Assignment 8 - Decision Tree on Donors choose dataset

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

Problem Objective - The objective is to predict whether project proposal submitted by a teacher or not, by applying KNN algorithm and deciding the best Feature generation technique for given problem.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`

Feature	Description
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

* See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

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
```

```
paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip install paramiko` to suppress
```

1.1) Reading the data

In [2]:

```
train_data= pd.read_csv('C:/Users/User/Downloads/train_data.csv', nrows = 50000)
resource_data = pd.read_csv('C:/Users/User/Downloads/resources.csv')
```

In [3]:

```
print('Number of data points in the train data', train_data.shape)
print('-'*127)
print('The attributes of the data points in the train data :', train_data.columns.values)
train_data.head(2)
```

```
Number of data points in the train data (50000, 17)
---------------------------------------------------------------------------------------------------------------
------------------------
The attributes of the data points in the train 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']
```

Out[3]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [4]:

```
# 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(train_data.columns)]

#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
train_data['Date'] = pd.to_datetime(train_data['project_submitted_datetime'])
train_data.drop('project_submitted_datetime', axis=1, inplace=True)
train_data.sort_values(by=['Date'], inplace=True)

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

#train_data.head(2)
```

In [5]:

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

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

Out[5]:

	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

1.2) Preprocessing project_subject_categories

In [6]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
pro_sub_cat_list = []
for i in pro_sub_catogories:
    train = ""
    # 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", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "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 placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        train+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        train = train.replace('&','_') # we are replacing the & value into
    pro_sub_cat_list.append(train.strip())
```

In [7]:

```
train_data['clean_categories'] = pro_sub_cat_list
train_data.drop(['project_subject_categories'], axis=1, inplace=True)
```

In [8]:

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

In [9]:

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

1.3) Preprocessing project_subject_subcategories

In [10]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python

pro_sub_subcat_list = []
for i in pro_sub_subcatogories:
    train = ""
    # 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", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "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 placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        train +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        train = train.replace('&','_')
    pro_sub_subcat_list.append(train.strip())
```

In [11]:

```
train_data['clean_subcategories'] = pro_sub_subcat_list
train_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
```

In [12]:

```
from collections import Counter
my_counter = Counter()
for word in train_data['clean_subcategories'].values:
    my_counter.update(word.split())
```

In [13]:

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

1.4) Text Preprocessing the titles

In [14]:

```
# https://gist.github.com/sebleier/554280
# 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', 'e
ach', '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', "d
esn'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"]
```

In [15]:

```
# 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 [16]:

```
clean_titles = []

for titles in tqdm(train_data["project_title"]):
    title = decontracted(titles)
    title = title.replace('\\r', ' ')
    title = title.replace('\\"', ' ')
    title = title.replace('\\n', ' ')
    title = re.sub('[^A-Za-z0-9]+', ' ', title)
    title = ' '.join(f for f in title.split() if f not in stopwords)
    clean_titles.append(title.lower().strip())
```

```
100%|██████████████████████████████████| 50000/50000 [00:05<00:00, 8822.51it/s]
```

In [17]:

```
train_data["clean_titles"] = clean_titles
```

In [18]:

```
train_data.drop(['project_title'], axis=1, inplace=True)
```

Number of words in titles

Number of words in titles

In [19]:

```
title_word_count = []
```

In [20]:

```
for a in train_data["clean_titles"] :
    b = len(a.split())
    title_word_count.append(b)
```

In [21]:

```
train_data["title_word_count"] = title_word_count
```

In [22]:

```
train_data.head(2)
```

Out[22]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_e
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	I recently articl giving s
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	My s crave ch f ob

1.5) Combine 4 project essay

In [23]:

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

1.6) Text preprocessing the essay

In [24]:

```
clean_essay = []

for ess in tqdm(train_data["essay"]):
    ess = decontracted(ess)
    ess = ess.replace('\\r', ' ')
    ess = ess.replace('\\"', ' ')
    ess = ess.replace('\\n', ' ')
    ess = re.sub('[^A-Za-z0-9]+', ' ', ess)
    ess = ' '.join(f for f in ess.split() if f not in stopwords)
    clean_essay.append(ess.lower().strip())
```

```
100%|██████████████████████████████████| 50000/50000 [01:50<00:00, 451.08it/s]
```

In [25]:

```
train_data["clean_essays"] = clean_essay
```

In [26]:

```
train_data.drop(['essay'], axis=1, inplace=True)
```

Number of words in Essay

In [27]:

```
essay_word_count = []
```

In [28]:

```
for ess in train_data["clean_essays"] :
    c = len(ess.split())
    essay_word_count.append(c)
```

In [29]:

```
train_data["essay_word_count"] = essay_word_count
```

In [30]:

```
train_data.head(2)
```

Out[30]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_e
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	I recently artic giving s
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	My s crave ch ob

1.7) Calculate sentiment score in essay

In [31]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
analyser = SentimentIntensityAnalyzer()
```

In [32]:

```
neg = []
pos = []
neu = []
compound = []

for a in tqdm(train_data["clean_essays"]) :
    b = analyser.polarity_scores(a)['neg']
    c = analyser.polarity_scores(a)['pos']
    d = analyser.polarity_scores(a)['neu']
    e = analyser.polarity_scores(a)['compound']
    neg.append(b)
    pos.append(c)
    neu.append(d)
    compound.append(e)
```

```
100%|██████████████████████████████████| 50000/50000 [20:59<00:00, 39.69it/s]
```

In [33]:

```
train_data["pos"] = pos
```

In [34]:

```
train_data["neg"] = neg
```

In [35]:

```
train_data["neu"] = neu
```

In [36]:

```
train_data["compound"] = compound
```

In [37]:

```
train_data.head(2)
```

Out[37]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_e
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	I recently artic giving s
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	My s crave ch ob

2 rows × 24 columns

In [38]:

```
train_data.project_grade_category = train_data.project_grade_category.str.replace('\s','_')
train_data['project_grade_category'].value_counts()
train_data.project_grade_category = train_data.project_grade_category.str.replace('-','_')
train_data['project_grade_category'].value_counts()
```

Out[38]:

```
Grades_PreK_2    20316
Grades_3_5       16968
Grades_6_8        7750
Grades_9_12       4966
Name: project_grade_category, dtype: int64
```

In [39]:

```
train_data.teacher_prefix = train_data.teacher_prefix.str.replace('.',' ')
train_data['teacher_prefix'].value_counts()
```

Out[39]:

```
Mrs        26140
Ms         17936
Mr          4859
Teacher     1061
Dr             2
Name: teacher_prefix, dtype: int64
```

In [40]:

```
train_data.teacher_prefix = train_data.teacher_prefix.str.replace('NaN','0')
```

1.8) Train-Test split

In [41]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(train_data, train_data['project_is_approved'],\
                    test_size=0.33, stratify =train_data['project_is_approved'])
#X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33,
stratify=y_train)
```

In [42]:

```
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)
```

1.9) Preparing data for model

In [43]:

```
train_data.columns
```

Out[43]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'clean_titles',
       'title_word_count', 'clean_essays', 'essay_word_count', 'pos', 'neg',
       'neu', 'compound'],
      dtype='object')
```

Vectorizing the categorial features

1.9.1) One hot encode - Clean categories of project_subject_category

In [44]:

```
# we use count vectorizer to convert the values into one

from sklearn.feature_extraction.text import CountVectorizer

vectorizer_proj = CountVectorizer(vocabulary=list(sorted_pro_sub_cat_dict.keys()), lowercase=False
, binary=True)
vectorizer_proj.fit(X_train['clean_categories'].values)

categories_one_hot_train = vectorizer_proj.transform(X_train['clean_categories'].values)
categories_one_hot_test = vectorizer_proj.transform(X_test['clean_categories'].values)
#categories_one_hot_cv = vectorizer_proj.transform(X_cv['clean_categories'].values)

print(vectorizer_proj.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",categories_one_hot_test.shape)
#print("Shape of matrix of CV data after one hot encoding ",categories_one_hot_cv.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix of Train data after one hot encoding  (33500, 9)
Shape of matrix of Test data after one hot encoding  (16500, 9)
```

1.9.2) One hot encode - Clean categories of project_sub_subcategories

In [45]:

```
# we use count vectorizer to convert the values into one

vectorizer_sub_proj = CountVectorizer(vocabulary=list(sorted_pro_sub_subcat_dict.keys()),
lowercase=False, binary=True)
vectorizer_sub_proj.fit(X_train['clean_subcategories'].values)

sub_categories_one_hot_train = vectorizer_sub_proj.transform(X_train['clean_subcategories'].values
)
sub_categories_one_hot_test = vectorizer_sub_proj.transform(X_test['clean_subcategories'].values)
#sub_categories_one_hot_cv = vectorizer_sub_proj.transform(X_cv['clean_subcategories'].values)

print(vectorizer_sub_proj.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_hot_test.shape)
#print("Shape of matrix of Cross Validation data after one hot encoding
",sub_categories_one_hot_cv.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix of Train data after one hot encoding  (33500, 30)
Shape of matrix of Test data after one hot encoding  (16500, 30)
```

1.9.3) One hot encode - School states

In [46]:

```
my_counter = Counter()
for state in train_data['school_state'].values:
    my_counter.update(state.split())
```

In [47]:

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

In [48]:

```
## we use count vectorizer to convert the values into one hot encoded features
vectorizer_state = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lowercase
=False, binary=True)
vectorizer_state.fit(X_train['school_state'].values)

school_state_categories_one_hot_train = vectorizer_state.transform(X_train['school_state'].values)
school_state_categories_one_hot_test = vectorizer_state.transform(X_test['school_state'].values)
#school_state_categories_one_hot_cv = vectorizer_state.transform(X_cv['school_state'].values)

print(vectorizer_state.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",school_state_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",school_state_categories_one_hot_test.
shape)
#print("Shape of matrix of Cross Validation data after one hot encoding
",school_state_categories_one_hot_cv.shape)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'SD', 'NE', 'AK', 'DE', 'WV', 'ME', 'NM', 'HI', 'DC', 'KS', 'I
D', 'IA', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'NV', 'MD', 'TN', 'CT', 'AL', 'UT', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'MA', 'LA', 'WA', 'MO', 'IN', 'OH', 'PA', 'MI', 'GA', 'SC', 'IL', 'NC', 'FL', 'TX', 'NY
', 'CA']
```

```
Shape of matrix of Train data after one hot encoding  (33500, 51)
Shape of matrix of Test data after one hot encoding  (16500, 51)
```

1.9.4) One hot encode - Teacher_prefix

In [49]:

```
my_counter = Counter()
for teacher_prefix in train_data['teacher_prefix'].values:
    teacher_prefix = str(teacher_prefix)
    my_counter.update(teacher_prefix.split())
```

In [50]:

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

In [51]:

```
## we use count vectorizer to convert the values into one hot encoded features
## Unlike the previous Categories this category returns a
## ValueError: np.nan is an invalid document, expected byte or unicode string.
## The link below explains h0w to tackle such discrepancies.
## https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-valueerror-np-nan-is-an-invalid-document/39308809#39308809
vectorizer_teacher = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lowercase=False, binary=True)
vectorizer_teacher.fit(X_train['teacher_prefix'].values.astype("U"))

teacher_prefix_categories_one_hot_train = vectorizer_teacher.transform(X_train['teacher_prefix'].values.astype("U"))
teacher_prefix_categories_one_hot_test =
vectorizer_teacher.transform(X_test['teacher_prefix'].values.astype("U"))
#teacher_prefix_categories_one_hot_cv =
vectorizer_teacher.transform(X_cv['teacher_prefix'].values.astype("U"))

print(vectorizer_teacher.get_feature_names())

print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_train.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_test.shape)
#print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_cv.shape)
```

```
['nan', 'Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
Shape of matrix after one hot encoding  (33500, 6)
Shape of matrix after one hot encoding  (16500, 6)
```

1.9.5) One hot encode - project_grade_category

In [52]:

```
my_counter = Counter()
for project_grade in train_data['project_grade_category'].values:
    my_counter.update(project_grade.split())
```

In [53]:

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

In [54]:

```
## we use count vectorizer to convert the values into one hot encoded features
vectorizer_grade = CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys()),
lowercase=False, binary=True)
vectorizer_grade.fit(X_train['project_grade_category'].values)
```

```
project_grade_categories_one_hot_train =
vectorizer_grade.transform(X_train['project_grade_category'].values)
project_grade_categories_one_hot_test = vectorizer_grade.transform(X_test['project_grade_category'
].values)
#project_grade_categories_one_hot_cv =
vectorizer_grade.transform(X_cv['project_grade_category'].values)

print(vectorizer_grade.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",project_grade_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",project_grade_categories_one_hot_test
.shape)
#print("Shape of matrix of Cross Validation data after one hot encoding
",project_grade_categories_one_hot_cv.shape)
```

```
['Grades_9_12', 'Grades_6_8', 'Grades_3_5', 'Grades_PreK_2']
Shape of matrix of Train data after one hot encoding  (33500, 4)
Shape of matrix of Test data after one hot encoding  (16500, 4)
```

Vectorizing the text data

I) Bag of words - with min_df=10

Bag of words - Train Data - Essays

In [55]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).

vectorizer_bow_essay = CountVectorizer(min_df=10)
vectorizer_bow_essay.fit(X_train["clean_essays"])
text_bow_train = vectorizer_bow_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (33500, 10432)
```

Bag of words - Test Data - Essays

In [56]:

```
text_bow_test = vectorizer_bow_essay.transform(X_test["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 10432)
```

Bag of words - CV Data - Essays

In [57]:

```
#text_bow_cv = vectorizer_bow_essay.transform(X_cv["clean_essays"])
#print("Shape of matrix after one hot encoding ",text_bow_cv.shape)
```

Bag of words - Train Data - Title

In [58]:

```
vectorizer_bow_title = CountVectorizer(min_df=10)

vectorizer_bow_title.fit(X_train["clean_titles"])

title_bow_train = vectorizer_bow_title.transform(X_train["clean_titles"])
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (33500, 1641)
```

Bag of words - Test Data - Title

In [59]:

```
title_bow_test = vectorizer_bow_title.transform(X_test["clean_titles"])
print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1641)
```

Bag of words - CV Data - Title

In [60]:

```
#title_bow_cv = vectorizer_bow_title.transform(X_cv["clean_titles"])
#print("Shape of matrix after one hot encoding ",title_bow_cv.shape)
```

II) TFIDF vectorizer with min_df=10

TFIDF - Train Data - Essays

In [61]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
vectorizer_tfidf_essay.fit(X_train["clean_essays"])

text_tfidf_train = vectorizer_tfidf_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (33500, 10432)
```

TFIDF - Test Data - Essays

In [62]:

```
text_tfidf_test = vectorizer_tfidf_essay.transform(X_test["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 10432)
```

TFIDF - Train Data - Titles

In [63]:

```
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

vectorizer_tfidf_titles.fit(X_train["clean_titles"])
title_tfidf_train = vectorizer_tfidf_titles.transform(X_train["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (33500, 1641)
```

TFIDF - Test Data - Titles

In [64]:

```
title_tfidf_test = vectorizer_tfidf_titles.transform(X_test["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1641)
```

III) Using pretrained model - Avg W2V

In [65]:

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

Train - Essays

In [66]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_train = [];

for sentence in tqdm(X_train["clean_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_vectors_train.append(vector)

print(len(avg_w2v_vectors_train))
print(len(avg_w2v_vectors_train[0]))
```

```
100%|████████████████████████████████████| 33500/33500 [00:28<00:00, 1164.46it/s]

33500
300
```

Test - Essays

In [67]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_test = [];

for sentence in tqdm(X_test["clean_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_vectors_test.append(vector)

print(len(avg_w2v_vectors_test))
print(len(avg_w2v_vectors_test[0]))
```

```
100%|████████████████████████████████████| 16500/16500 [00:16<00:00, 1030.03it/s]
```

100%|██████████| 16500/16500 [00:16<00:00, 1030.05it/s]

```
16500
300
```

Train - Titles

In [68]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_titles"]): # for each title
    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_vectors_titles_train.append(vector)

print(len(avg_w2v_vectors_titles_train))
print(len(avg_w2v_vectors_titles_train[0]))
```

100%|██████████| 33500/33500 [00:01<00:00, 24134.07it/s]

```
33500
300
```

Test - Titles

In [69]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_titles"]): # for each title
    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_vectors_titles_test.append(vector)

print(len(avg_w2v_vectors_titles_test))
print(len(avg_w2v_vectors_titles_test[0]))
```

100%|██████████| 16500/16500 [00:00<00:00, 26147.48it/s]

```
16500
300
```

IV) Using pretrained model - TFIDF weighted W2V

Train - Essays

In [70]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train["clean_essays"])
```

```
tfidf_model.fit(X_train['clean_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 = set(tfidf_model.get_feature_names())
```

In [71]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_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):
            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())) # getting the tf
idf 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_vectors_train.append(vector)

print(len(tfidf_w2v_vectors_train))
print(len(tfidf_w2v_vectors_train[0]))
```

```
100%|██████████████████████████████████| 33500/33500 [02:09<00:00, 259.56it/s]
```

```
33500
300
```

Test - Essays

In [72]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_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):
            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())) # getting the tf
idf 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_vectors_test.append(vector)

print(len(tfidf_w2v_vectors_test))
print(len(tfidf_w2v_vectors_test[0]))
```

```
100%|██████████████████████████████████| 16500/16500 [01:04<00:00, 254.95it/s]
```

```
16500
300
```

Train - Titles

In [73]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train["clean_titles"])
# 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 [74]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_train = [];

for sentence in tqdm(X_train["clean_titles"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_vectors_titles_train.append(vector)

print(len(tfidf_w2v_vectors_titles_train))
print(len(tfidf_w2v_vectors_titles_train[0]))
```

```
100%|██████████████████████████████████| 33500/33500 [00:01<00:00, 18936.17it/s]
```

```
33500
300
```

Test - Titles

In [75]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_test = [];

for sentence in tqdm(X_test["clean_titles"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_vectors_titles_test.append(vector)

print(len(tfidf_w2v_vectors_titles_test))
print(len(tfidf_w2v_vectors_titles_test[0]))
```

```
100%|██████████████████████████████████| 16500/16500 [00:00<00:00, 18986.25it/s]
```

```
16500
300
```

1.8) Vectorizing numerical features

1.6) Vectorizing numerical features

In [76]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[76]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [77]:

```
# join two dataframes in python:
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
#X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

1) Price

In [78]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()

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

normalizer.fit(X_train['price'].values.reshape(-1,1))

price_train = normalizer.transform(X_train['price'].values.reshape(-1,1))
#price_cv = normalizer.transform(X_cv['price'].values.reshape(-1,1))
price_test = normalizer.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(price_train.shape, y_train.shape)
#print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
print("="*100)
```

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

2) Quantity

In [79]:

```
normalizer = Normalizer()

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

normalizer.fit(X_train['quantity'].values.reshape(-1,1))
```

```
normalizer.fit(X_train['quantity'].values.reshape(-1,1))

quantity_train = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
#quantity_cv = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
quantity_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(quantity_train.shape, y_train.shape)
#print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
print("="*100)
```

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

3) Project proposal previously by Teacher

In [80]:

```
normalizer = Normalizer()

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

normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_posted_projects']
.values.reshape(-1,1))
#prev_projects_cv =
normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].v
alues.reshape(-1,1))

print("After vectorizations")
print(prev_projects_train.shape, y_train.shape)
#print(prev_projects_cv.shape, y_cv.shape)
print(prev_projects_test.shape, y_test.shape)
print("="*100)
```

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

4) Number of word in title

In [81]:

```
normalizer = Normalizer()

normalizer.fit(X_train['title_word_count'].values.reshape(-1,1))

title_word_count_train = normalizer.transform(X_train['title_word_count'].values.reshape(-1,1))
#title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape(-1,1))

print("After vectorizations")
print(title_word_count_train.shape, y_train.shape)
#print(title_word_count_cv.shape, y_cv.shape)
print(title_word_count_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
```

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

5) Number of word in essay

In [82]:

```
normalizer = Normalizer()

normalizer.fit(X_train['essay_word_count'].values.reshape(-1,1))

essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.reshape(-1,1))
#essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape(-1,1))

print("After vectorizations")
print(essay_word_count_train.shape, y_train.shape)
#print(essay_word_count_cv.shape, y_cv.shape)
print(essay_word_count_test.shape, y_test.shape)
print("="*100)
```

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

6) Essay sentiment - pos

In [83]:

```
normalizer = Normalizer()

normalizer.fit(X_train['pos'].values.reshape(-1,1))

essay_sent_pos_train = normalizer.transform(X_train['pos'].values.reshape(-1,1))
#essay_sent_pos_cv = normalizer.transform(X_cv['pos'].values.reshape(-1,1))
essay_sent_pos_test = normalizer.transform(X_test['pos'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_pos_train.shape, y_train.shape)
#print(essay_sent_pos_cv.shape, y_cv.shape)
print(essay_sent_pos_test.shape, y_test.shape)
print("="*100)
```

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

7) Essay sentiment - neg

In [84]:

```
normalizer = Normalizer()

normalizer.fit(X_train['neg'].values.reshape(-1,1))

essay_sent_neg_train = normalizer.transform(X_train['neg'].values.reshape(-1,1))
#essay_sent_neg_cv = normalizer.transform(X_cv['neg'].values.reshape(-1,1))
essay_sent_neg_test = normalizer.transform(X_test['neg'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_neg_train.shape, y_train.shape)
#print(essay_sent_neg_cv.shape, y_cv.shape)
```

```
print(essay_sent_neg_test.shape, y_test.shape)
print("="*100)
```

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

8) Essay sentiment - neu

In [85]:

```
normalizer = Normalizer()

normalizer.fit(X_train['neu'].values.reshape(-1,1))

essay_sent_neu_train = normalizer.transform(X_train['neu'].values.reshape(-1,1))
#essay_sent_neu_cv = normalizer.transform(X_cv['neu'].values.reshape(-1,1))
essay_sent_neu_test = normalizer.transform(X_test['neu'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_neu_train.shape, y_train.shape)
#print(essay_sent_neu_cv.shape, y_cv.shape)
print(essay_sent_neu_test.shape, y_test.shape)
print("="*100)
```

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

9) Essay sentiment - compound

In [86]:

```
normalizer = Normalizer()

normalizer.fit(X_train['compound'].values.reshape(-1,1))

essay_sent_compound_train = normalizer.transform(X_train['compound'].values.reshape(-1,1))
#essay_sent_compound_cv = normalizer.transform(X_cv['compound'].values.reshape(-1,1))
essay_sent_compound_test = normalizer.transform(X_test['compound'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_compound_train.shape, y_train.shape)
#print(essay_sent_compound_cv.shape, y_cv.shape)
print(essay_sent_compound_test.shape, y_test.shape)
print("="*100)
```

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

Feature Aggregation:

In [87]:

```
#https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb

#Feature aggregation
f1=vectorizer_proj.get_feature_names()
f2=vectorizer_sub_proj.get_feature_names()
f3=vectorizer_state.get_feature_names()
```

```
f4=vectorizer_teacher.get_feature_names()
f5=vectorizer_grade.get_feature_names()
fb=vectorizer_bow_essay.get_feature_names()
ft=vectorizer_bow_title.get_feature_names()
fb1=vectorizer_tfidf_essay.get_feature_names()
ft1=vectorizer_tfidf_titles.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 [88]:

```
bow_features_names = []

## Obtain Feature names for Project titles

for a in vectorizer_proj.get_feature_names() :
    bow_features_names.append(a)


## Obtain Feature names for Project Sub-titles
for a in vectorizer_sub_proj.get_feature_names() :
    bow_features_names.append(a)

## Obtain Feature names for states
for a in vectorizer_state.get_feature_names() :
    bow_features_names.append(a)

## Obtain Feature names for Project Grade Category
for a in vectorizer_grade.get_feature_names() :
    bow_features_names.append(a)

## Obtain Feature names for Teacher Title
for a in vectorizer_teacher.get_feature_names() :
    bow_features_names.append(a)

bow_features_names.append("price")
bow_features_names.append("quantity")
bow_features_names.append("prev_proposed_projects")
bow_features_names.append("title_word_count")
bow_features_names.append("essay_word_count")
bow_features_names.append("pos")
bow_features_names.append("neg")
bow_features_names.append("neu")
bow_features_names.append("compound")
for a in vectorizer_bow_title.get_feature_names() :
    bow_features_names.append(a)
for a in vectorizer_bow_essay.get_feature_names() :
    bow_features_names.append(a)
len(bow_features_names)
```

Out[88]:

```
12182
```

In [89]:

```
tfidf_features_names = []

## Obtain Feature names for Project titles

for a in vectorizer_proj.get_feature_names() :
    tfidf_features_names.append(a)

## Obtain Feature names for Project Sub-titles
for a in vectorizer_sub_proj.get_feature_names() :
    tfidf_features_names.append(a)
```

```
## Obtain Feature names for states
for a in vectorizer_state.get_feature_names() :
    tfidf_features_names.append(a)

## Obtain Feature names for Project Grade Category
for a in vectorizer_grade.get_feature_names() :
    tfidf_features_names.append(a)

## Obtain Feature names for Teacher Title
for a in vectorizer_teacher.get_feature_names() :
    tfidf_features_names.append(a)

tfidf_features_names.append("price")
tfidf_features_names.append("price")
tfidf_features_names.append("prev_proposed_projects")
tfidf_features_names.append("title_word_count")
tfidf_features_names.append("essay_word_count")
tfidf_features_names.append("pos")
tfidf_features_names.append("neg")
tfidf_features_names.append("neu")
tfidf_features_names.append("compound")

for a in vectorizer_tfidf_titles.get_feature_names() :
    tfidf_features_names.append(a)
for a in vectorizer_tfidf_essay.get_feature_names() :
    tfidf_features_names.append(a)
len(tfidf_features_names)
```

Out[89]:

```
12182
```

Assignment 8: DT

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **Hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**
    - Find the best hyper parameter which will give the maximum AUC value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Graphviz**
    - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
    - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
    - Make sure to print the words in each node of the decision tree instead of printing its index.
    - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.

4. **Representation of results**
    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
    - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points
    - Once after you plot the confusion matrix with the test data, get all the `false positive data points`
        - Plot the WordCloud WordCloud
        - Plot the box plot with the `price` of these `false positive data points`

- Plot the box plot with the `price` of these `false positive data points`
- Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

5. **[Task-2]**

   - 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 you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

6. **Conclusion**

   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

---

Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay (BOW with min_df=10)

In [186]:

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

X_tr1 = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, essay_sent_pos_train, essay_sent_neg_train,
essay_sent_neu_train, essay_sent_compound_train, title_bow_train, text_bow_train)).tocsr()
X_te1 = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, essay_sent_pos_test, essay_sent_neg_test, essay_sent_
neu_test, essay_sent_compound_test, title_bow_test, text_bow_test)).tocsr()
#X_cv = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv,
title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv,
essay_sent_compound_cv, title_bow_cv, text_bow_cv)).tocsr()


print("Final Data matrix")
print(X_tr1.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
print(X_te1.shape, y_test.shape)
print("="*100)
```

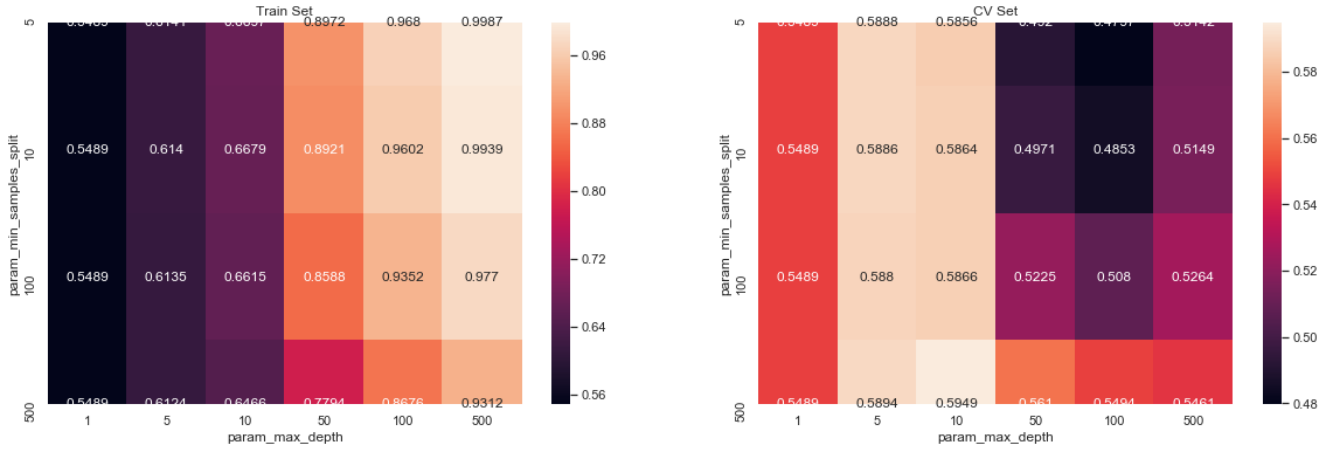
```
Final Data matrix
(33500, 12195) (33500,)
(16500, 12195) (16500,)
====================================================================================================
```

In [187]:

```
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).i

from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100], 'min_samples_split': [5, 10, 100, 500]}

clf1 = GridSearchCV(dt, parameters, cv= 3, scoring='roc_auc', return_train_score = True,n_jobs = -1
)

clf1.fit(X_tr1, y_train)

train_auc= clf1.cv_results_['mean_train_score']
train_auc_std= clf1.cv_results_['std_train_score']
cv_auc = clf1.cv_results_['mean_test_score']
cv_auc_std= clf1.cv_results_['std_test_score']
```

In [188]:

```
##https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb
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 [189]:

```
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).i

print(clf1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf1.score(X_tr1,y_train))
print(clf1.score(X_te1,y_test))
```

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=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')
0.6577012452197715
0.6074177656560029
```

In [190]:

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

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

Out[190]:

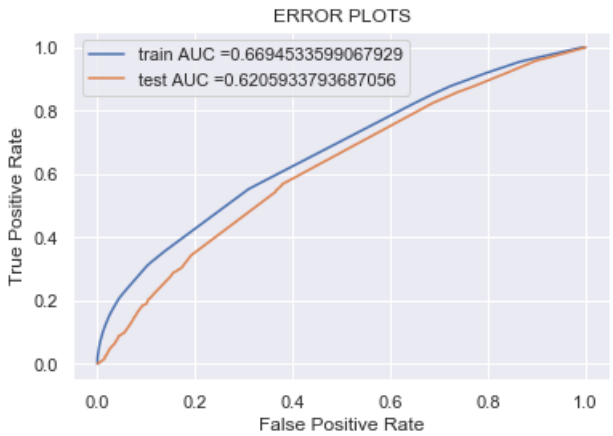
```
dict_keys(['cv', 'error_score', 'estimator__class_weight', 'estimator__criterion',
'estimator__max_depth', 'estimator__max_features', 'estimator__max_leaf_nodes',
'estimator__min_impurity_decrease', 'estimator__min_impurity_split',
'estimator__min_samples_leaf', 'estimator__min_samples_split',
```

```
'estimator__min_weight_fraction_leaf', 'estimator__presort', 'estimator__random_state',
'estimator__splitter', 'estimator', 'fit_params', 'iid', 'n_jobs', 'param_grid', 'pre_dispatch', '
refit', 'return_train_score', 'scoring', 'verbose'])
```

ROC Curve:

In [191]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.ro
ve


import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import learning_curve, GridSearchCV

#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function



clf1= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
classifier_bow=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=50
0)

clf1.fit(X_tr1, y_train)

# for visulation

classifier_bow.fit(X_tr1, y_train)

y_train_pred1 = clf1.predict_proba(X_tr1) [:,1]
y_test_pred1 = clf1.predict_proba(X_te1) [:,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 [192]:

```
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.ro
und(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
```

Train

In [193]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_tpr1, train_fpr1)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.14 for threshold 0.45
[[ 3492  1676]
 [12352 15980]]
```

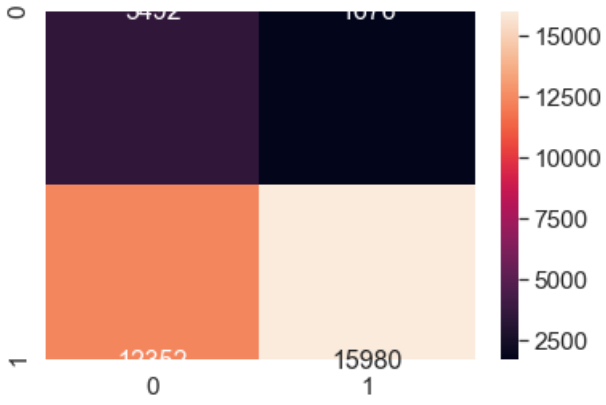
In [194]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1,
tr_thresholds1, train_tpr1, train_fpr1)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.14 for threshold 0.45
```

Out[194]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16f281c8>
```



test

In [195]:

```
print("="*100)
```

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, test_tpr1, test_fpr1)))
```

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.17 for threshold 0.45
[[1583  963]
 [6040 7914]]
```

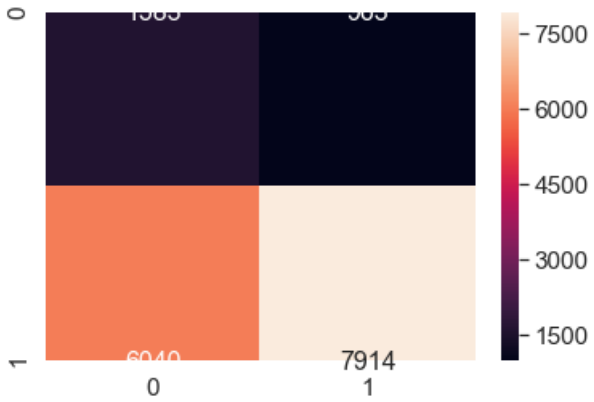
In [196]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, t
est_tpr1, test_fpr1)), range(2),range(2))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.17 for threshold 0.45
```

Out[196]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16efb3c8>
```



Visualizing Decision Tree:

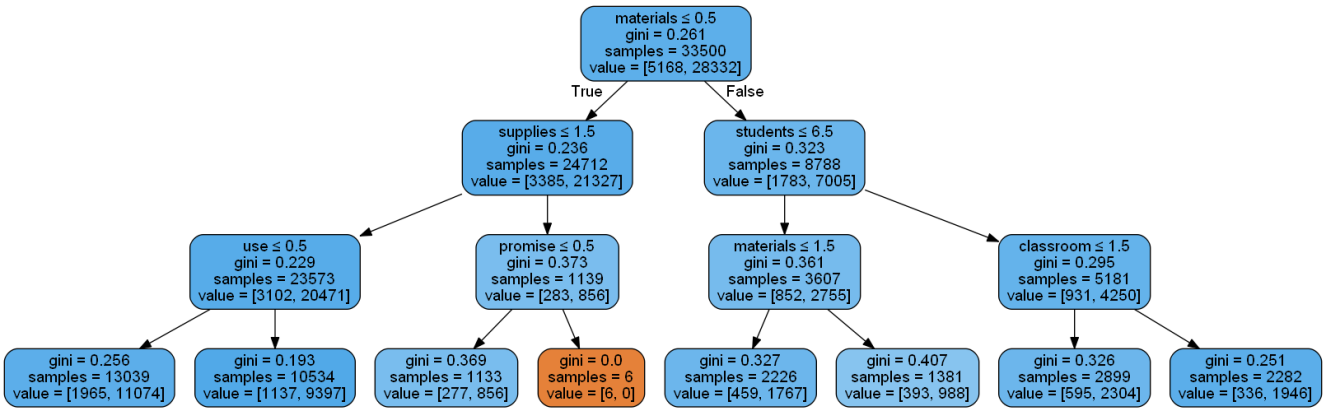
In [197]:

```
import os
os.environ["PATH"] += os.pathsep + r'C:\Users\User\Desktop\graphviz'
```

In [198]:

```
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1)..

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

dtree = DecisionTreeClassifier(max_depth=3)
clf1 = dtree.fit(X_tr1, y_train)

dot_data = StringIO()

#dt_feat_names = list(X_test.columns)
#dt_target_names = [str(s) for s in [0,1]]
export_graphviz(clf1, out_file=dot_data, filled=True, rounded=True, special_characters=True, featur
e_names=bow_features_names)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[198]:



False Positive words from BOW encoded Essays

In [199]:

```
bow_test = text_bow_test.todense()
bow_test.shape
```

Out[199]:

```
(16500, 10446)
```

In [200]:

```
vectorizer_bow_essay = CountVectorizer(min_df=10)

a = vectorizer_bow_essay.fit(X_train["clean_essays"])

bow_features = a.get_feature_names()
len(bow_features)
```

Out[200]:

```
10446
```

In [201]:

```
y_test_conaverted = list(y_test[::])

false_positives_index_p = []
fp_count = 0

for i in tqdm(range(len(y_test_pred1))):
    if y_test_conaverted[i] == 0 and y_test_pred1[i] <= 0.839:
        false_positives_index_p.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████████████████████████| 16500/16500 [00:00<00:00, 445917.92it/s]
```

In [202]:

```
fp_count
```

Out[202]:

```
2438
```

In [203]:

```
false_positives_index_p[0:7]
```

Out[203]:

```
[5, 12, 19, 37, 49, 51, 62]
```

In [204]:

```
df1 = pd.DataFrame(bow_test)
df1_final = df1.iloc[false_positives_index_p,:]

df1_final.shape

df1_final[0].sum()
```

Out[204]:

```
6
```

In [205]:

```
best_indices = []

for j in range(8885):

    s = df1_final[j].sum()

    if s >= 100 :
        best_indices.append(j)
    else :
        continue

len(best_indices)
```

Out[205]:

```
470
```

In [206]:

```
best_indices[0:10]
```

Out[206]:

```
[3, 57, 124, 184, 185, 186, 212, 213, 214, 226]
```

In [207]:

```
bow_features[0:10]
```

Out[207]:

```
['00', '000', '10', '100', '1000', '101', '103', '104', '10th', '11']
```

In [208]:

```
fp_words = []

for a in best_indices :
    fp_words.append(str(bow_features[a]))

fp_words[0:10]
```

Out[208]:

```
['100',
 '21st',
 '5th',
 'abilities',
 'ability',
 'able'
```

```
 'academic',
 'academically',
 'academics',
 'access']
```

Word cloud for false positive words:

In [209]:

```
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).i

from wordcloud import WordCloud, STOPWORDS


#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 800, height = 800,background_color ='white',stopwords =stopwords,min_
font_size=10).generate(unique_string)

plt.figure(figsize=(6,6))

plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
plt.close()
```

Box - Plot with the price of these False positive data points

In [210]:

```
len(false_positives_index_p)
```

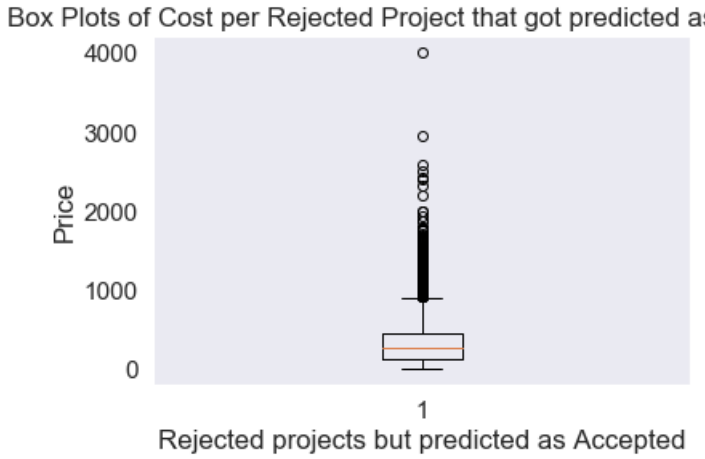
Out[210]:

```
2438
```

In [211]:

```
df1 = pd.DataFrame(X_test['price'])
df1_final = df1.iloc[false_positives_index_p,:]
```

```
plt.boxplot(df1_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```



PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points

In [213]:

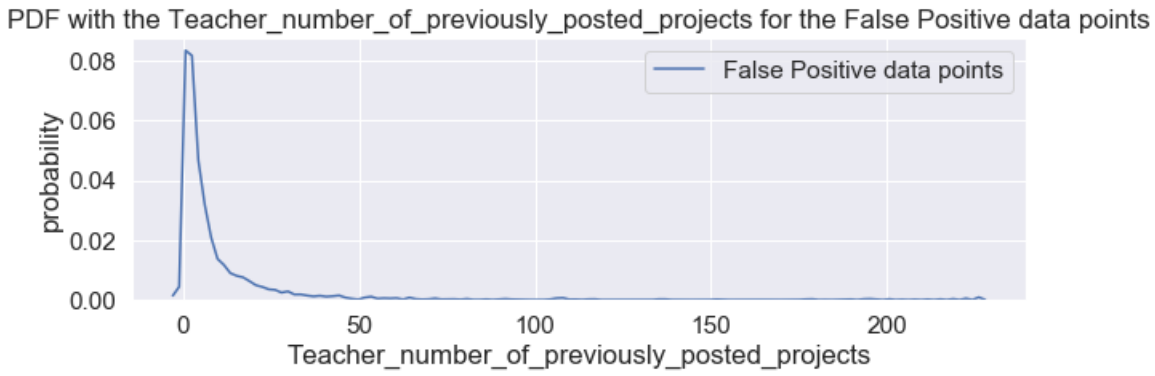
```
df1 = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
df1_final = df1.iloc[false_positives_index_p,:]
df1_final.shape
```

Out[213]:

```
(2438, 1)
```

In [214]:

```
plt.figure(figsize=(10,3))
sns.distplot(df1_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



Set 2 : Categorical, Numerical features + Project_title(TFIDF) + Preprocessed_essay (TFIDF min_df=10)

In [90]:

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

X_tr2 = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, essay_sent_pos_train, essay_sent_neg_train,
essay_sent_neu_train, essay_sent_compound_train, title_tfidf_train, text_tfidf_train)).tocsr()
X_te2 = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, essay_sent_pos_test, essay_sent_neg_test, essay_sent_
neu_test, essay_sent_compound_test, title_tfidf_test, text_tfidf_test)).tocsr()
#X_cv = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv,
title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv,
essay_sent_compound_cv, title_tfidf_cv, text_tfidf_cv)).tocsr()

print("Final Data matrix")
print(X_tr2.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
print(X_te2.shape, y_test.shape)
print("="*100)
```

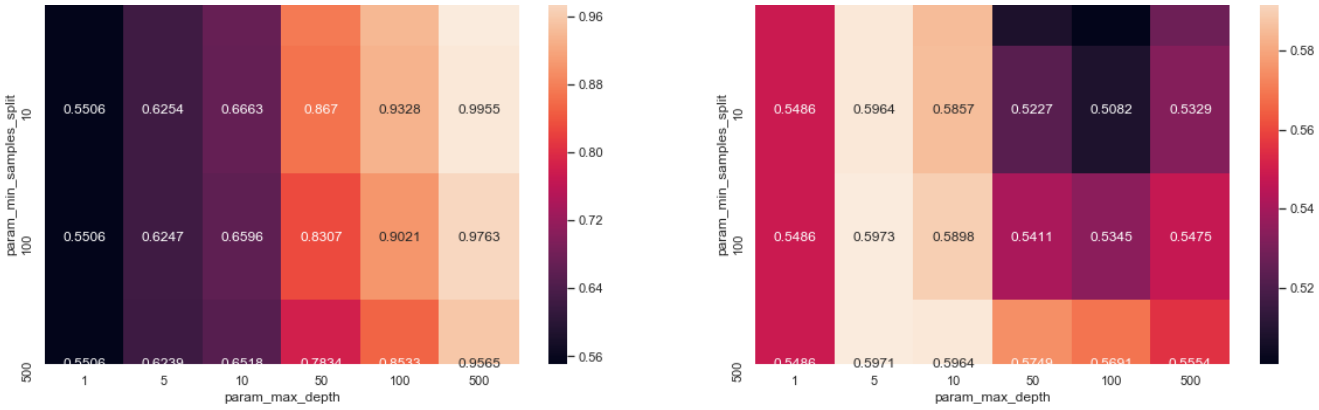
```
Final Data matrix
(33500, 12182) (33500,)
(16500, 12182) (16500,)
====================================================================================================
```

In [91]:

```
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).i

from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100], 'min_samples_split': [5, 10, 100, 500]}

clf2 = GridSearchCV(dt, parameters, cv= 3, scoring='roc_auc', return_train_score = True,n_jobs = -1
)

clf2.fit(X_tr2, y_train)

train_auc= clf2.cv_results_['mean_train_score']
train_auc_std= clf2.cv_results_['std_train_score']
cv_auc = clf2.cv_results_['mean_test_score']
cv_auc_std= clf2.cv_results_['std_test_score']
```

In [217]:

```
##https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb
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()
```



ROC Curve:

In [219]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve


import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import learning_curve, GridSearchCV

#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function



clf2= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
classifier_bow=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=50
0)

clf2.fit(X_tr2, y_train)

# for visulation

classifier_bow.fit(X_tr2, y_train)

y_train_pred1 = clf2.predict_proba(X_tr2) [:,1]
y_test_pred1 = clf2.predict_proba(X_te2) [:,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 [220]:

```
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.ro
und(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 [221]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_tpr1, train_fpr1)))

print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, test_tpr1, test_fpr1)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.13 for threshold 0.49
[[ 3624  1544]
 [12555 15777]]
====================================================================================================

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.17 for threshold 0.49
[[1626  920]
 [6479 7475]]
```

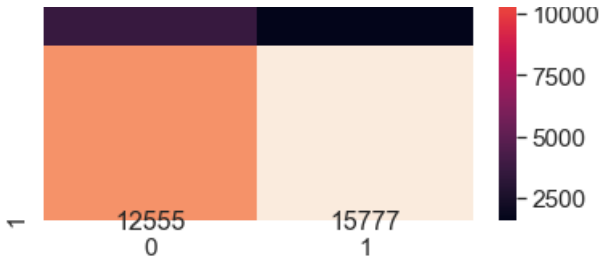
In [222]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1,
tr_thresholds1, train_tpr1, train_fpr1)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.13 for threshold 0.49
```

Out[222]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25d4f908>
```



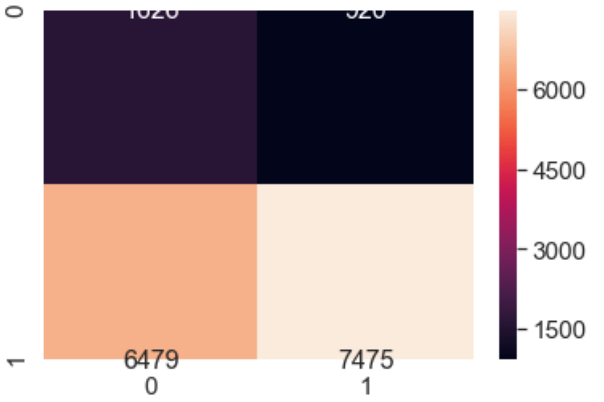
In [223]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, t
est_tpr1, test_fpr1)), range(2),range(2))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.17 for threshold 0.49
```

Out[223]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2184a9c8>
```



Visualizing Decision Tree:

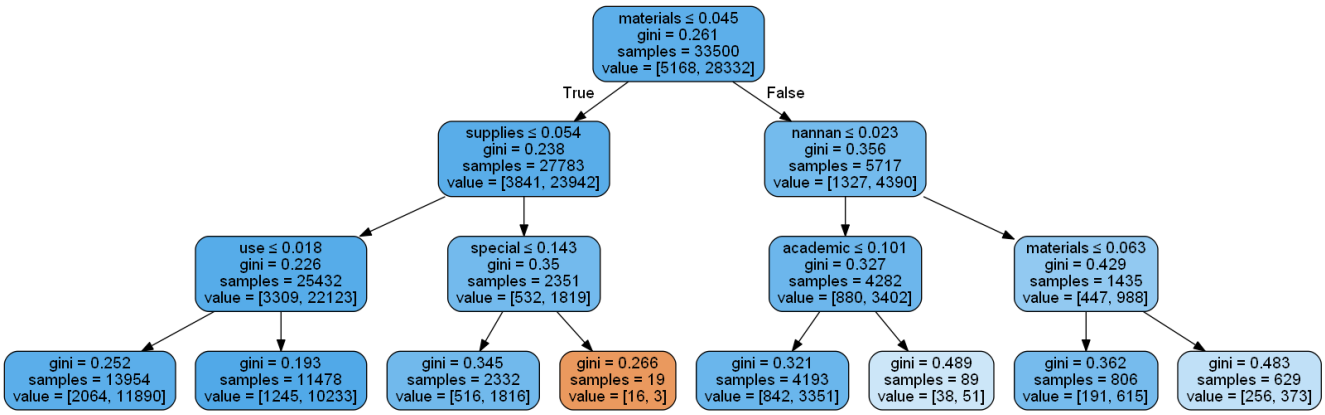
In [224]:

```
import os
os.environ["PATH"] += os.pathsep + r'C:\Users\User\Desktop\graphviz'
```

In [225]:

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

dtree = DecisionTreeClassifier(max_depth=3)
clf2 = dtree.fit(X_tr2, y_train)

dot_data = StringIO()

#dt_feat_names = list(X_test.columns)
#dt_target_names = [str(s) for s in [0,1]]
export_graphviz(clf2, out_file=dot_data, filled=True, rounded=True, special_characters=True, featur
e_names=bow_features_names)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[225]:



False Positive words from TFIDF encoded Essays

In [226]:

```
tfidf_test = text_tfidf_test.todense()
tfidf_test.shape
```

Out[226]:

```
(16500, 10446)
```

In [227]:

```
vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
bv = vectorizer_tfidf_essay.fit(X_train["clean_essays"])

tfidf_features = bv.get_feature_names()

len(tfidf_features)
```

Out[227]:

```
10446
```

In [228]:

```
y_test_converted = list(y_test[::])

false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred1))):
    if y_test_converted[i] == 0 and y_test_pred1[i] <= 0.84:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████████████████████████████| 16500/16500 [00:00<00:00, 499974.83it/s]
```

In [229]:

```
fp_count
```

Out[229]:

```
2401
```

In [230]:

```
false_positives_index_b[0:5]
```

Out[230]:

```
[5, 12, 19, 37, 49]
```

In [231]:

```
df2 = pd.DataFrame(tfidf_test)
df2_final = df2.iloc[false_positives_index_b,:]
df2_final.shape
```

Out[231]:

```
(2401, 10446)
```

In [232]:

```
best_indices_b = []

for j in range(8885):

    s = df2_final[j].sum()

    if s >= 10 :
        best_indices_b.append(j)
    else :
        continue
```

In [233]:

```
len(best_indices_b)
```

Out[233]:

```
363
```

In [234]:

```
best_indices_b[0:10]
```

Out[234]:

```
[124, 184, 185, 186, 212, 226, 272, 296, 302, 303]
```

In [235]:

```
tfidf_features[0:10]
```

Out[235]:

```
['00', '000', '10', '100', '1000', '101', '103', '104', '10th', '11']
```

In [236]:

```
fp_words_b = []

for a in best_indices_b :
    fp_words_b.append(str(tfidf_features[a]))

fp_words_b[0:10]
```

Out[236]:

```
['5th',
 'abilities',
 'ability',
 'able',
 'academic',
 'access',
 'achieve',
 'active',
```

```
 'activities',
 'activity']
```

Word Cloud for False Positives words

In [237]:

```
from wordcloud import WordCloud, STOPWORDS


#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 800, height = 800,background_color ='white',stopwords =stopwords,min_
font_size=10).generate(unique_string)

plt.figure(figsize=(6,6))

plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
plt.close()
```

Box - Plot with the price of these False positive data points

In [238]:

```
len(false_positives_index_p)
```

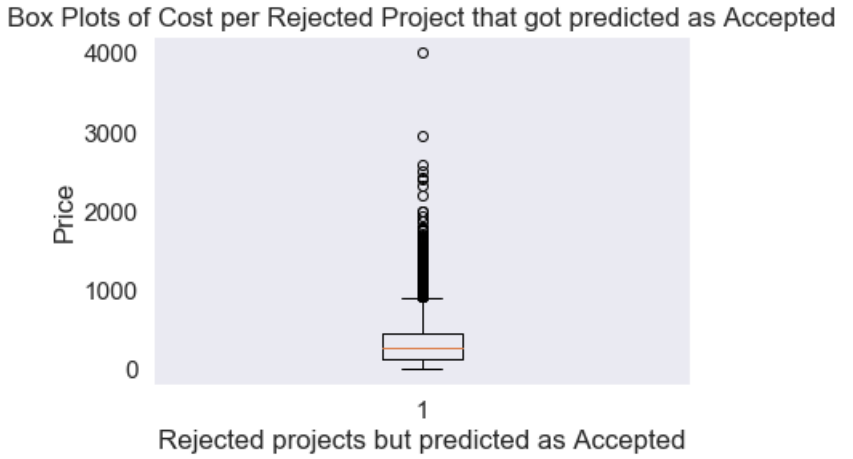
Out[238]:

```
2438
```

In [239]:

```
df2 = pd.DataFrame(X_test['price'])
df2_final = df2.iloc[false_positives_index_p,:]

plt.boxplot(df2_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
```

```
plt.grid()
plt.show()
```



PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points

In [240]:

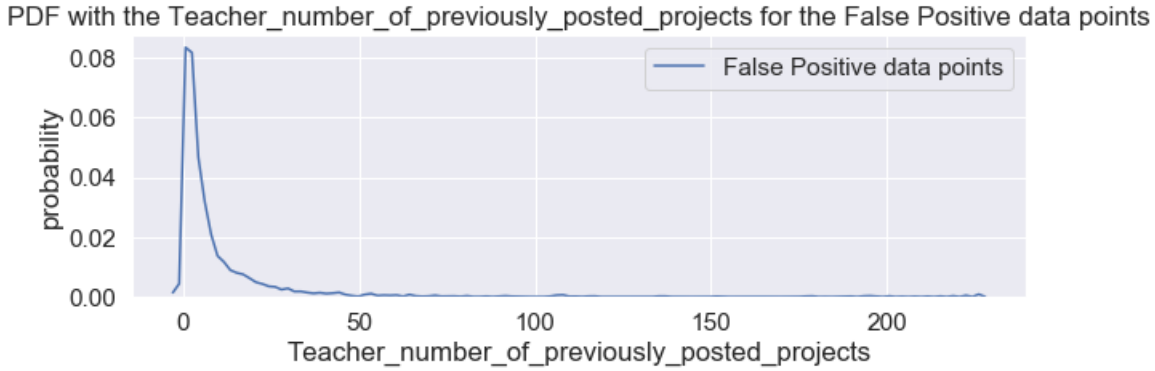
```
df2 = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
df2_final = df2.iloc[false_positives_index_p,:]
df2_final.shape
```

Out[240]:

```
(2438, 1)
```

In [241]:

```
plt.figure(figsize=(10,3))
sns.distplot(df2_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



Set 3 : Categorical, Numerical features + Project_title(AVG W2V) + Preprocessed_essay (AVG W2V)

In [242]:

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

X_tr3 = hstack((categories_one_hot_train, sub_categories_one_hot_train,
```

```
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, essay_sent_pos_train, essay_sent_neg_train,
essay_sent_neu_train, essay_sent_compound_train, avg_w2v_vectors_train,
avg_w2v_vectors_titles_train)).tocsr()
X_te3 = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, essay_sent_pos_test, essay_sent_neg_test, essay_sent_
neu_test, essay_sent_compound_test, avg_w2v_vectors_test, avg_w2v_vectors_titles_test)).tocsr()
#X_cv = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv,
title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv,
essay_sent_compound_cv, avg_w2v_vectors_cv, avg_w2v_vectors_titles_cv)).tocsr()

print("Final Data matrix")
print(X_tr3.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
print(X_te3.shape, y_test.shape)
print("="*100)
```

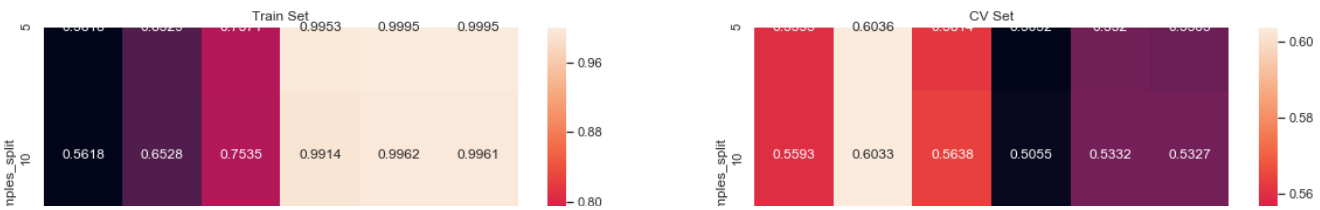
```
Final Data matrix
(33500, 709) (33500,)
(16500, 709) (16500,)
====================================================================================================
```

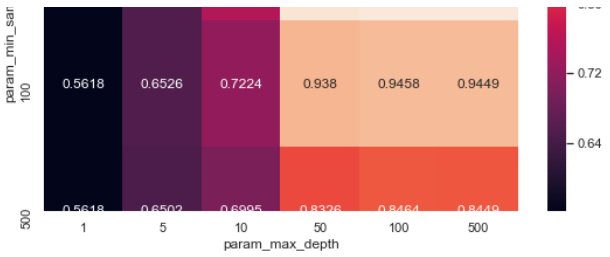
In [244]:

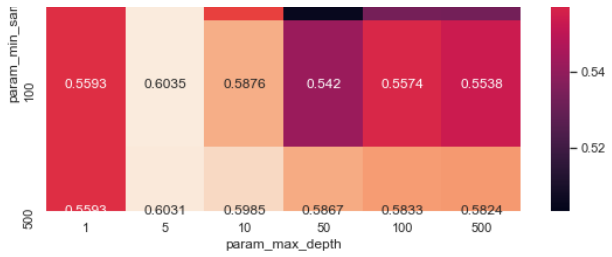
```
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100], 'min_samples_split': [5, 10, 100, 500]}

clf3 = GridSearchCV(dt, parameters, cv= 3, scoring='roc_auc', return_train_score = True,n_jobs = -1
)

clf3.fit(X_tr3, y_train)

train_auc= clf3.cv_results_['mean_train_score']
train_auc_std= clf3.cv_results_['std_train_score']
cv_auc = clf3.cv_results_['mean_test_score']
cv_auc_std= clf3.cv_results_['std_test_score']
```

In [245]:

```
##https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb
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()
```



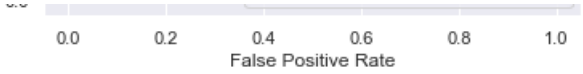




ROC Curve:

In [246]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve


import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import learning_curve, GridSearchCV

#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function



clf3= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
classifier_bow=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=50
0)

clf3.fit(X_tr3, y_train)

# for visulation

classifier_bow.fit(X_tr3, y_train)

y_train_pred1 = clf3.predict_proba(X_tr3) [:,1]
y_test_pred1 = clf3.predict_proba(X_te3) [:,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 [247]:

```
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.ro
und(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 [248]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_tpr1, train_fpr1)))

print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, test_tpr1, test_fpr1)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.11 for threshold 0.5
[[ 3591  1577]
 [10187 18145]]
====================================================================================================

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2 for threshold 0.54
[[1418 1128]
 [6119 7835]]
```

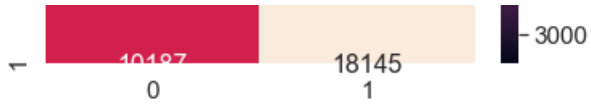
In [249]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1,
tr_thresholds1, train_tpr1, train_fpr1)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.11 for threshold 0.5
```

Out[249]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fd98c08>
```



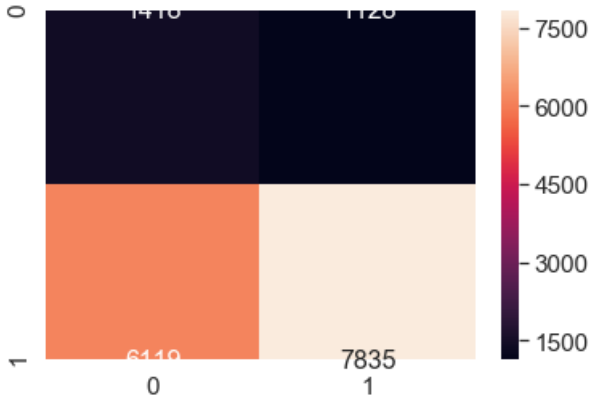
In [250]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, t
est_tpr1, test_fpr1)), range(2),range(2))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.2 for threshold 0.54
```

Out[250]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1e854d88>
```



False Positives Retrieval:

In [251]:

```
fpi = []
fp_count = 0

for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions1[i] == 1) :
        fpi.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

In [252]:

```
fp_essay3 = []
for i in fpi :
    fp_essay3.append(X_test['clean_essays'].values[i])
```

In [253]:

```
fp_count
```

Out[253]:

```
1128
```

In [254]:

```
fpi[0:5]
```

Out[254]:

```
[103, 111, 157, 159, 177]
```

In [255]:

```
df3 = pd.DataFrame(avg_w2v_vectors_test )
```

In [256]:

```
df3_final = df3.iloc[fpi,:]
df3_final.shape
```

Out[256]:

```
(1128, 300)
```

In [257]:

```
best_indices_b = []

for j in range(300):

    s = df3_final[j].sum()

    if s >= 10 :
        best_indices_b.append(j)
    else :
        continue
```

In [258]:

```
len(best_indices_b)
```

Out[258]:

```
128
```

In [259]:

```
best_indices_b[0:10]
```

Out[259]:

```
[0, 1, 7, 8, 10, 12, 16, 18, 20, 21]
```

Word cloud for false positive words:

In [260]:

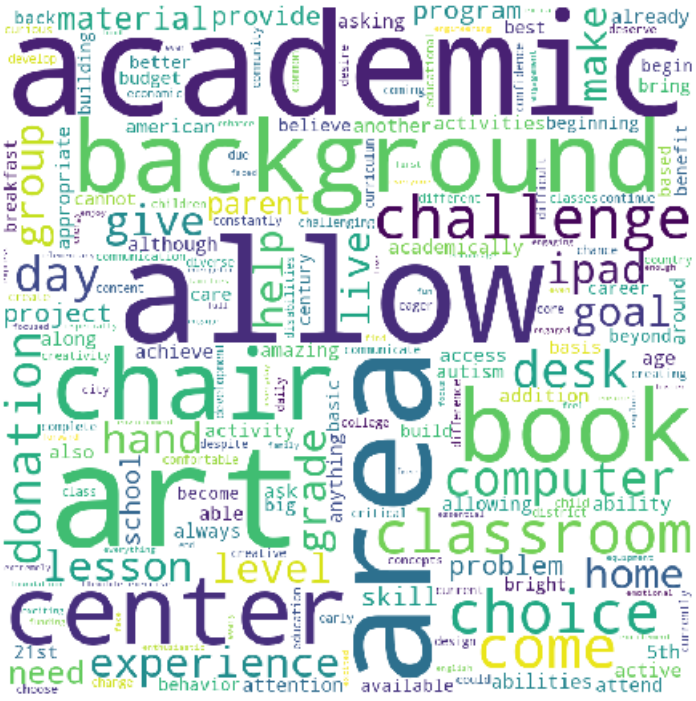
```
pip install wordcloud
```

```
Requirement already satisfied: wordcloud in c:\users\user\anaconda3\lib\site-packages (1.5.0)
Requirement already satisfied: numpy>=1.6.1 in c:\users\user\anaconda3\lib\site-packages (from
wordcloud) (1.15.4)
Requirement already satisfied: pillow in c:\users\user\anaconda3\lib\site-packages (from
wordcloud) (5.4.1)
Note: you may need to restart the kernel to use updated packages.
```

In [261]:

```
from wordcloud import WordCloud, STOPWORDS


#convert list to string and generate
unique_string=(" ").join(fp_words)
```

```
wordcloud = WordCloud(width = 800, height = 800,background_color ='white',stopwords =stopwords,min_
font_size=10).generate(unique_string)

plt.figure(figsize=(6,6))

plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
plt.close()
```



Box - Plot with the price of these False positive data points:

In [262]:

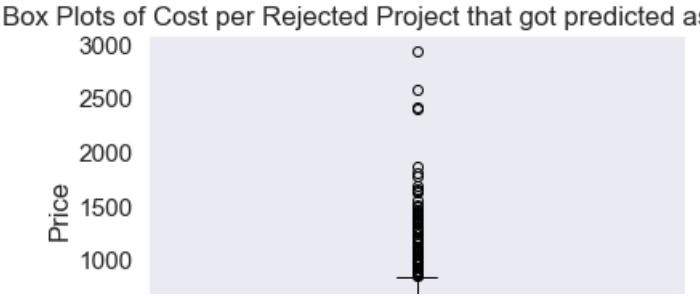
```
len(fpi)
```

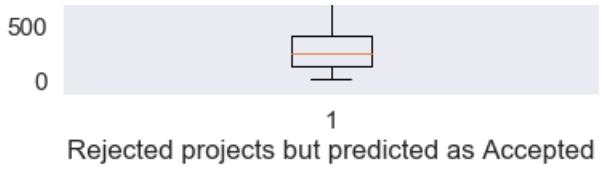
Out[262]:

```
1128
```

In [263]:

```
df3 = pd.DataFrame(X_test['price'])
df3_final = df3.iloc[fpi,:]

plt.boxplot(df3_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```





PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points:

In [264]:

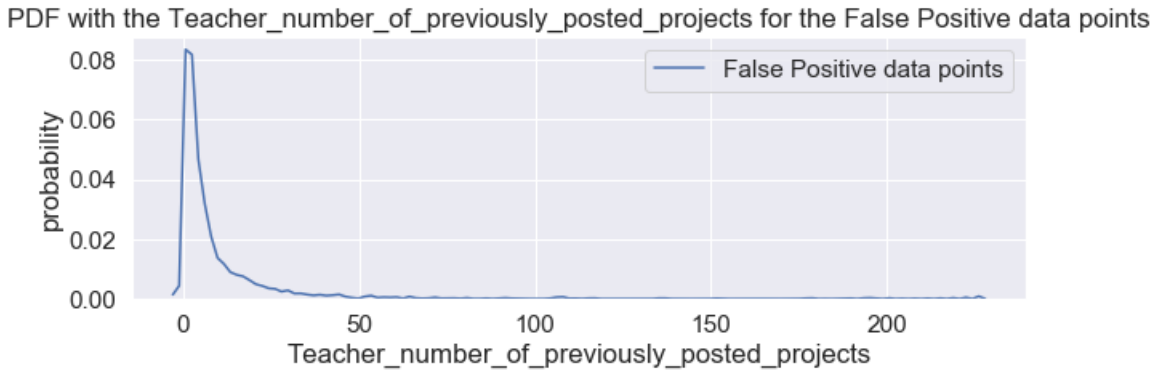
```
df3 = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
df3_final = df3.iloc[false_positives_index_p,:]
df3_final.shape
```

Out[264]:

```
(2438, 1)
```

In [265]:

```
plt.figure(figsize=(10,3))
sns.distplot(df2_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



Set 4 : Categorical, Numerical features + Project_title(TFIDF W2V) + Preprocessed_essay (TFIDF W2V)

In [266]:

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

X_tr4 = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, essay_sent_pos_train, essay_sent_neg_train,
essay_sent_neu_train, essay_sent_compound_train, tfidf_w2v_vectors_train,
tfidf_w2v_vectors_titles_train)).tocsr()
X_te4 = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, essay_sent_pos_test, essay_sent_neg_test, essay_sent_
neu_test, essay_sent_compound_test, tfidf_w2v_vectors_test, tfidf_w2v_vectors_titles_test)).tocsr(
)
#X_cv = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv,
```

```
title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv,
essay_sent_compound_cv, tfidf_w2v_vectors_cv, tfidf_w2v_vectors_titles_cv)).tocsr()

print("Final Data matrix")
print(X_tr4.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
print(X_te4.shape, y_test.shape)
print("="*100)
```

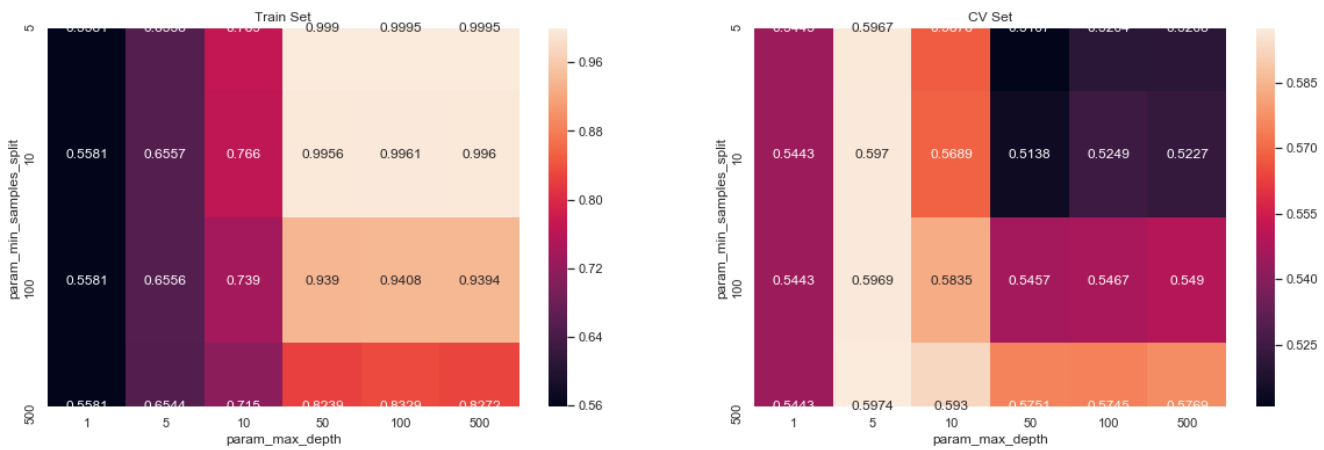
```
Final Data matrix
(33500, 709) (33500,)
(16500, 709) (16500,)
====================================================================================================
```

In [267]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100], 'min_samples_split': [5, 10, 100, 500]}

clf4 = GridSearchCV(dt, parameters, cv= 3, scoring='roc_auc', return_train_score = True,n_jobs = -1
)

clf4.fit(X_tr4, y_train)

train_auc= clf4.cv_results_['mean_train_score']
train_auc_std= clf4.cv_results_['std_train_score']
cv_auc = clf4.cv_results_['mean_test_score']
cv_auc_std= clf4.cv_results_['std_test_score']
```

In [268]:

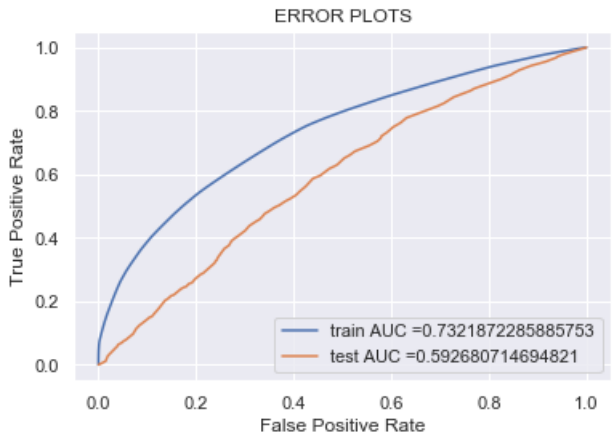
```
##https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb
import seaborn as sns; sns.set()

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()
```



ROC Curve:

In [269]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.ro
ve


import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import learning_curve, GridSearchCV

#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function



clf4= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
classifier_bow=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=50
0)

clf4.fit(X_tr4, y_train)

# for visulation

classifier_bow.fit(X_tr4, y_train)

y_train_pred1 = clf4.predict_proba(X_tr4) [:,1]
y_test_pred1 = clf4.predict_proba(X_te4) [:,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 [270]:

```
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.ro
```

```
und(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 [271]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_tpr1, train_fpr1)))

print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, test_tpr1, test_fpr1)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.11 for threshold 0.49
[[ 3545  1623]
 [ 9818 18514]]
====================================================================================================

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.19 for threshold 0.5
[[1426 1120]
 [5763 8191]]
```

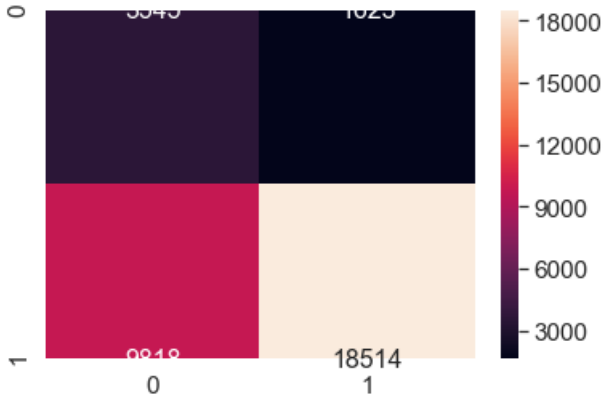
In [272]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1,
tr_thresholds1, train_tpr1, train_fpr1)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.11 for threshold 0.49
```

Out[272]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x162f9408>
```



In [273]:

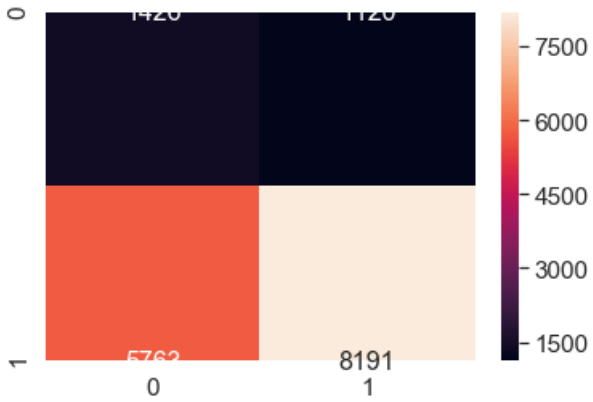
```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, t
est_tpr1, test_fpr1)), range(2),range(2))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))

sns.set(font_scale=1.4)#for label size
```

```
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.19 for threshold 0.5
```

Out[273]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1dd90a08>
```



False Positives Retrieval:

In [274]:

```
y_test_conaverted = list(y_test[::])

false_positives_index_p = []
fp_count = 0

for i in tqdm(range(len(y_test_pred1))):
    if y_test_conaverted[i] == 0 and y_test_pred1[i] <= 0.839:
        false_positives_index_p.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████████████████████████| 16500/16500 [00:00<00:00, 323512.03it/s]
```

In [275]:

```
fp_count
```

Out[275]:

```
2349
```

In [276]:

```
false_positives_index_p[0:7]
```

Out[276]:

```
[5, 12, 19, 37, 49, 51, 62]
```

In [277]:

```
df4 = pd.DataFrame(tfidf_w2v_vectors_train)
df4_final = df4.iloc[false_positives_index_p,:]

df4_final.shape

df4_final[0].sum()
```

Out[277]:

Out[277]:

47.86317441816917

In [281]:

```
best_indices = []

for j in range(300):

    s = df4_final[j].sum()

    if s >= 100 :
        best_indices.append(j)
    else :
        continue

len(best_indices)
```

Out[281]:

69

In [282]:

```
best_indices[0:10]
```

Out[282]:

[7, 12, 18, 26, 33, 41, 46, 56, 59, 62]

Word cloud for false positive words

In [283]:

```
from wordcloud import WordCloud, STOPWORDS


#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 800, height = 800,background_color ='white',stopwords =stopwords,min_
font_size=10).generate(unique_string)

plt.figure(figsize=(6,6))

plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
plt.close()
```

Box - Plot with the price of these False positive data points

In [284]:

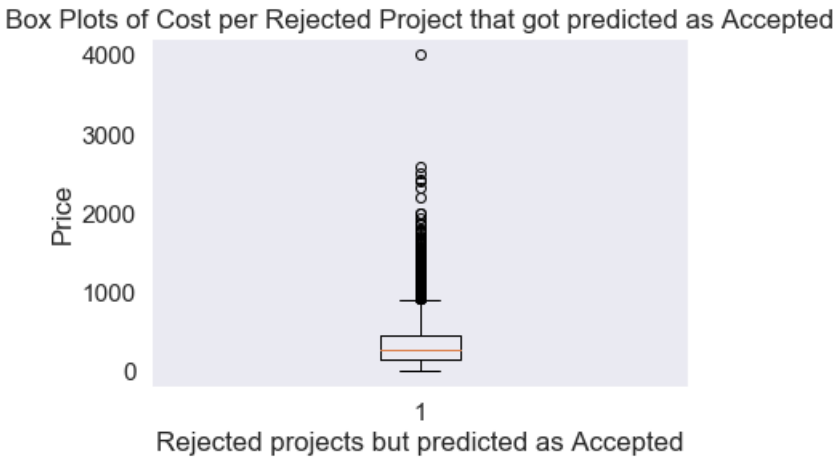
```
len(false_positives_index_p)
```

Out[284]:

2349

In [285]:

```
df4 = pd.DataFrame(X_test['price'])
df4_final = df4.iloc[false_positives_index_p,:]

plt.boxplot(df4_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```



Summary - Majority of projects rejected but predicted as accepted cost nearly less than 500 dollars. A few of them are Extremely costing over 3000 dollars.

PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points

In [286]:

```
df4 = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
df4_final = df4.iloc[false_positives_index_p,:]
df4_final.shape
```

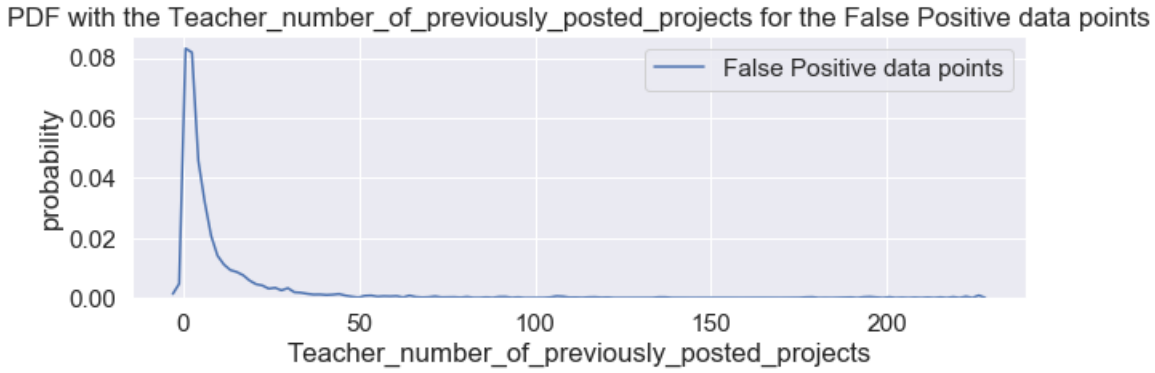
Out[286]:

(2349, 1)

In [287]:

```
plt.figure(figsize=(10,3))
sns.distplot(df4_final.values, hist=False, label="False Positive data points")
```

```
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



Summary - Most cases have teachers with projects previously posted as 0 (nearly 10% of the total data)

[Task 2] Select best 5k features from Set 2

In [96]:

```
#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 [124]:

```
X_tr5 = selectKImportance(clf2, X_tr2, 5000)
X_te5 = selectKImportance(clf2, X_te2, 5000)
print(X_tr5.shape)
print(X_te5.shape)
```

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

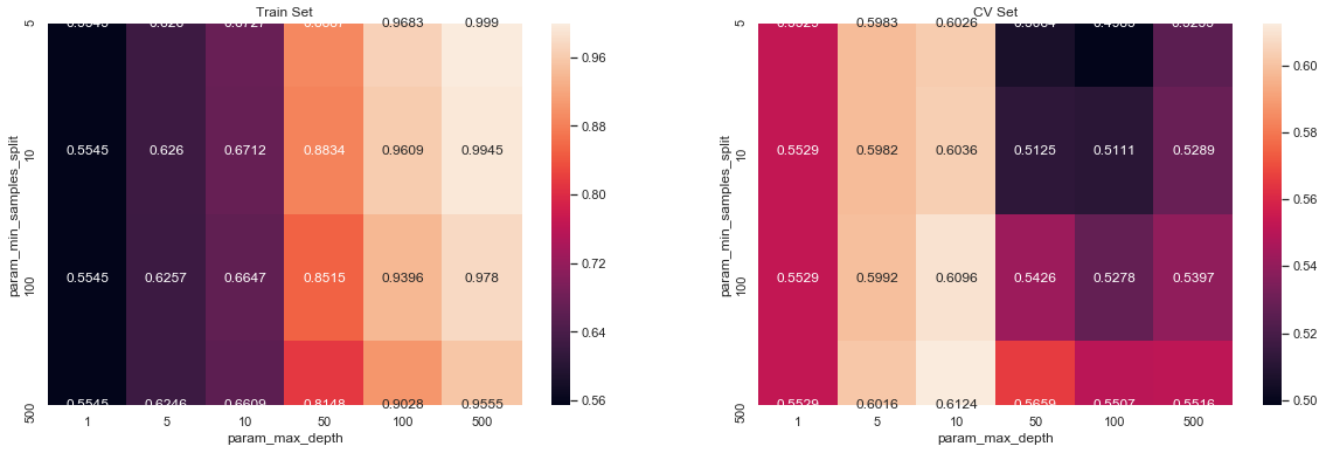
Decision tree on Important features

In [125]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100], 'min_samples_split': [5, 10, 100, 500]}

clf5 = GridSearchCV(dt, parameters, cv= 3, scoring='roc_auc', return_train_score = True,n_jobs = -1
)

clf5.fit(X_tr5, y_train)

train_auc= clf5.cv_results_['mean_train_score']
train_auc_std= clf5.cv_results_['std_train_score']
cv_auc = clf5.cv_results_['mean_test_score']
cv_auc_std= clf5.cv_results_['std_test_score']
```

In [126]:

```
##https://github.com/shashimanyam/DECISION-TREE-ON-DONORSCHOOSE-
DATASET/blob/master/DECISION%20TREE%20ON%20DONORSCHOOSE.ipynb
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 [127]:

```
#Best Estimator and Best tune parameters
print(clf5.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf5.score(X_tr5,y_train))
print(clf5.score(X_te5,y_test))
```

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=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')
0.6633545218645875
0.6176711698104457
```

In [128]:

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

clf5.get_params().keys()
```

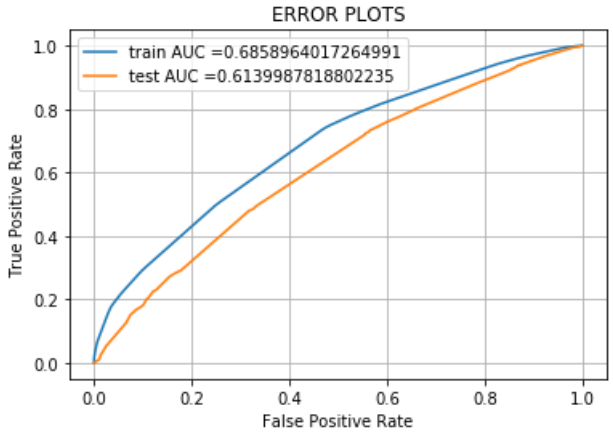
Out[128]:

```
dict_keys(['cv', 'error_score', 'estimator__class_weight', 'estimator__criterion',
'estimator__max_depth', 'estimator__max_features', 'estimator__max_leaf_nodes',
'estimator__min_impurity_decrease', 'estimator__min_impurity_split',
'estimator__min_samples_leaf', 'estimator__min_samples_split',
'estimator__min_weight_fraction_leaf', 'estimator__presort', 'estimator__random_state',
'estimator__splitter', 'estimator', 'fit_params', 'iid', 'n_jobs', 'param_grid', 'pre_dispatch', '
refit', 'return_train_score', 'scoring', 'verbose'])
```

ROC

In [111]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.ro
ve


import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import learning_curve, GridSearchCV

#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function



clf5= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clf_5=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=500)

clf5.fit(newX_tr, y_train)

# for visulation

clf_5.fit(newX_tr, y_train)

y_train_pred1 = clf5.predict_proba(newX_tr) [:,1]
y_test_pred1 = clf5.predict_proba(newX_te) [:,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 [115]:

```
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.ro
```

```
und(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 [129]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_tpr1, train_fpr1)))

print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred1, tr_thresholds1, test_tpr1, test_fpr1)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.13 for threshold 0.52
[[ 2765  2403]
 [ 7572 20760]]
====================================================================================================

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.17 for threshold 0.54
[[1699  847]
 [7048 6906]]
```

In [119]:

```
conf_matr_df_train_5 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1,
tr_thresholds1, train_tpr1, train_fpr1)), range(2),range(2))
```

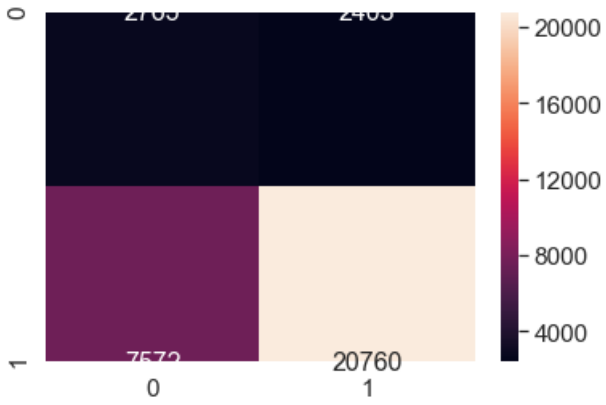
```
the maximum value of tpr*(1-fpr) 0.13 for threshold 0.52
```

In [120]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_5, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[120]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7cc2b08>
```



In [121]:

```
conf_matr_df_test_5 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1,
```

```
train_tpr1, train_fpr1)), range(2),range(2))
```

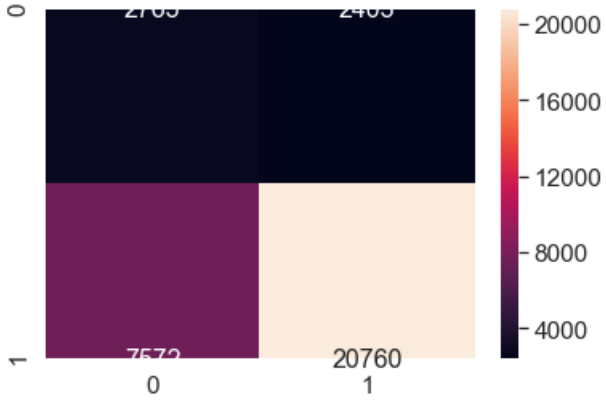
```
the maximum value of tpr*(1-fpr) 0.13 for threshold 0.52
```

In [122]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_5, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[122]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1e755148>
```



3. Conclusion

In [174]:

```
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameters(max depth,min samples split)", "Train AUC"
, "Test AUC"]

x.add_row(["BOW", "Decision Trees","(10, 100)", 0.669, 0.620])
x.add_row(["TFIDF", "Decision Trees", "(10, 500)", 0.688, 0.620])
x.add_row(["AVG W2V", "Decision Trees", "(5, 500)", 0.727, 0.583])
x.add_row(["TFIDF W2V", "Decision Trees", "(10, 100)", 0.732, 0.592])
x.add_row(["TFIDF-5k Features","Decision Trees", "(10, 500 ) ",  0.685, 0.613])
print(x.get_string(titles = "Decision trees- Observations"))
```

```
+------------------+---------------+-----------------------------------------------+-----------+--
-----+
|     Vectorizer   |     Model     | Hyperparameters(max depth,min samples split) | Train AUC | T
est AUC |
+------------------+---------------+-----------------------------------------------+-----------+--
-----+
|        BOW       | Decision Trees |                 (10, 100)                   |   0.669   |
.62   |
|       TFIDF      | Decision Trees |                 (10, 500)                   |   0.688   |
.62   |
|      AVG W2V     | Decision Trees |                  (5, 500)                   |   0.727   |
0.583   |
|    TFIDF W2V     | Decision Trees |                 (10, 100)                   |   0.732   |
0.592   |
| TFIDF-5k Features | Decision Trees |                (10, 500 )                   |   0.685   |
.613   |
+------------------+---------------+-----------------------------------------------+-----------+--
-----+
```

In [ ]: