_list):
    train_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is store
d in this list
    for sentence in tqdm(word_list): # 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():#.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in tfidf_words):
              #vec = model.wv[word]
              vec = model[word] # getting the vector for each word
# here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count
(word)/len(sentence.split())))
              tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
              vector += (vec * tf_idf) # calculating tfidf weighted w2v
              tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        train_title_tfidf_w2v_vectors.append(vector)
    print(len(train_title_tfidf_w2v_vectors))
    print(len(train_title_tfidf_w2v_vectors[0]))
    return train_title_tfidf_w2v_vectors
```

In [47]:

```
train_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_train)
test_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_test)
cv_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_cv)
```

```
100%|█████████████████████████████████████████████████████████████████████
██████| 18045/18045 [01:19<00:00, 225.72it/s]

18045
300

100%|█████████████████████████████████████████████████████████████████████
██████| 19800/19800 [01:27<00:00, 225.26it/s]

19800
300

100%|█████████████████████████████████████████████████████████████████████
████████| 8889/8889 [00:39<00:00, 222.26it/s]

8889
300
```

In [48]:

```
train_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_train)
test_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_test)
cv_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_cv)
```

```
100%|█████████████████████████████████████████████████████████████████████
████| 18045/18045 [00:00<00:00, 19526.07it/s]

18045
300

100%|█████████████████████████████████████████████████████████████████████
████| 19800/19800 [00:01<00:00, 17606.28it/s]


19800
300

100%|█████████████████████████████████████████████████████████████████████
██████| 8889/8889 [00:00<00:00, 17790.29it/s]

8889
300
```

Vectorizing Numerical features

In [49]:

```
price_data = dfr.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
dft = pd.merge(dft, price_data, on='id', how='left')
print(price_data.head(2))
# we also have to do this in tran,test and cv
# so also merge the resource data with the trian,cv and test
X_train = pd.merge(X_train, price_data, on = "id", how = "left")
#print(x_train.columns)
X_test = pd.merge(X_test, price_data, on = "id", how = "left")
X_cv = pd.merge(X_cv, price_data, on = "id", how = "left")
```

```
        id   price  quantity
0  p000001  459.56         7
1  p000002  515.89        21
```

In [50]:

```
#standardization
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikitlearn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn import preprocessing


price_scalar = StandardScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard deviationof this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above mean and variance.
train_price_standar = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
test_price_standar = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_price_standar = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

In [51]:

```
# previous_year_projects
price_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_prev_proj_standar =price_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
# Now standardize the data with above maen and variance.
test_prev_proj_standar =price_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_prev_proj_standar = price_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
```

In [52]:

```
price_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and standarddeviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_qnty_standar = price_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_qnty_standar = price_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
test_qnty_standar = price_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
```

merging

In [53]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_train = hstack((X_train_bow_title,X_train_bow,# all bows
                       X_train_teacher_prefix,X_train_cat,X_train_subcat
                      ,X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set1_train.shape, y_train.shape)
```

```
(18045, 6429) (18045,)
```

In [54]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_cv = hstack((X_cv_bow_title,X_cv_bow,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set1_cv.shape, y_cv.shape)
```

```
(8889, 6429) (8889,)
```

In [55]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_test = hstack((X_test_bow_title,X_test_bow,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar))
print(X_set1_test.shape, y_test.shape)
```

```
(19800, 6429) (19800,)
```

In [136]:

```
xtr = X_set2_train.tocsr() # Here I have just applied kind of trail and logic. It was i
n coomatrix kada. Coomatrix is not accessible.
```

In [137]:

```
xtr
```

Out[137]:

```
<18045x6429 sparse matrix of type '<class 'numpy.float64'>'
        with 2359759 stored elements in Compressed Sparse Row format>
```

In [56]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_train = hstack((X_train_tf_essay,X_train_tf_title,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set2_train.shape, y_train.shape)
```

```
(18045, 6429) (18045,)
```

In [57]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_cv = hstack((X_cv_tf_essay,X_cv_tf_title,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set2_cv.shape, y_cv.shape)
```

```
(8889, 6429) (8889,)
```

In [144]:

```
# You are getting error coomatrix which is not accessible. For this reason, you are getting subscriptable issue.

# Overall, you want things in sparse form. I just checked the type of data and it is coomatrix type which we don't want actually.

# So we have converted coomatrix type to sparse type using csr

# Here is the coomatrix type.

#type(X_set2_test)   # This is in coomatrix which we don't want and is not accessible.


xte = X_set2_test.tocsr()   # We want in sparse type and so we are convertin it to sparse matrix rather sparse type
type(xte)

#Instead of renamed everything just add an extension of .tocsr() wherever there is coomatrix type. Check below how am doing
```

Out[144]:

```
scipy.sparse.csr.csr_matrix
```

In [145]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set2_test = hstack((X_test_tf_essay,X_test_tf_title,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar)).toc
sr()
print(X_set2_test.shape, y_test.shape)
```

```
(19800, 6429) (19800,)
```

In [59]:

```
import numpy
s=numpy.array(train_avg_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(18045, 4)
(18045, 300)
```

In [60]:

```
from scipy.sparse import hstack
import numpy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set3_train = hstack((numpy.array(train_avg_w2v_vectors),numpy.array(train_avg_w2v_vec
tors_title),train_prev_proj_standar,train_price_standar,train_qnty_standar,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state))
print(X_set3_train.shape, y_train.shape)
```

```
(18045, 702) (18045,)
```

In [61]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set3_cv =hstack((cv_avg_w2v_vectors,cv_avg_w2v_vectors_title,cv_prev_proj_standar,cv_
price_standar,cv_qnty_standar,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state))
print(X_set3_cv.shape, y_cv.shape)
```

```
(8889, 702) (8889,)
```

In [62]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set3_test =hstack((test_avg_w2v_vectors,test_avg_w2v_vectors_title,test_prev_proj_sta
ndar,test_price_standar,
                     test_qnty_standar,
                     X_test_teacher_prefix,X_test_cat,X_test_subcat,
                     X_test_project_grade_category,X_test_school_state))
print(X_set3_test.shape, y_test.shape)
```

```
(19800, 702) (19800,)
```

In [63]:

```
import numpy
s=numpy.array(train_tfidf_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(18045, 4)
(18045, 300)
```

In [64]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set4_train =hstack((train_tfidf_w2v_vectors, train_title_tfidf_w2v_vectors,train_prev
_proj_standar,
                     train_price_standar,train_qnty_standar,
                      X_train_teacher_prefix,X_train_cat,X_train_subcat,
                      X_train_project_grade_category,X_train_school_state))

print(X_set4_train.shape, y_train.shape)
```

```
(18045, 702) (18045,)
```

In [65]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set4_cv =hstack((cv_tfidf_w2v_vectors,cv_title_tfidf_w2v_vectors,cv_prev_proj_standar
,
                   cv_price_standar,cv_qnty_standar,
                   X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                   X_cv_project_grade_category,X_cv_school_state))


print(X_set4_cv.shape, y_cv.shape)
```

```
(8889, 702) (8889,)
```

In [66]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
X_set4_test = hstack((test_title_tfidf_w2v_vectors,test_tfidf_w2v_vectors,test_prev_pro
j_standar,test_price_standar,test_qnty_standar,X_test_teacher_prefix,X_test_cat,X_test_
subcat,
                      X_test_project_grade_category,X_test_school_state))
print(X_set4_test.shape, y_test.shape)
```

```
(19800, 702) (19800,)
```

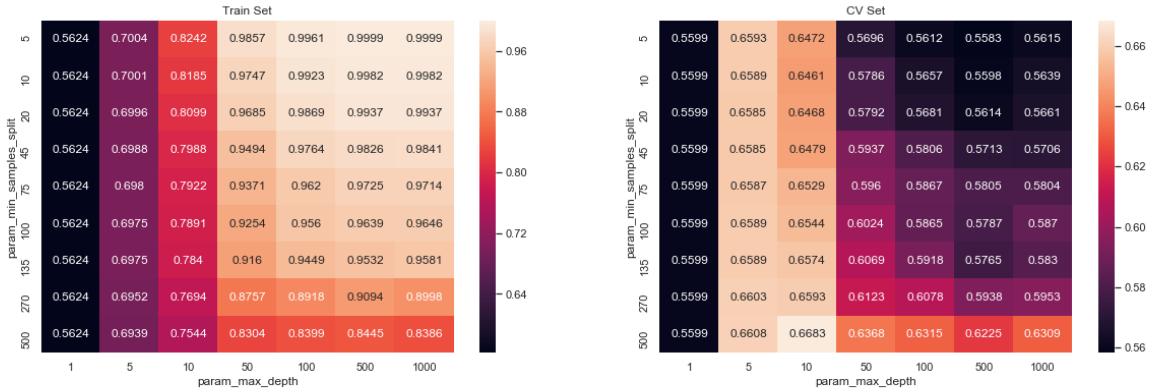
Decison trees on BOW

In [67]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt1 = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10,
20, 45, 75, 100, 135, 270, 500]}
clf1 = GridSearchCV(dt1, parameters, cv=3, scoring='roc_auc',return_train_score=True)
se1 = clf1.fit(X_set1_train, y_train)
```

In [68]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf1.cv_results_).groupby(['param_min_samples_split', 'param
_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



Best Estimator and Best tune parameters

In [69]:

```
print(clf1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf1.score(X_set1_train,y_train))
print(clf1.score(X_set1_test,y_test))
```

```
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=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7511722190852625
0.6719906398813649
```

In [159]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[10], 'min_samples_split':[500] } ]
```

In [160]:

```
clf1.get_params().keys()
```

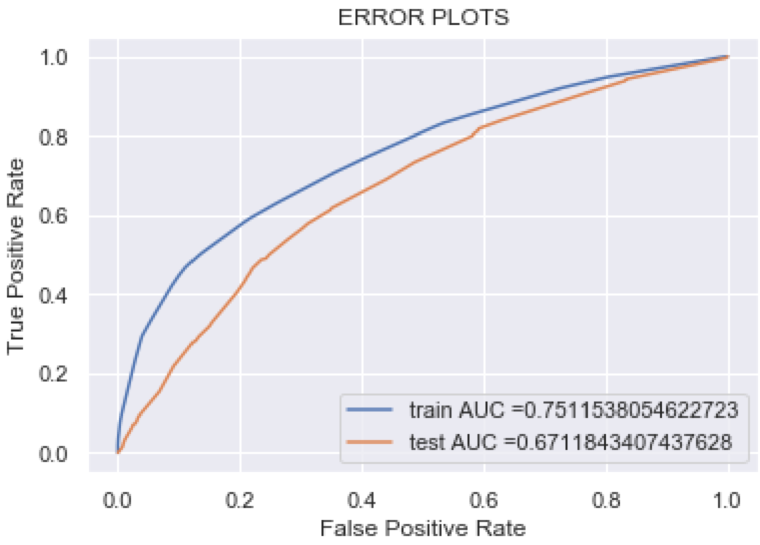
Out[160]:

```
dict_keys(['cv', 'error_score', 'estimator__class_weight', 'estimator__cri
terion', 'estimator__max_depth', 'estimator__max_features', 'estimator__ma
x_leaf_nodes', 'estimator__min_impurity_decrease', 'estimator__min_impurit
y_split', 'estimator__min_samples_leaf', 'estimator__min_samples_split',
'estimator__min_weight_fraction_leaf', 'estimator__presort', 'estimator__r
andom_state', 'estimator__splitter', 'estimator', 'iid', 'n_jobs', 'param_
grid', 'pre_dispatch', 'refit', 'return_train_score', 'scoring', 'verbos
e'])
```

Fitting Model to Hyper-Parameter Curve -> Best Max_depth-> 10 , Best Min_sample_split-> 100

In [205]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=500)
clf11.fit(X_set1_train, y_train)
# for visulation
clfV1.fit(X_set1_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set1_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set1_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

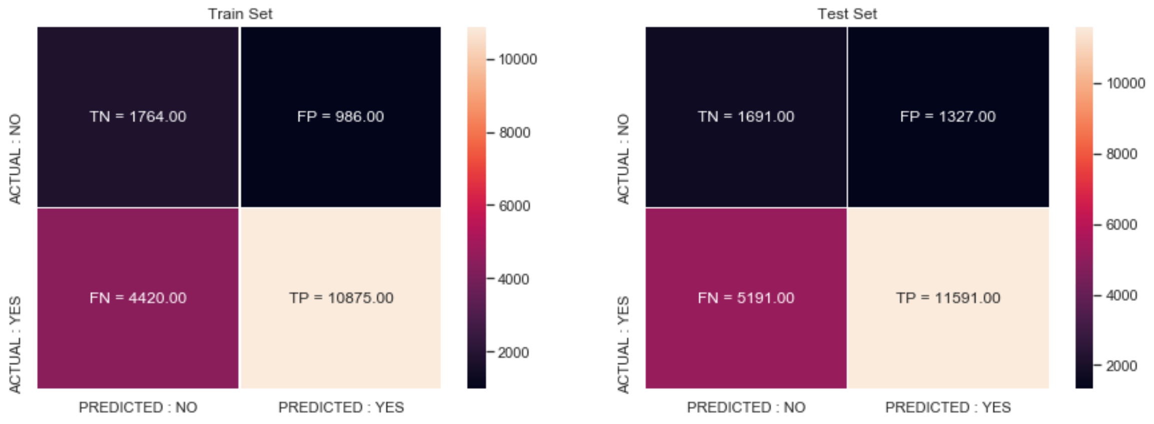
In [162]:

```
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", np.round(max(tpr*(1-fpr)),2) , "for threshold", np.round(t,2))
    predictions = []
    global predictions1 # make it global
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1= predictions
    return predictions
```

In [163]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.47 for threshold 0.44
the maximum value of tpr*(1-fpr) 0.4 for threshold 0.45
```



Visualizing Decision Tree

In [164]:

```
#Feature aggregation
f1=vectorizer1.get_feature_names()
f2=vectorizer2.get_feature_names()
f3=vectorizer3.get_feature_names()
f4=vectorizer4.get_feature_names()
f5=vectorizer5.get_feature_names()
fb=vectorizer6.get_feature_names()
ft=vectorizer7.get_feature_names()
fb1=vectorizer8.get_feature_names()
ft1=vectorizer9.get_feature_names()

feature_agg_bow = f1 + f2 + f3 + f4 + f5 + fb + ft
feature_agg_tfidf = f1 + f2 + f3 + f4 + f5 + fb1 + ft1
# p is price, q is quantity, t is teacher previous year projects
feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_previous_projects')
feature_agg_tfidf.append('teacher_previous_projects')
```

In [165]:

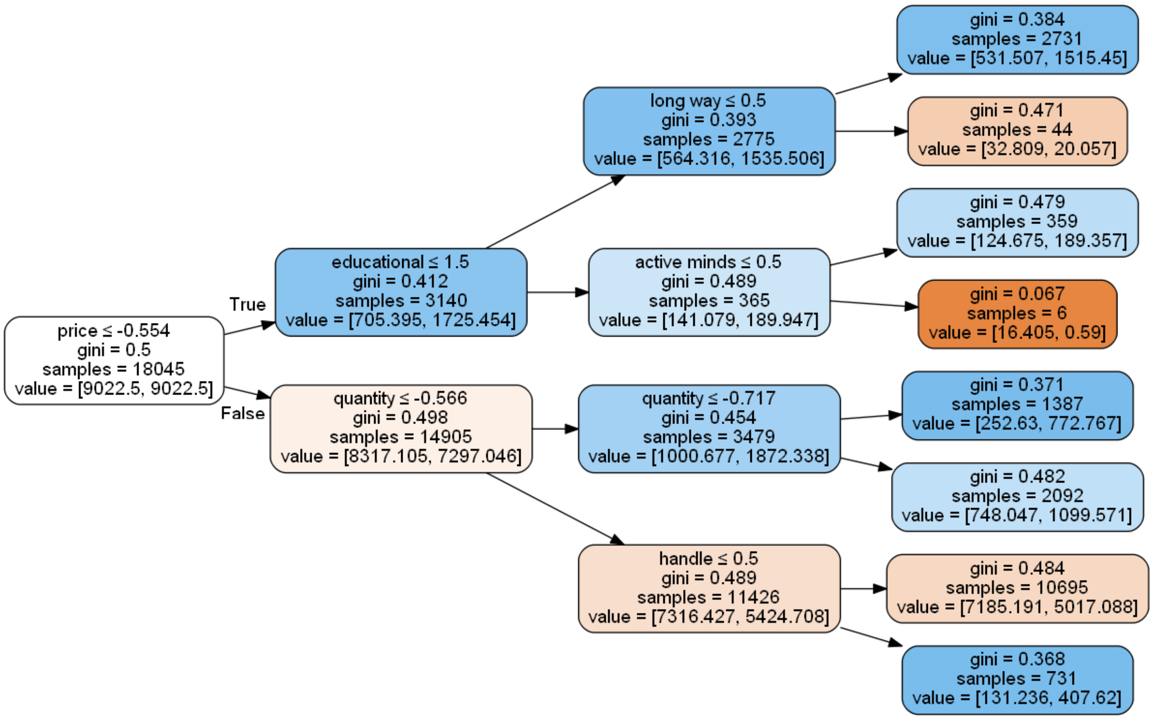
```
pip install pydotplus
```

```
Requirement already satisfied: pydotplus in c:\users\hp\anaconda3\lib\site
-packages (2.0.2)
Requirement already satisfied: pyparsing>=2.0.1 in c:\users\hp\anaconda3\l
ib\site-packages (from pydotplus) (2.3.1)
Note: you may need to restart the kernel to use updated packages.
```

In [166]:

```
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clfV1, out_file=dot_data, filled=True, rounded=True, special_characters
=True, feature_names=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[166]:



Analysis on the False positives

In [167]:

```
#Get the False positives datapoints
X_test['essay'].values[1]
```

Out[167]:

```
"My classroom is filled with fun-loving special education students that ar
e happy, active, and ready to learn. Their ages range between 3-5 years. A
ll of my students have special needs, including autism, speech and languag
e impairments, and intellectual disabilities, but we don't let that slow u
s down! We are part of a low income school district on an elementary schoo
l campus. Many of my students are nonverbal and need lots of visual and ph
ysical supports. We only get a few dollars a year for paper and crayons. W
e are in desperate need of enrichment supplies!I have a very busy group of
students in my preschool special education class. We are so excited, we ju
st can't sit still. We need some special stools to help us move while sitt
ing at the table. This way we can sit with our friends but still keep movi
ng. \\r\\nThe scooter boards will let us twist and shout when we need a br
eak from sitting. The science materials are hands-on to help us move and g
et kinesthetic input when learning difficult topics. The ball toss will he
lp us develop our gross motor skills and encourage our desire to move in a
n appropriate and fun way. Help us Move it, Move it!nannan"
```

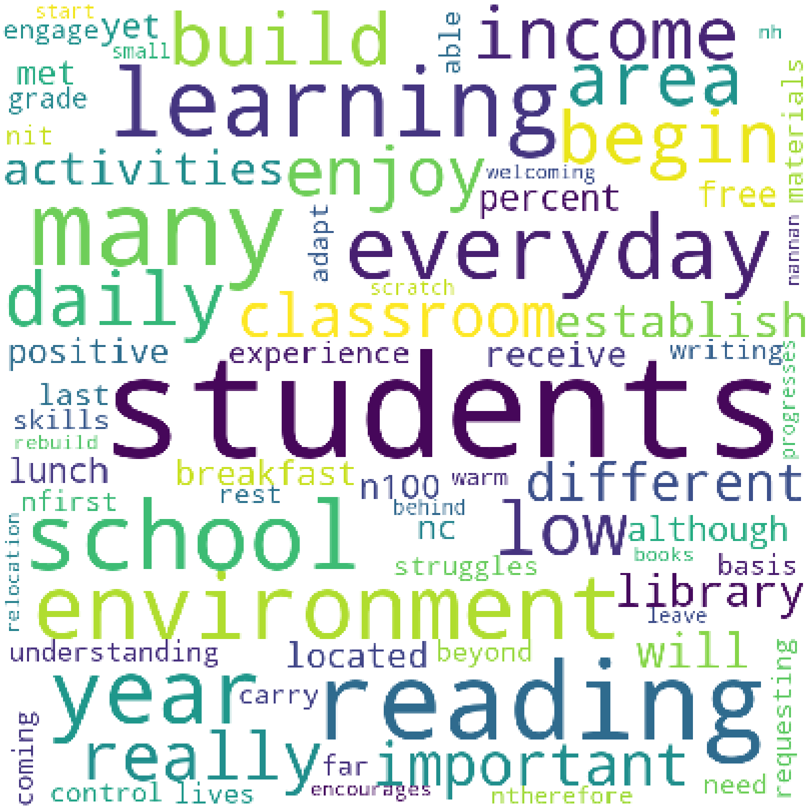
In [168]:

```
#https://www.google.com/search?q=geeks+for+geeks+false+positive&rlz=1C1SQJL_enIN849IN84
9&oq=geeks+for+geeks+false+positive&aqs=chrome..69i57j33l5.6431j0j7&sourceid=chrome&ie=
UTF-8
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsCho
ose_DT_(1).ipynb
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

WORD CLOUD OF ESSAY: Word Cloud is a data visualization technique used for representing text data in which the size of each word indicates its frequency or importance. Significant textual data points can be highlighted using a word cloud. Word clouds are widely used for analyzing data from social network websites.

In [169]:

```
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '
wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords =
stopwords,min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



DataFrame of False Positives

In [170]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)

  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

Out[170]:

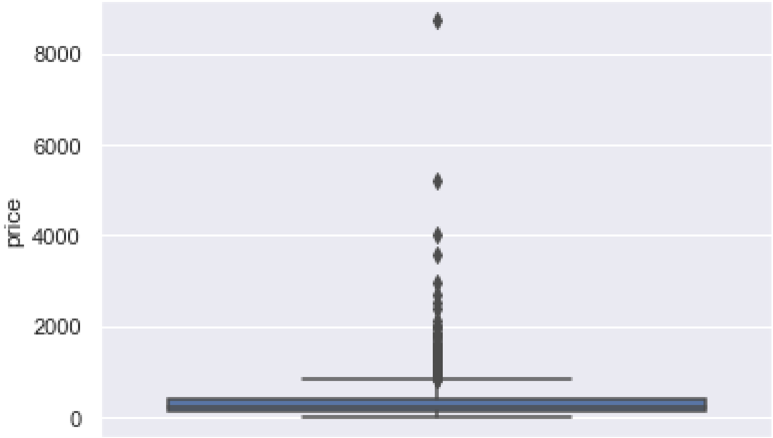
```
1327
```

In [171]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

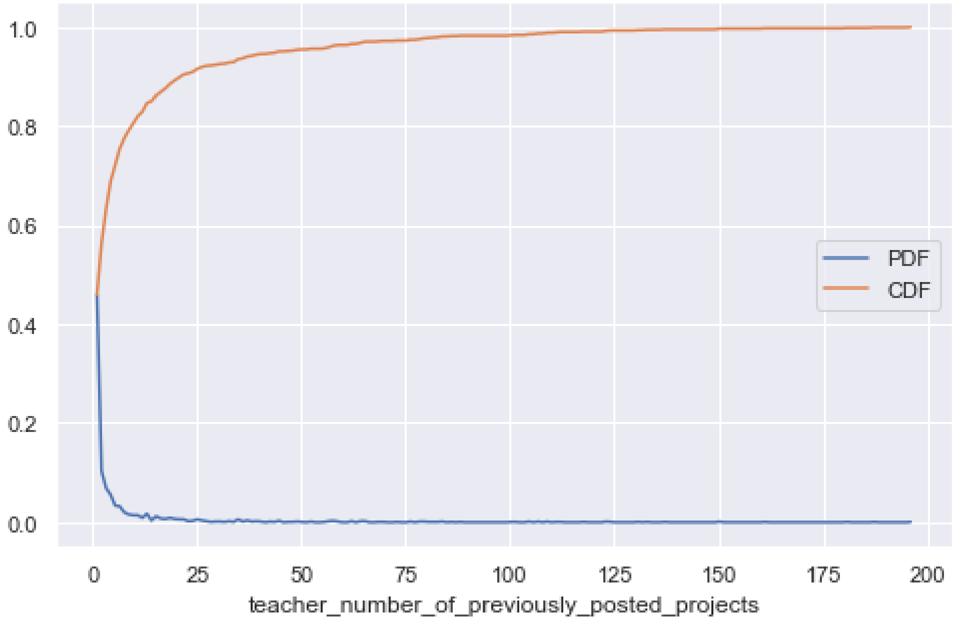
Out[171]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16d2c8e7588>
```



In [172]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



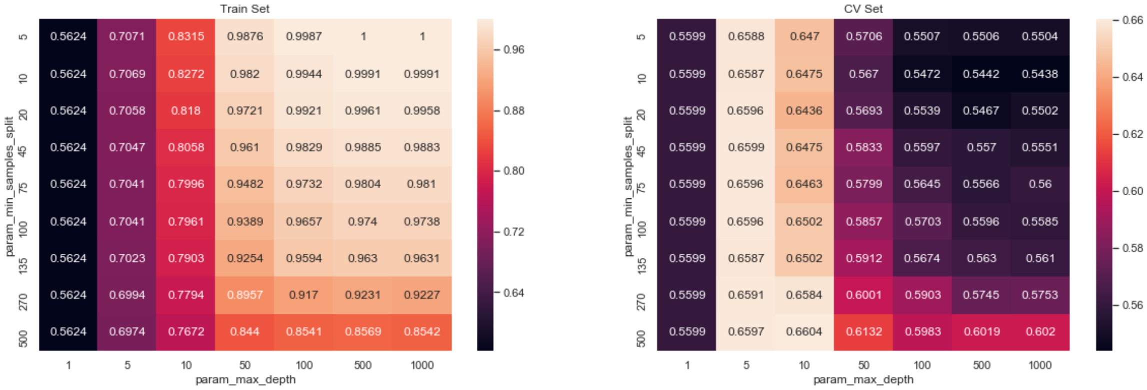
Applying Decision trees on TFIDF

In [84]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt2 = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10,
20, 45, 75, 100, 135, 270, 500]}
clf2 = GridSearchCV(dt2, parameters, cv=3, scoring='roc_auc',return_train_score=True)
se2 = clf2.fit(X_set2_train, y_train)
```

In [85]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf2.cv_results_).groupby(['param_min_samples_split', 'param
_max_depth']).max().unstack()[['mean_test_score','mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



Best Estimator and Best tune parameters

In [86]:

```
print(clf2.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf2.score(X_set2_train,y_train))
print(clf2.score(X_set2_test,y_test))
```

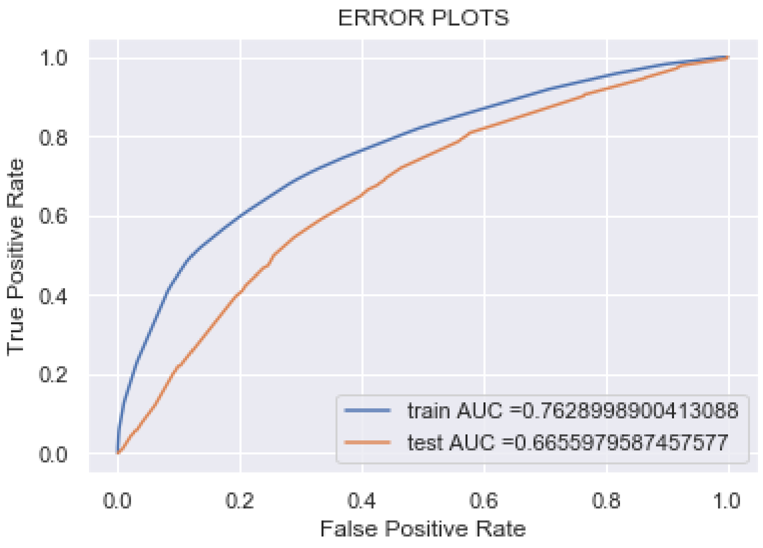
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7628998900413088
0.6658739514606636
```

In [173]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[10], 'min_samples_split':[500] }]
```

In [206]:

```
#*Fitting Model to Hyper-Parameter Curve
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklea
rn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parame
ters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=
500)
clf11.fit(X_set2_train, y_train)
# for visulation
clfV1.fit(X_set2_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
ml#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set2_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set2_test) [:,1]

train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)

plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

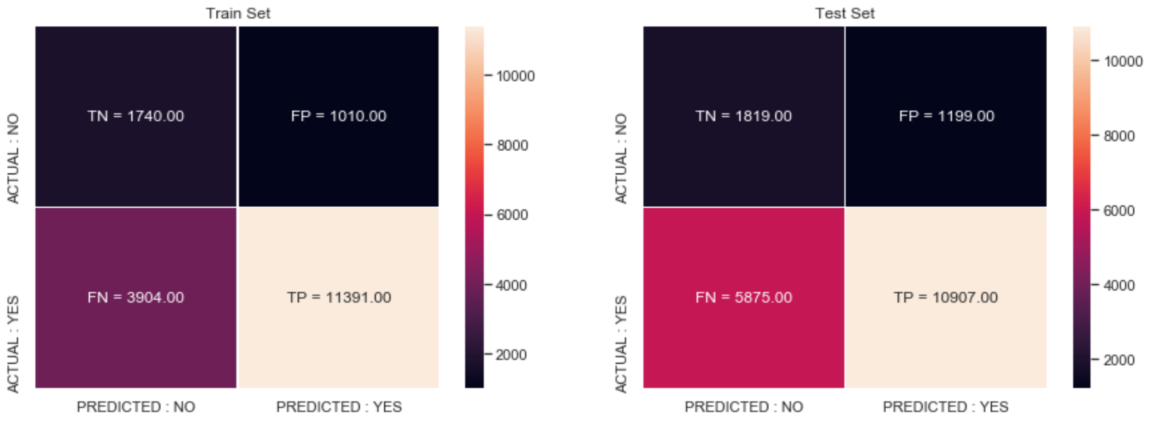


Confusion matrix

In [175]:

```
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fp
r1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1,
test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(k
ey.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(ke
y.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YE
S'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[
0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'
],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.49 for threshold 0.39
the maximum value of tpr*(1-fpr) 0.39 for threshold 0.5
```

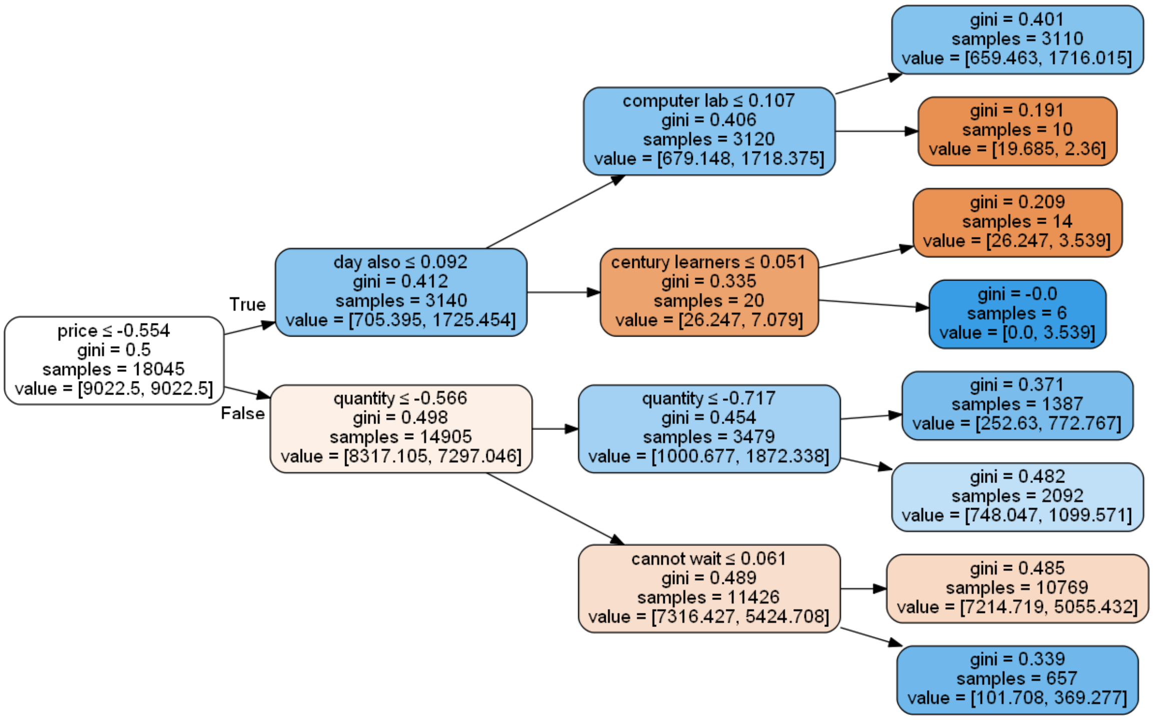


Visualizing Decision Tree

In [176]:

```
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clfV1, out_file=dot_data, filled=True, rounded=True, special_characters
=True, feature_names=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[176]:



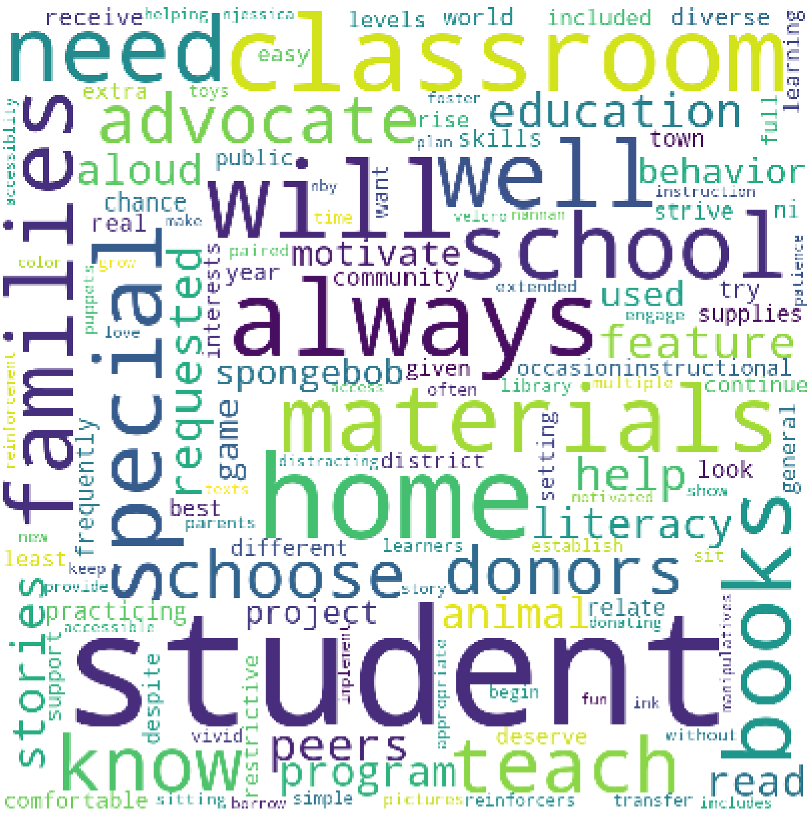
Analysis on the False positives

In [177]:

```
#https://www.google.com/search?q=geeks+for+geeks+false+positive&rlz=1C1SQJL_enIN849IN84
9&oq=geeks+for+geeks+false+positive&aqs=chrome..69i57j33l5.6431j0j7&sourceid=chrome&ie=
UTF-8
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsCho
ose_DT_(1).ipynb
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [178]:

```
# Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords =
stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



DataFrame of False Positives

In [179]:

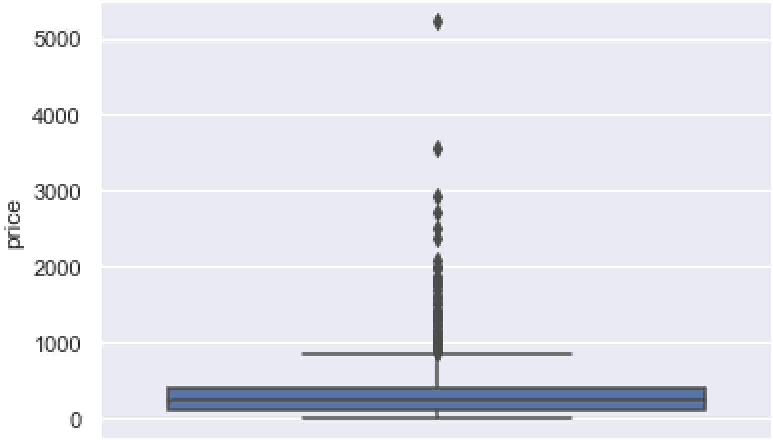
```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
```

In [180]:

```
#Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

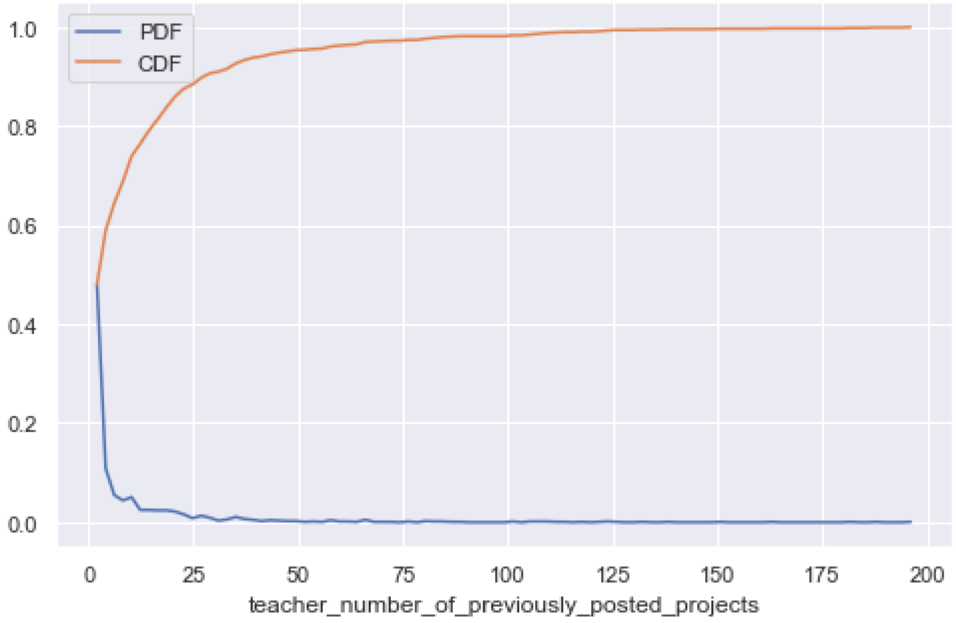
Out[180]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16bc09070b8>
```



In [181]:

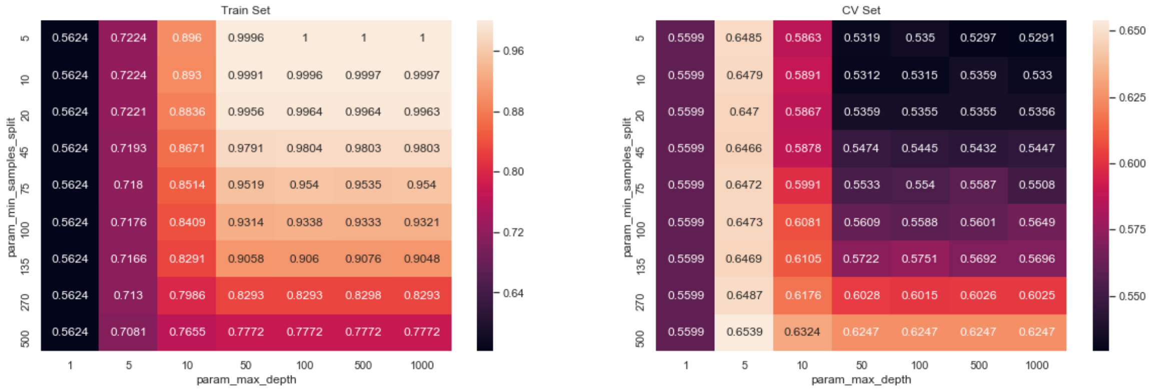
```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_
projects'],bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Applying Decision trees on AVG W2V

In [96]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt3= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 
20, 45, 75, 100, 135, 270, 500]}
clf3 = GridSearchCV(dt3, parameters, cv=3, scoring='roc_auc',n_jobs=4,return_train_scor
e=True)
se3 = clf3.fit(X_set3_train, y_train)

import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf3.cv_results_).groupby(['param_min_samples_split', 'param
_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [97]:

```
#Best Estimator and Best tune parameters
print(clf3.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf3.score(X_set3_train,y_train))
print(clf3.score(X_set3_test,y_test))
```

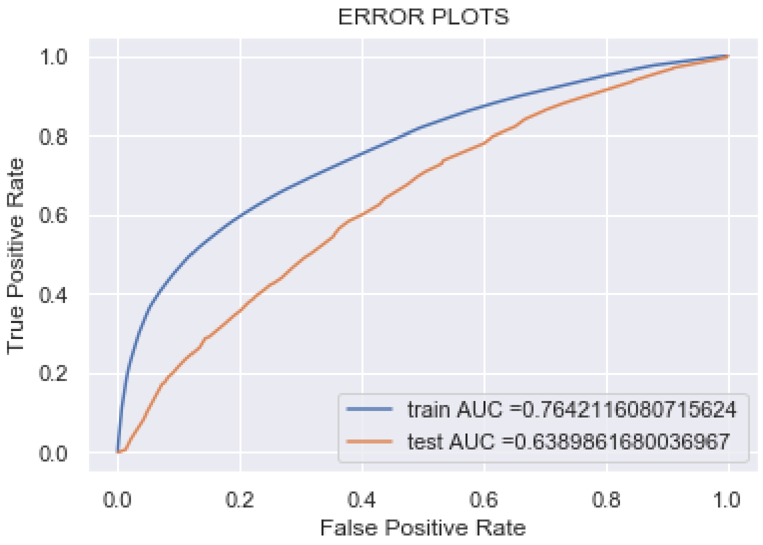
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6965402121905555
0.6437607521359746
```

In [182]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[5], 'min_samples_split':[500] } ]
```

In [207]:

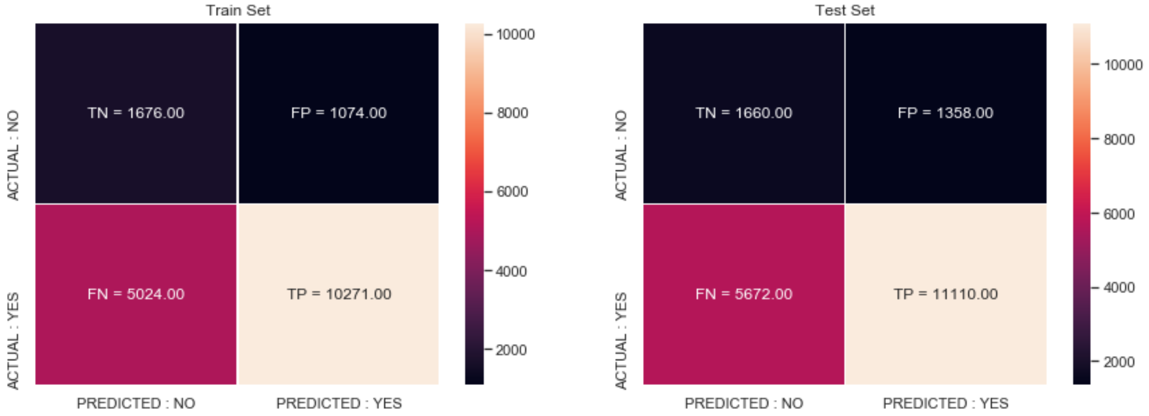
```
#Fitting Model to Hyper-Parameter Curve
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklea
rn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parame
ters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=5,min_samples_split=5
00)
clf11.fit(X_set3_train, y_train)
# for visulation
clfV1.fit(X_set3_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
ml#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set3_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set3_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [184]:

```
#confusion matrix test data
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fp
r1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1,
test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(k
ey.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(ke
y.flatten(),con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YE
S'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'
],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.41 for threshold 0.47
the maximum value of tpr*(1-fpr) 0.37 for threshold 0.47
```



In [185]:

```
##Analysis on the False positives
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

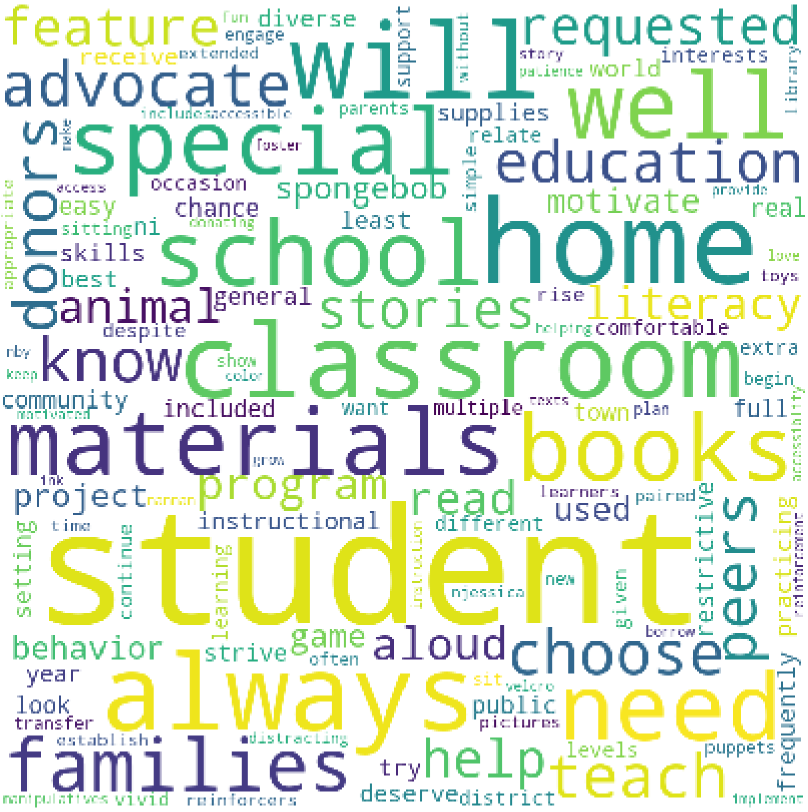
In [186]:

```
pip install wordcloud
```

```
Requirement already satisfied: wordcloud in c:\users\hp\anaconda3\lib\site
-packages (1.5.0)
Requirement already satisfied: numpy>=1.6.1 in c:\users\hp\anaconda3\lib\s
ite-packages (from wordcloud) (1.16.2)
Requirement already satisfied: pillow in c:\users\hp\anaconda3\lib\site-pa
ckages (from wordcloud) (5.4.1)
Note: you may need to restart the kernel to use updated packages.
```

In [187]:

```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '
wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords =
stopwords,min_font_size = 10).generate(comment_words)
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



In [188]:

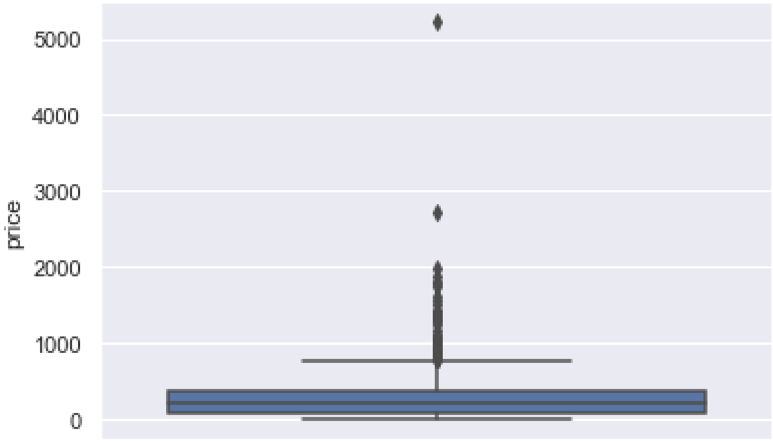
```
#DataFrame of False Positives
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
```

In [189]:

```
#Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

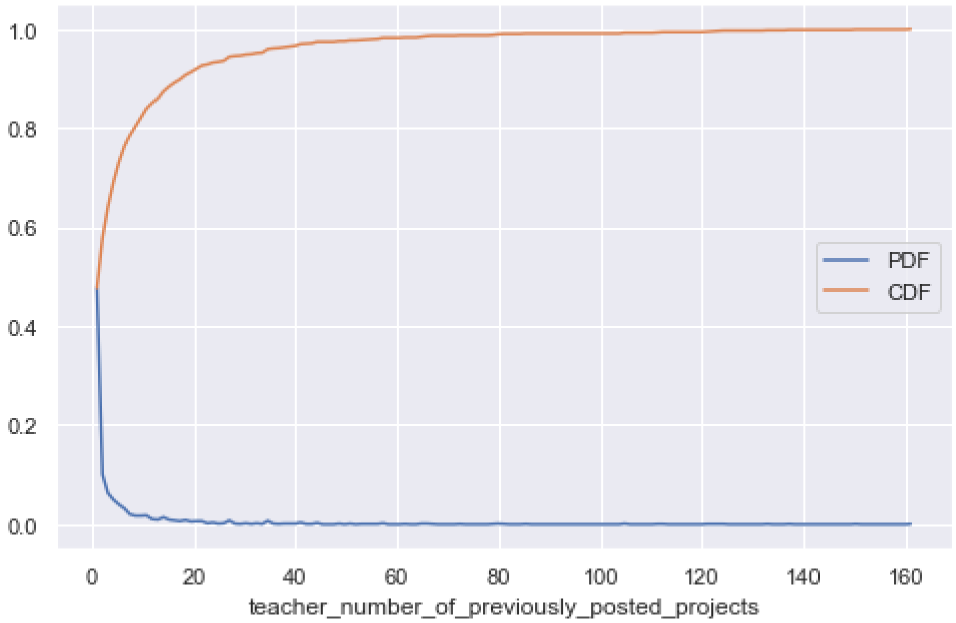
Out[189]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16bb87b9240>
```



In [190]:

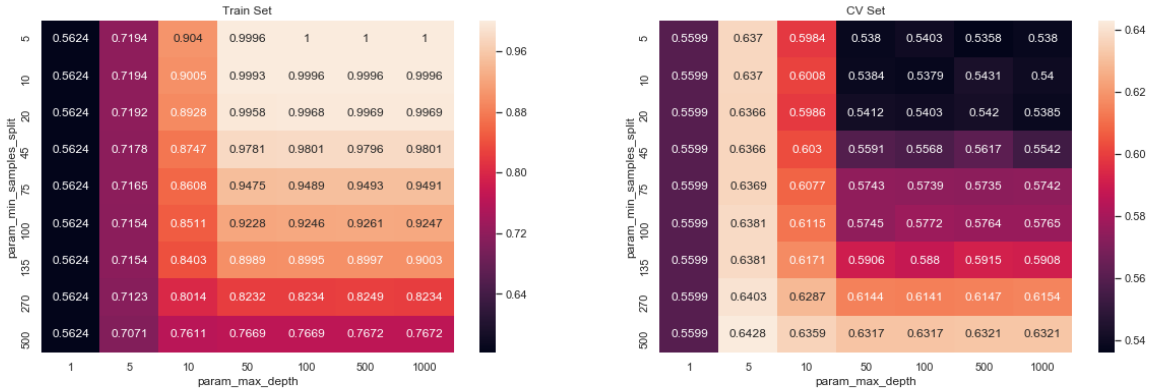
```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_
projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Applying Decision trees on td_idf W2V

In [107]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt4= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10,
20, 45, 75, 100, 135, 270, 500]}
clf4 = GridSearchCV(dt4, parameters, cv=3, scoring='roc_auc',return_train_score=True)
set4= clf4.fit(X_set4_train, y_train)

import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf4.cv_results_).groupby(['param_min_samples_split', 'param
_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [108]:

```
#Best Estimator and Best tune parameters
print(clf4.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf4.score(X_set4_train,y_train))
print(clf4.score(X_set4_test,y_test))
```

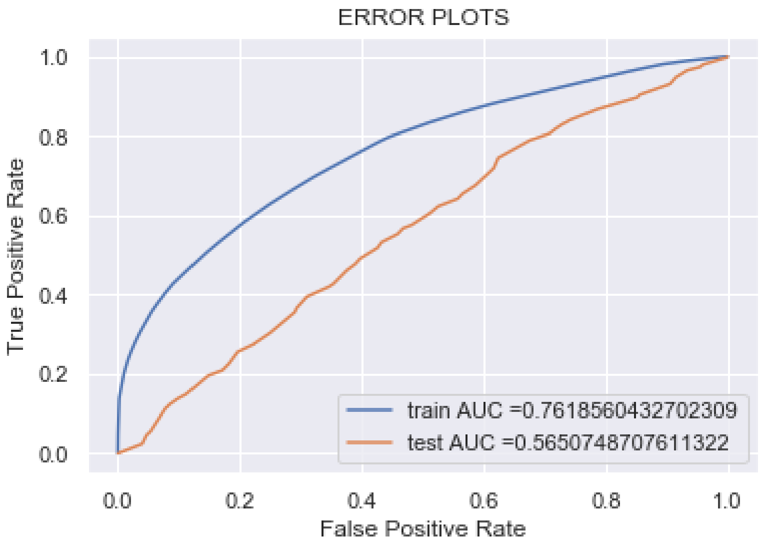
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6969748759249904
0.6138512151971972
```

In [191]:

```
best_tune_parameters= [{'max_depth': [5], 'min_samples_split':[500] }]
```

In [208]:

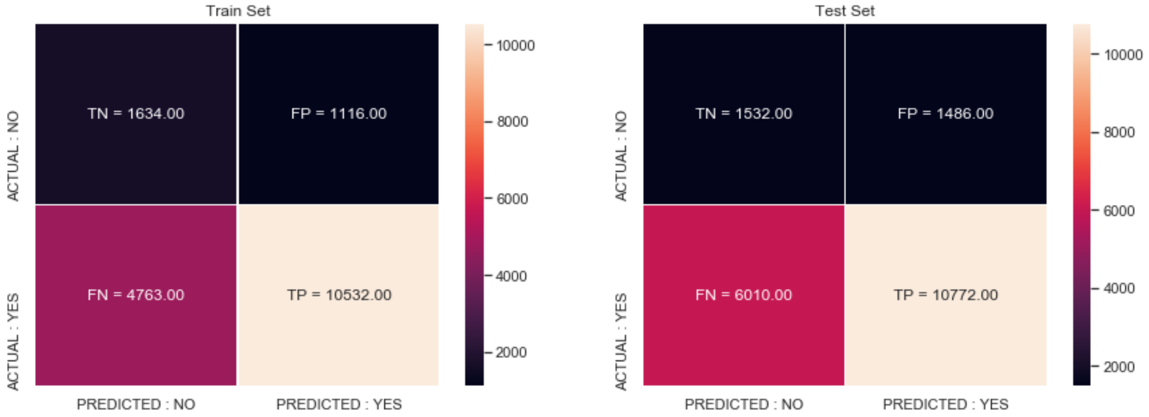
```
#Fitting Model to Hyper-Parameter Curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=5,min_samples_split=500)
clf11.fit(X_set4_train, y_train)
# for visulation
clfV1.fit(X_set4_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set4_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set4_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [193]:

```
#CONFUSION MATRIX
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fp
r1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1,
test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(k
ey.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(ke
y.flatten(),con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YE
S'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[
0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'
],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.42 for threshold 0.45
the maximum value of tpr*(1-fpr) 0.33 for threshold 0.5
```

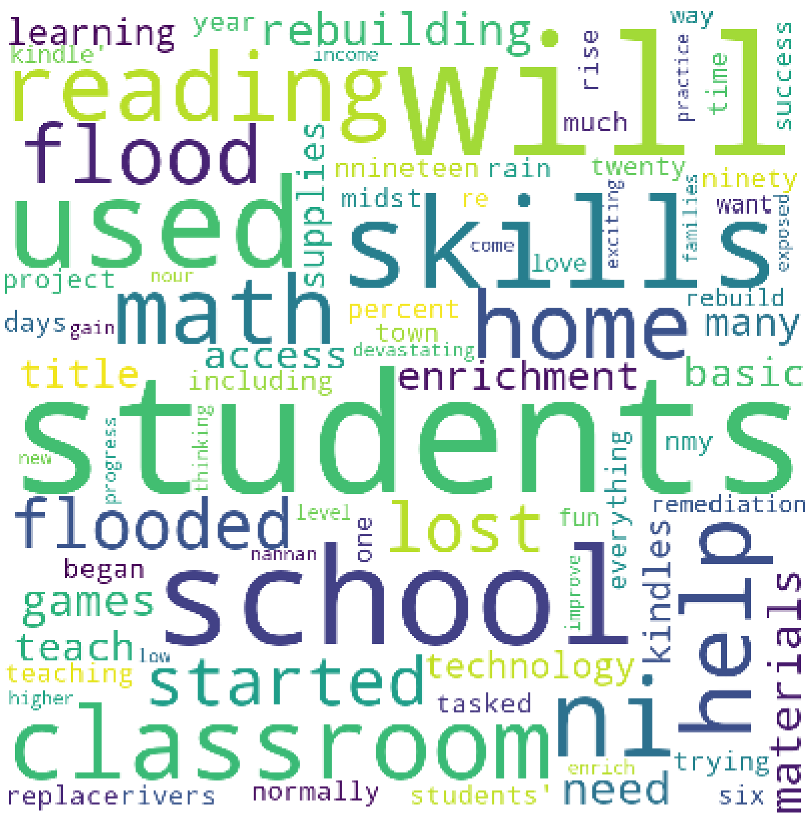


In [194]:

```
#Analysis on the False positives
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
   fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [195]:

```
#WORD CLOUD OF ESSAY
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = 
stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

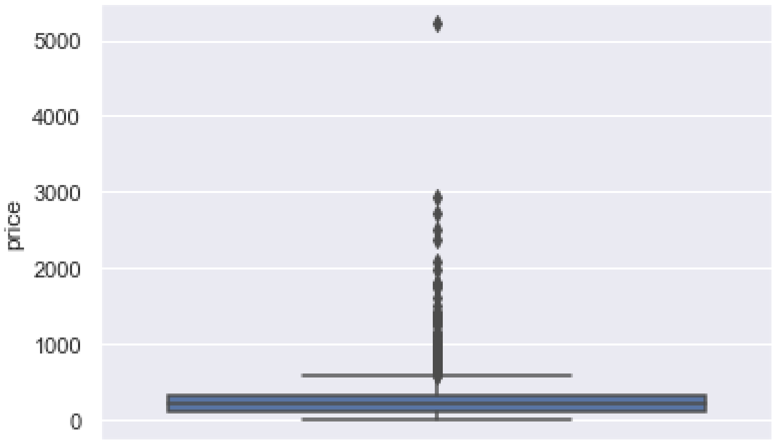


In [196]:

```
#Box Plot (FP 'price')
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
sns.boxplot(y='price', data=X_test_falsePos1)
```

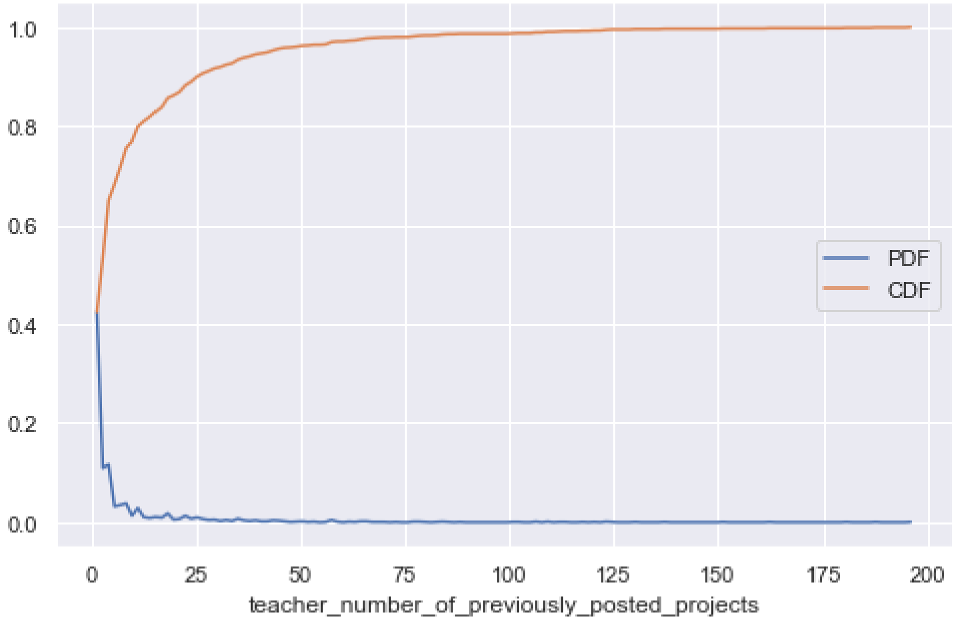
Out[196]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16d281599b0>
```



In [197]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Select 5k best features from features of Set 2 using feature_importances,discard all the other remaining features and then apply any of the model of your 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

In [130]:

```
#https://stackoverflow.com/questions/47111434/randomforestregressor-and-feature-importances-error
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV
def selectKImportance(model, X, k=5):
    return X[:,model.best_estimator_.feature_importances_.argsort()[::-1][:k]]
```

In [146]:

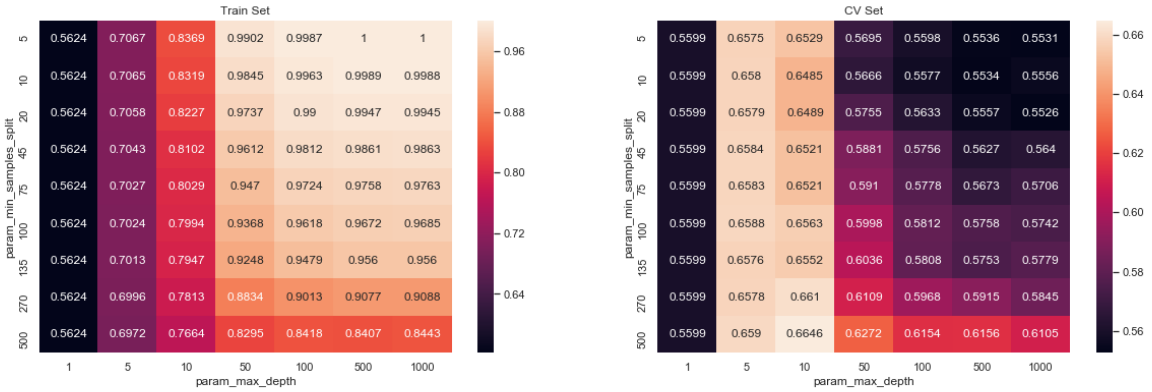
```
# for tf-idf set 2
X_set5_train = selectKImportance(clf2, xtr,5000)
X_set5_test = selectKImportance(clf2, X_set2_test, 5000)

print(X_set5_train.shape)
print(X_set5_test.shape)
```

```
(18045, 5000)
(19800, 5000)
```

Decision tree on Important features

In [147]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt5= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10,
20, 45, 75, 100, 135, 270, 500]}
clf5 = GridSearchCV(dt5, parameters, cv=3, scoring='roc_auc',return_train_score=True)
set5= clf5.fit(X_set5_train, y_train)


import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf5.cv_results_).groupby(['param_min_samples_split', 'param
_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [148]:

```
#Best Estimator and Best tune parameters
print(clf5.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf5.score(X_set5_train,y_train))
print(clf5.score(X_set5_test,y_test))
```

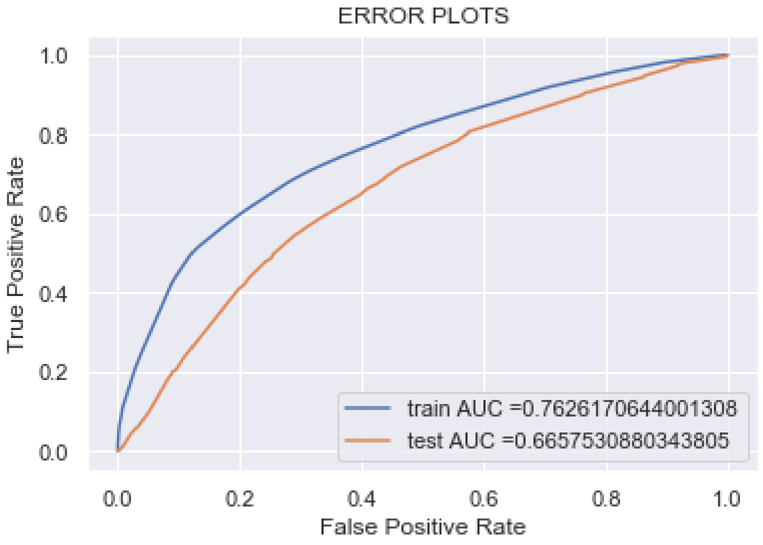
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_dept
h=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7628998900413088
0.6659494725920092
```

In [198]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth': [10], 'min_samples_split':[500] } ]
```

In [209]:

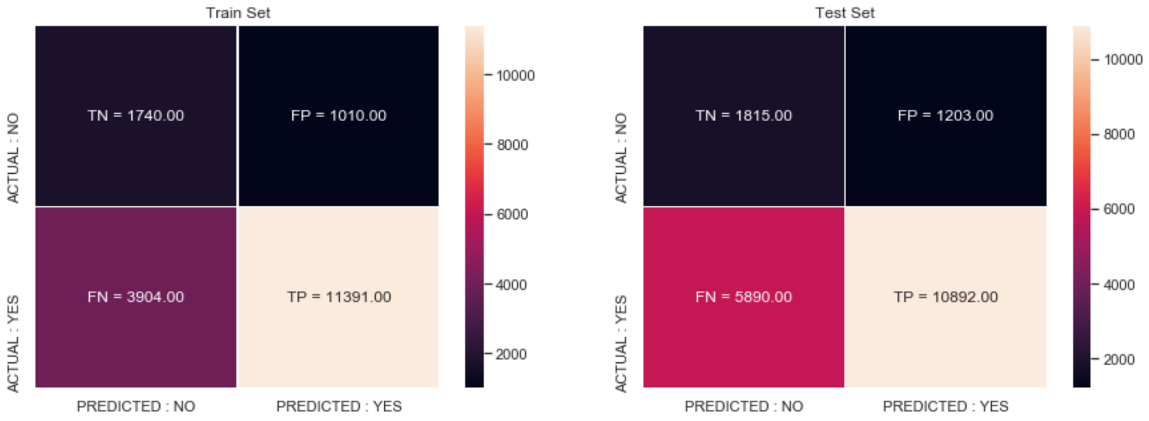
```
# train with best hyperparameter
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklea
rn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parame
ters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=
500)
clf11.fit(X_set5_train, y_train)
# for visulation
clfV1.fit(X_set5_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
ml#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set5_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set5_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [200]:

```
#CONFUSION MATRIX
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.49 for threshold 0.39
the maximum value of tpr*(1-fpr) 0.39 for threshold 0.5
```

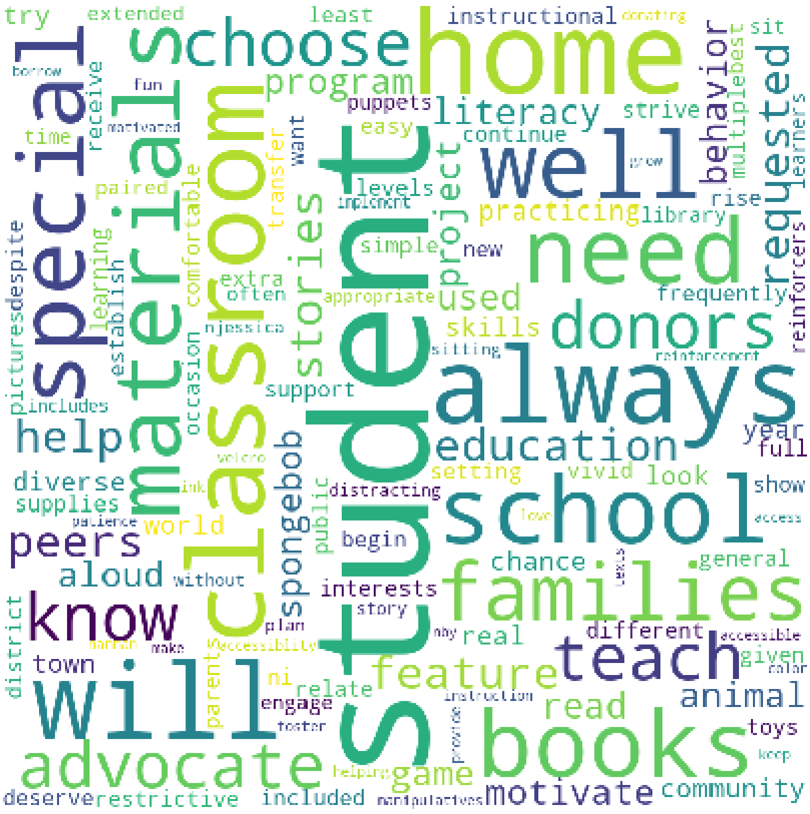


In [201]:

```
#Analysis on the False positives

fpi = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions1[i] == 1) :
      fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [202]:

```
# Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords =
stopwords,min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

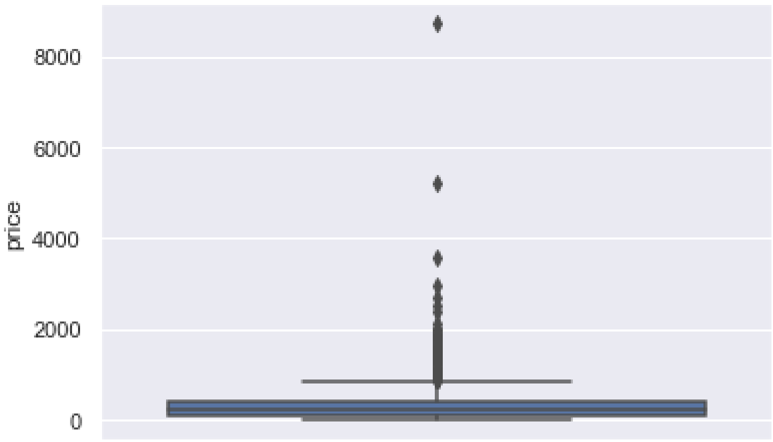


In [203]:

```
#Box Plot (FP 'price')
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
sns.boxplot(y='price', data=X_test_falsePos1)
```

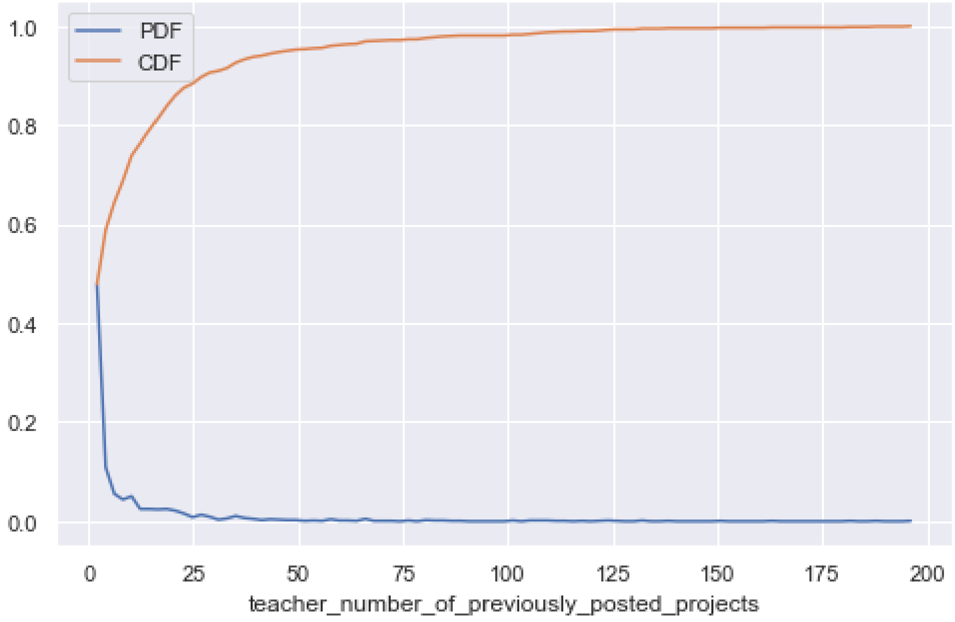
Out[203]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16bc088ad68>
```



In [204]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_
projects'],bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Conclusions

In [210]:

```
# Please compare all your models using Prettytable library
#how to use pretty table http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= (" Vectorizer ", " Max_depth ", " Min_sample_split "," Test -AUC ")
tb.add_row([" BOW ", 10, 500, 67])
tb.add_row([" Tf - Idf", 10 , 500 ,66.5 ])
tb.add_row([" AVG-W2V", 5, 500,63.8 ])
tb.add_row(["A VG - Tf - Idf", 5 , 500 ,56.5])
tb.add_row(["Top 5000 Features", 10, 500 ,66.5 ])
print(tb.get_string(titles = "Decision trees- Observations"))
```

```
+-------------------+-------------+--------------------+-------------+
|     Vectorizer    |  Max_depth  |  Min_sample_split  |  Test -AUC  |
+-------------------+-------------+--------------------+-------------+
|        BOW        |      10     |        500         |      67     |
|      Tf - Idf     |      10     |        500         |     66.5    |
|       AVG-W2V     |      5      |        500         |     63.8    |
|  A VG - Tf - Idf  |      5      |        500         |     56.5    |
| Top 5000 Features |      10     |        500         |     66.5    |
+-------------------+-------------+--------------------+-------------+
```