DonorsChoose

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.

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!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*

Feature	Description
`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 [2]:

```
%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
```

1.1 Reading Data

In [4]:

```
project_data = pd.read_csv('train_data.csv', nrows = 50000)
```

In [5]:

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

```
Number of data points in train data (50000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [6]:

```
resource_data = pd.read_csv('resources.csv')
```

In [7]:

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

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

Out[7]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying	1	149.00

	id	description	quantity	price
		Rack		
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

1.2 preprocessing of `project_subject_categories`

In [8]:

```
catogories = list(project_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
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "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"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [9]:

```
sub_catogories = list(project_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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "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"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

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

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

1.3 Text preprocessing

In [10]:

```
# merge two column ext dataframe:
project_data['essay'] = project_data['project_essay_1'].map(str) +\
                        project_data['project_essay_2'].map(str) + \
                        project_data['project_essay_3'].map(str) + \
                        project_data['project_essay_4'].map(str)
```

In [11]:

```
project_data.head(2)
```

Out[11]:

	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
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [12]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [12]:

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
```

glish Learner Teacher and will be sent home regularly to watch. The videos are to help the child develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the opportunity to check out a dvd player to use for the year. The plan is to use these videos and ed ucational dvd's for the years to come for other EL students.\r\nnannan
==
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together and celebrate. Around Halloween there is a whole school parade to show off the bea utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t he hard work put in during the school year, with a dunk tank being the most popular activity.My st udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in the classroom and not enough for each student to hav e an individual one, they will be used in a variety of ways. During independent reading time they will be used as special chairs students will each use on occasion. I will utilize them in place of chairs at my small group tables during math and reading times. The rest of the day they will be us ed by the students who need the highest amount of movement in their life in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i n group with me on the Hokki Stools, they are always moving, but at the same time doing their work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta ken. There are always students who head over to the kidney table to get one of the stools who are disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th e same time. These stools will help students to meet their 60 minutes a day of movement by allowing them to activate their core muscles for balance while they sit. For many of my students, these chairs will take away the barrier that exists in schools for a child who can't sit still.nannan
==
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n \r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage r learners; they are like sponges, absorbing all the information and experiences and keep on wanti ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to be one of a themed nautical environment. Creating a classroom environment is very important in the success in each and every child's education. The nautical photo props will be used with each child as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic tures of each child with them, have them developed, and then hung in our classroom ready for their first day of 4th grade. This kind gesture will set the tone before even the first day of school! The nautical thank you cards will be used throughout the year by the students as they create thank you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on resources to get our classroom ready. Please consider helping with this project t o make our new school year a very successful one. Thank you!nannan
==
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I teach in a Title I school where most of the students receive free or reduced pr ice lunch. Despite their disabilities and limitations, my students love coming to school and come eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju mping and playing. Physical engagement is the key to our success. The number toss and color and sh ape mats can make that happen. My students will forget they are doing work and just have the fun a 6 year old deserves.nannan
==

In [13]:

```
# 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 [14]:

```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids do not want to sit and do worksheets. They want to learn to count by j
umping and playing. Physical engagement is the key to our success. The number toss and color and s
hape mats can make that happen. My students will forget they are doing work and just have the fun
a 6 year old deserves.nannan
==================================================
```

In [15]:

```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations.     The materials we have are the ones I seek out for
my students. I teach in a Title I school where most of the students receive free or reduced price
lunch.  Despite their disabilities and limitations, my students love coming to school and come eag
er to learn and explore.Have you ever felt like you had ants in your pants and you needed to groov
e and move as you were in a meeting? This is how my kids feel all the time. The want to be able to
move as they learn or so they say.Wobble chairs are the answer and I love then because they develo
p their core, which enhances gross motor and in Turn fine motor skills.   They also want to learn t
hrough games, my kids do not want to sit and do worksheets. They want to learn to count by jumping
and playing. Physical engagement is the key to our success. The number toss and color and shape ma
ts can make that happen. My students will forget they are doing work and just have the fun a 6 yea
r old deserves.nannan
```

In [16]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitiv
e delays gross fine motor delays to autism They are eager beavers and always strive to work their
hardest working past their limitations The materials we have are the ones I seek out for my studen
ts I teach in a Title I school where most of the students receive free or reduced price lunch
Despite their disabilities and limitations my students love coming to school and come eager to lea
rn and explore Have you ever felt like you had ants in your pants and you needed to groove and mov
e as you were in a meeting This is how my kids feel all the time The want to be able to move as th
ey learn or so they say Wobble chairs are the answer and I love then because they develop their co
re which enhances gross motor and in Turn fine motor skills They also want to learn through games
my kids do not want to sit and do worksheets They want to learn to count by jumping and playing Ph
ysical engagement is the key to our success The number toss and color and shape mats can make that
happen My students will forget they are doing work and just have the fun a 6 year old deserves nan
```

happen My students will forget they are doing work and just have the fun a 6 year old deserves nan
nan

In [17]:

```
# 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 [18]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000 [01:
17<00:00, 644.13it/s]
```

In [20]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[20]:

```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gros
s fine motor delays autism they eager beavers always strive work hardest working past limitations
the materials ones i seek students i teach title i school students receive free reduced price lunc
h despite disabilities limitations students love coming school come eager learn explore have ever
felt like ants pants needed groove move meeting this kids feel time the want able move learn say w
obble chairs answer i love develop core enhances gross motor turn fine motor skills they also want
learn games kids not want sit worksheets they want learn count jumping playing physical engagement
key success the number toss color shape mats make happen my students forget work fun 6 year old de
serves nannan'
```

1.4 Preprocessing of `project_title`

In [21]:

```
# similarly you can preprocess the titles also
```

In [19]:

```
sent = decontracted(project_data['project_title'].values[0])
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
Educational Support for English Learners at Home
```

In [20]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000
[00:03<00:00, 13045.27it/s]
```

Introducing New Features¶

Consider these set of features for Set 5 in Assignment: categorical dataschool_state clean_categories....clean_subcategories....project_grade_category....teacher_prefix numerical data quantity....teacher_number_of_previously_posted_projects....price New Features sentiment score's of each of the essay : numerical data number of words in the title : numerical data number of words in the combine essays : numerical data

In [21]:

```
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 [22]:

```
new_title = []
for i in tqdm(project_data['project_title']):
    j = decontracted(i)
    new_title.append(i)
```

```
    new_title.append(j)
```

```
100%|██████████| 50000/50000 [00:02<00:00, 23321.98it/s]
```

In [23]:

```
#Introducing New Features
title_word_count = []
#for i in project_data['project_title']:
for i in tqdm(new_title):
    j = len(i.split())
    title_word_count.append(j)
    #print(j)
project_data['title_word_count'] = title_word_count
```

```
100%|██████████| 50000/50000 [00:00<00:00, 498616.72it/s]
```

In [24]:

```
project_data.head(2)
```

Out[24]:

	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
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [25]:

```
new_essay = []
for i in tqdm(project_data['essay']):
    j = decontracted(i)
    new_essay.append(j)
```

```
100%|██████████| 50000/50000 [00:02<00:00, 19709.52it/s]
```

In [26]:

```
essay_word_count = []
for i in tqdm(new_essay):
    j = len(i.split())
    essay_word_count.append(j)
    #print(j)
project_data['essay_word_count'] = essay_word_count
```

```
100%|██████████| 50000/50000 [00:03<00:00, 14621.77it/s]
```

In [30]:

```
project_data.head(2)
```

Out[30]:

	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
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [31]:

```
#Computing Sentiment Scores
```

In [27]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# import nltk
#nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students w
ith the biggest enthusiasm'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
neg: 0.109, neu: 0.693, pos: 0.198, compound: 0.2023,
```

In [28]:

```
SID = SentimentIntensityAnalyzer()
#There is NEGITIVE and POSITIVE and NEUTRAL and COMPUND SCORES
#http://www.nltk.org/howto/sentiment.html

negitive = []
positive = []
neutral = []
compound = []
for i in tqdm(project_data['essay']):
    j = SID.polarity_scores(i)['neg']
    k = SID.polarity_scores(i)['neu']
    l = SID.polarity_scores(i)['pos']
    m = SID.polarity_scores(i)['compound']
    negitive.append(j)
    positive.append(k)
    neutral.append(l)
    compound.append(m)
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 50000/50000 [28
:14<00:00, 29.51it/s]
```

In [29]:

```
project_data['negitive'] = negitive
project_data['positive'] = positive
project_data['neutral'] = neutral
```

```
project_data['compound'] = compound
```

In [30]:

```
project_data.head()
```

Out[30]:

	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
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grade
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Grades P
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Grades P

5 rows × 24 columns

1.5 Preparing data for models

In [31]:

```
project_data.columns
```

Out[31]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', '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',
       'clean_categories', 'clean_subcategories', 'essay', 'title_word_count',
       'essay_word_count', 'negitive', 'positive', 'neutral', 'compound'],
      dtype='object')
```

we are going to consider

```
- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- project_grade_category : categorical data
- teacher_prefix : categorical data

- project_title : text data
- text : text data
- project resource summary: text data (optinal)
```

- quantity : numerical (optinal)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

In [33]:

```
from sklearn.model_selection import train_test_split
```

In [34]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
#Splitting data into Train and cross validation
# split the data set into train and test
x_train, x_test, y_train, y_test = train_test_split(project_data,
project_data['project_is_approved'],
                                                    test_size = 0.33, stratify = project_data['proj
t_is_approved'],
                                                    random_state = 42)
# split the train data set into cross validation train and cross validation test
x_train, x_cv, y_train, y_cv = train_test_split(x_train, y_train, test_size = 0.33, stratify = y_tr
ain,
                                                random_state = 42)
```

In [35]:

```
print(x_train.shape,y_train.shape)
print(x_test.shape,y_test.shape)
print(x_cv.shape,y_cv.shape)
```

```
(22445, 24) (22445,)
(16500, 24) (16500,)
(11055, 24) (11055,)
```

In [36]:

```
print(x_train.columns)
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', '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',
       'clean_categories', 'clean_subcategories', 'essay', 'title_word_count',
       'essay_word_count', 'negitive', 'positive', 'neutral', 'compound'],
      dtype='object')
```

In [37]:

```
#Dropping Class Label in train test and cv data
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)
```

In [42]:

```
#preprocessing of train ,cross validation and test essay data
```

In [38]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_essay_train_data = []
# tqdm is for printing the status bar
for sentance in tqdm(x_train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
```

```
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280aq`
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essay_train_data.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445 [00:
49<00:00, 455.01it/s]
```

In [39]:

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

```
100%|████████████████████████████████████████████████████████████████| 16500/16500 [00:
31<00:00, 520.48it/s]
```

In [40]:

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

```
100%|████████████████████████████████████████████████████████████████| 11055/11055 [00:
22<00:00, 487.58it/s]
```

In [46]:

```
#preprocessing of x_train,x_cv and x_test of project title
```

In [41]:

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

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:02<00:00, 10215.62it/s]
```

In [42]:

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

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:01<00:00, 10052.59it/s]
```

In [43]:

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

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:01<00:00, 9704.27it/s]
```

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/

In [50]:

```
#vectorisation of clean categories
```

In [44]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vect_categories= CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=
True)
vect_categories.fit(project_data['clean_categories'].values)

train_categories_one_hot=vect_categories.transform(x_train['clean_categories'].values)
cv_categories_one_hot=vect_categories.transform(x_cv['clean_categories'].values)
test_categories_one_hot=vect_categories.transform(x_test['clean_categories'].values)

print(vect_categories.get_feature_names())
print("Shape of train matrix after one hot encodig ",train_categories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_categories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of train matrix after one hot encodig  (22445, 9)
Shape of train matrix after one hot encodig  (11055, 9)
Shape of train matrix after one hot encodig  (16500, 9)
```

In [45]:

```
cat_feature=vect_categories.get_feature_names()
len(cat_feature)
```

Out[45]:

9

In [53]:

```
#vectorisation of clean subcategories
```

In [46]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_subcategories= CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=F
alse, binary=True)
vectorizer_subcategories.fit(project_data['clean_subcategories'].values)

train_subcategories_one_hot=vectorizer_subcategories.transform(x_train['clean_subcategories'].valu
es)
cv_subcategories_one_hot=vectorizer_subcategories.transform(x_cv['clean_subcategories'].values)
test_subcategories_one_hot=vectorizer_subcategories.transform(x_test['clean_subcategories'].values
)

print(vectorizer_subcategories.get_feature_names())
print("Shape of train matrix after one hot encodig ",train_subcategories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_subcategories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_subcategories_one_hot.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 train matrix after one hot encodig  (22445, 30)
Shape of train matrix after one hot encodig  (11055, 30)
Shape of train matrix after one hot encodig  (16500, 30)
```

In [47]:

```
subcat_feature=vectorizer_subcategories.get_feature_names()
len(subcat_feature)
```

Out[47]:

30

In [56]:

```
# Build the data matrix using these features-- school_state : categorical data (one hot encoding)
##Encoding for school state
```

In [48]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
from collections import Counter
my_counter = Counter()
for word in project_data['school_state'].values:
    my_counter.update(word.split())

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict_state = dict(my_counter)
sorted_cat_dict_state = dict(sorted(cat_dict_state.items(), key=lambda kv: kv[1]))


from sklearn.feature_extraction.text import CountVectorizer
```

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_state = CountVectorizer(vocabulary=list(sorted_cat_dict_state.keys()), lowercase=False,
binary=True)
vectorizer_state.fit(project_data['school_state'].values)

train_state_one_hot=vectorizer_state.transform(x_train['school_state'].values)
cv_state_one_hot=vectorizer_state.transform(x_cv['school_state'].values)
test_state_one_hot=vectorizer_state.transform(x_test['school_state'].values)

print(vectorizer_state.get_feature_names())
print("Shape of train matrix after one hot encodig ",train_state_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_state_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_state_one_hot.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', 'CT', 'TN', '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 train matrix after one hot encodig  (22445, 51)
Shape of train matrix after one hot encodig  (11055, 51)
Shape of train matrix after one hot encodig  (16500, 51)
```

In [49]:

```
state_feature=vectorizer_state.get_feature_names()
len(state_feature)
```

Out[49]:

```
51
```

In [59]:

```
#Encoding for project_grade_category
```

In [50]:

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

Out[50]:

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

In [51]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039

from collections import Counter
my_counter = Counter()
for word in project_data['project_grade_category']:
    my_counter.update(word.split())

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict_grade = dict(my_counter)
sorted_cat_dict_grade = dict(sorted(cat_dict_grade.items(), key=lambda kv: kv[1]))
print(sorted_cat_dict_grade)

# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_grade_cat = CountVectorizer(vocabulary=list(sorted_cat_dict_grade.keys()), lowercase=Fa
lse, binary=True)
vectorizer_grade_cat.fit(project_data['project_grade_category'].values)

train_grade_one_hot=vectorizer_grade_cat.transform(x_train['project_grade_category'].values)
cv_grade_one_hot=vectorizer_grade_cat.transform(x_cv['project_grade_category'].values)
test_grade_one_hot=vectorizer_grade_cat.transform(x_test['project_grade_category'].values)
```

```
print(vectorizer_grade_cat.get_feature_names())
print("Shape of train matrix after one hot encodig ",train_grade_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_grade_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_grade_one_hot.shape)
```

```
{'Grades_9_12': 4966, 'Grades_6_8': 7750, 'Grades_3_5': 16968, 'Grades_PreK_2': 20316}
['Grades_9_12', 'Grades_6_8', 'Grades_3_5', 'Grades_PreK_2']
Shape of train matrix after one hot encodig  (22445, 4)
Shape of train matrix after one hot encodig  (11055, 4)
Shape of train matrix after one hot encodig  (16500, 4)
```

In [52]:

```
grade_feature=vectorizer_grade_cat.get_feature_names()
len(grade_feature)
```

Out[52]:

```
4
```

In [63]:

```
#Encoding for teacher_prefix
```

In [53]:

```
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna("")
```

In [55]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039

from collections import Counter
my_counter = Counter()
for word in project_data['teacher_prefix']:
    my_counter.update(word.split())

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict_prefix = dict(my_counter)
sorted_cat_dict_prefix = dict(sorted(cat_dict_prefix.items(), key=lambda kv: kv[1]))


# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_teacher_prefix = CountVectorizer(vocabulary=list(sorted_cat_dict_prefix.keys()), lowerc
ase=False, binary=True)
vectorizer_teacher_prefix.fit(project_data['teacher_prefix'].values.astype('U'))

train_teacher_prefix_one_hot=vectorizer_teacher_prefix.transform(x_train['teacher_prefix'].values.
astype('U'))
cv_teacher_prefix_one_hot=vectorizer_teacher_prefix.transform(x_cv['teacher_prefix'].values.astype
('U'))
test_teacher_prefix_one_hot=vectorizer_teacher_prefix.transform(x_test['teacher_prefix'].values.as
type('U'))

print(vectorizer_teacher_prefix.get_feature_names())
print("Shape of train matrix after one hot encodig ",train_teacher_prefix_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_teacher_prefix_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_teacher_prefix_one_hot.shape)
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of train matrix after one hot encodig  (22445, 5)
Shape of train matrix after one hot encodig  (11055, 5)
Shape of train matrix after one hot encodig  (16500, 5)
```

In [56]:

```
teacher_feature=vectorizer_teacher_prefix.get_feature_names()
len(teacher_feature)
```

```
len(teacher_feature)
```

Out[56]:

```
5
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [57]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_essay_bow = CountVectorizer(min_df=10)
vectorizer_essay_bow.fit(preprocessed_essay_train_data)

text_bow_essays_train = vectorizer_essay_bow.transform(preprocessed_essay_train_data)
print("Shape of matrix after one hot encodig ",text_bow_essays_train.shape)
```

```
Shape of matrix after one hot encodig  (22445, 8869)
```

In [58]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
text_bow_essays_cv = vectorizer_essay_bow.transform(preprocessed_essay_cv_data)
print("Shape of matrix after one hot encodig ",text_bow_essays_cv.shape)
```

```
Shape of matrix after one hot encodig  (11055, 8869)
```

In [59]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
text_bow_essays_test= vectorizer_essay_bow.transform(preprocessed_essay_test_data)
print("Shape of matrix after one hot encodig ",text_bow_essays_test.shape)
```

```
Shape of matrix after one hot encodig  (16500, 8869)
```

In [60]:

```
bow_eassay_feature=vectorizer_essay_bow.get_feature_names()
len(bow_eassay_feature)
```

Out[60]:

```
8869
```

In [71]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

In [61]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_bow_title = CountVectorizer(min_df=10)
vectorizer_bow_title.fit(train_preprocessed_project_title)

text_bow_title_train= vectorizer_bow_title.transform(train_preprocessed_project_title)
print("Shape of matrix after one hot encodig ",text_bow_title_train.shape)
```

```
Shape of matrix after one hot encodig  (22445, 1229)
```

In [62]:

```
text_bow_title_cv=vectorizer_bow_title.transform(cv_preprocessed_project_title)
```

```
print("Shape of matrix after one hot encodig ",text_bow_title_cv.shape)
```

```
Shape of matrix after one hot encodig  (11055, 1229)
```

In [63]:

```
text_bow_title_test= vectorizer_bow_title.transform(test_preprocessed_project_title)
print("Shape of matrix after one hot encodig ",text_bow_title_test.shape)
```

```
Shape of matrix after one hot encodig  (16500, 1229)
```

In [64]:

```
bow_title_feature=vectorizer_bow_title.get_feature_names()
len(bow_title_feature)
```

Out[64]:

```
1229
```

1.5.2.2 TFIDF vectorizer

In [65]:

```
# Similarly you can vectorize for title also
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(train_preprocessed_project_title)

text_tfidf_title_train = vectorizer.transform(train_preprocessed_project_title)
print("Shape of matrix after one hot encodig ",text_tfidf_title_train.shape)
```

```
Shape of matrix after one hot encodig  (22445, 1229)
```

In [66]:

```
# Similarly you can vectorize for title
text_tfidf_title_cv = vectorizer.transform(cv_preprocessed_project_title)
print("Shape of matrix after one hot encodig ",text_tfidf_title_cv.shape)
```

```
Shape of matrix after one hot encodig  (11055, 1229)
```

In [67]:

```
# Similarly you can vectorize for title also
text_tfidf_title_test = vectorizer.transform(test_preprocessed_project_title)
print("Shape of matrix after one hot encodig ",text_tfidf_title_test.shape)
```

```
Shape of matrix after one hot encodig  (16500, 1229)
```

In [68]:

```
title_tfidf_feature=vectorizer.get_feature_names()
len(title_tfidf_feature)
```

Out[68]:

```
1229
```

TFIDF Vectorizer on preprocessed essay

In [69]:

```
# Similarly you can vectorize for title also
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(preprocessed_essay_train_data)

tfidf_essay_train = vectorizer.transform(preprocessed_essay_train_data)
print("Shape of matrix after one hot encodig ",tfidf_essay_train.shape)
```

```
Shape of matrix after one hot encodig  (22445, 8869)
```

In [70]:

```
# Similarly you can vectorize for title also
tfidf_essay_cv = vectorizer.transform(preprocessed_essay_cv_data)
print("Shape of matrix after one hot encodig ",tfidf_essay_cv.shape)
```

```
Shape of matrix after one hot encodig  (11055, 8869)
```

In [71]:

```
tfidf_essay_test = vectorizer.transform(preprocessed_essay_test_data)
print("Shape of matrix after one hot encodig ",tfidf_essay_test.shape)
```

```
Shape of matrix after one hot encodig  (16500, 8869)
```

In [72]:

```
tfidf_essay_feature=vectorizer.get_feature_names()
len(tfidf_essay_feature)
```

Out[72]:

```
8869
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [77]:

```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

# ============================
Output:

Loading Glove Model
1917495it [06:32, 4879.69it/s]
Done. 1917495  words loaded!

# ============================

words = []
for i in preproced_texts:
    words.extend(i.split(' '))

for i in preproced_titles:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
```

```
print("the unique words in the coupus", len(words))

inter_words = set(model.keys()).intersection(words)
print("The number of words that are present in both glove vectors and our coupus", \
      len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")

words_courpus = {}
words_glove = set(model.keys())
for i in words:
    if i in words_glove:
        words_courpus[i] = model[i]
print("word 2 vec length", len(words_courpus))


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_courpus, f)


'''
```

Out[77]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef
loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\',
encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n
word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        m
odel[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel =
loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n#
============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\'
\'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the
coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus",
len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words tha
t are present in both glove vectors and our coupus",       len(inter_words),"
(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove =
set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\r
print("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python
: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pic
kle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [79]:

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

In [80]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essay_train_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_train_data): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_train_data.append(vector)

print(len(avg_w2v_essay_train_data))
print(len(avg_w2v_essay_train_data[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 22445/22445
[00:21<00:00, 1067.65it/s]
```

```
22445
300
```

In [81]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essay_cv_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_cv_data): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_cv_data.append(vector)

print(len(avg_w2v_essay_cv_data))
print(len(avg_w2v_essay_cv_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055 [00:
15<00:00, 722.20it/s]
```

```
11055
300
```

In [82]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essay_test_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_test_data): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_test_data.append(vector)

print(len(avg_w2v_essay_test_data))
print(len(avg_w2v_essay_test_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:15<00:00, 1046.32it/s]
```

```
16500
300
```

In [90]:

```
#Using Pretrained Models: Avg W2V for project title
```

In [84]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_project_title_train_data = []; # the avg-w2v for each sentence/review is stored in this li
st
for sentence in tqdm(train_preprocessed_project_title): # 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]
```

```
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_project_title_train_data.append(vector)

print(len(avg_w2v_project_title_train_data))
print(len(avg_w2v_project_title_train_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:01<00:00, 18807.35it/s]
```

```
22445
300
```

In [85]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_project_title_cv_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(cv_preprocessed_project_title): # 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_project_title_cv_data.append(vector)

print(len(avg_w2v_project_title_cv_data))
print(len(avg_w2v_project_title_cv_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 20605.01it/s]
```

```
11055
300
```

In [86]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_project_title_test_data = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(test_preprocessed_project_title): # 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_project_title_test_data.append(vector)

print(len(avg_w2v_project_title_test_data))
print(len(avg_w2v_project_title_test_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 19848.33it/s]
```

```
16500
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [88]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essay_train_data)
# 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 [89]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essay_train_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_train_data): # 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_essay_train_data.append(vector)

print(len(tfidf_w2v_essay_train_data))
print(len(tfidf_w2v_essay_train_data[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 22445/22445 [02:
33<00:00, 146.49it/s]
```

```
22445
300
```

In [90]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essay_cv_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_cv_data): # 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_essay_cv_data.append(vector)

print(len(tfidf_w2v_essay_cv_data))
print(len(tfidf_w2v_essay_cv_data[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055 [01:
20<00:00, 137.30it/s]
```

```
11055
300
```

In [91]:

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

```
tfidf_w2v_essay_test_data = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essay_test_data): # 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_essay_test_data.append(vector)

print(len(tfidf_w2v_essay_test_data))
print(len(tfidf_w2v_essay_test_data[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500 [02:
04<00:00, 132.35it/s]
```

```
16500
300
```

In [98]:

```
# Similarly you can vectorize for title also
```

In [92]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(train_preprocessed_project_title)
# 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 [93]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_project_title_train_data = []; # the avg-w2v for each sentence/review is stored in this
list
for sentence in tqdm(train_preprocessed_project_title): # 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_project_title_train_data.append(vector)

print(len(tfidf_w2v_project_title_train_data ))
print(len(tfidf_w2v_project_title_train_data [0]))
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:02<00:00, 8191.13it/s]
```

```
22445
300
```

In [94]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_project_title_cv_data = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(cv_preprocessed_project_title): # 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_project_title_cv_data.append(vector)

print(len(tfidf_w2v_project_title_cv_data))
print(len(tfidf_w2v_project_title_cv_data[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055
[00:01<00:00, 9044.82it/s]
```

```
11055
300
```

In [95]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_project_title_test_data = []; # the avg-w2v for each sentence/review is stored in this l
ist
for sentence in tqdm(test_preprocessed_project_title): # 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_project_title_test_data.append(vector)

print(len(tfidf_w2v_project_title_test_data))
print(len(tfidf_w2v_project_title_test_data[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 16500/16500
[00:01<00:00, 9483.00it/s]
```

```
16500
300
```

In [96]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [97]:

```
project_data.head(2)
```

Out[97]:

	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_Pr
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades

2 rows × 26 columns

In [98]:

```
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")
```

In [99]:

```
x_train.columns
```

Out[99]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'title_word_count', 'essay_word_count',
       'negitive', 'positive', 'neutral', 'compound', 'price', 'quantity'],
      dtype='object')
```

Standardize Price

In [100]:

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

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()

price_scalar.fit(x_train['price'].values.reshape(-1,1)) # finding the mean and standard deviation
of this data
print(f"TRAIN -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_price_standar = price_scalar.transform(x_train['price'].values.reshape(-1, 1))

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

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

```
TRAIN -> Mean : 297.71562753397194, Standard deviation : 373.5890845438879
TEST -> Mean : 301.40470666666664, Standard deviation : 387.6948484063583
CV -> Mean : 299.52771506105836, Standard deviation : 373.1478347400019
```

In [101]:

```
print(train_price_standar.shape, y_train.shape)
print(test_price_standar.shape, y_test.shape)
print(cv_price_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [102]:

```
print(price_scalar.get_params)
```

```
<bound method BaseEstimator.get_params of StandardScaler(copy=True, with_mean=True,
with_std=True)>
```

teacher_number_of_previously_posted_projects

In [103]:

```
warnings.filterwarnings("ignore")
price_scalar.fit(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # fi
nding the mean and standard deviation of this data
print(f"TRAIN -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_prev_proj_standar =
price_scalar.transform(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))

price_scalar.fit(x_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # fin
ding the mean and standard deviation of this data
print(f"TEST -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
test_prev_proj_standar =
price_scalar.transform(x_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1)
)

price_scalar.fit(x_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # findi
ng the mean and standard deviation of this data
print(f"CV -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
cv_prev_proj_standar = price_scalar.transform(x_cv['teacher_number_of_previously_posted_projects']
.values.reshape(-1, 1))
```

```
TRAIN -> Mean : 11.66473602138561, Standard deviation : 29.394684894505467
TEST -> Mean : 10.824363636363636, Standard deviation : 26.94848396907338
CV -> Mean : 11.040253279059248, Standard deviation : 27.32928192601594
```

In [104]:

```
print(train_prev_proj_standar.shape, y_train.shape)
print(test_prev_proj_standar.shape, y_test.shape)
print(cv_prev_proj_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [105]:

```
print(price_scalar.get_params)
```

```
<bound method BaseEstimator.get_params of StandardScaler(copy=True, with_mean=True,
with_std=True)>
```

Standardize Quantity

In [106]:

```
price_scalar.fit(x_train['quantity'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"TRAIN -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_quantity_standar = price_scalar.transform(x_train['quantity'].values.reshape(-1, 1))

price_scalar.fit(x_test['quantity'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"TEST -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
test_quantity_standar = price_scalar.transform(x_test['quantity'].values.reshape(-1, 1))

price_scalar.fit(x_cv['quantity'].values.reshape(-1,1)) # finding the mean and standard deviation
of this data
print(f"CV -> Mean : {price_scalar.mean_[0]}, Standard deviation :
{np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
cv_quantity_standar = price_scalar.transform(x_cv['quantity'].values.reshape(-1, 1))
```

```
TRAIN -> Mean : 17.001470260637113, Standard deviation : 26.03701886058425
TEST -> Mean : 17.05290909090909, Standard deviation : 27.494020077501187
CV -> Mean : 17.173224785165083, Standard deviation : 27.30705061932881
```

In [107]:

```
print(train_quantity_standar.shape, y_train.shape)
print(test_quantity_standar.shape, y_test.shape)
print(cv_quantity_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [115]:

```
#standerdrise the tittle word count
```

In [108]:

```
title_scalar = StandardScaler()
title_scalar.fit(x_train['title_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"Mean : {title_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
train_title_word_count_standar = title_scalar.transform(x_train['title_word_count'].values.reshape
(-1, 1))

title_scalar.fit(x_test['title_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"Mean : {title_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
```

```
test_title_word_count_standar = title_scalar.transform(x_test['title_word_count'].values.reshape(-1
, 1))

title_scalar.fit(x_cv['title_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"Mean : {title_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
cv_title_word_count_standar = title_scalar.transform(x_cv['quantity'].values.reshape(-1, 1))

print(train_title_word_count_standar.shape, y_train.shape)
print(test_title_word_count_standar.shape, y_test.shape)
print(cv_title_word_count_standar.shape, y_cv.shape)
```

```
Mean : 5.215103586544887, Standard deviation : 27.30705061932881
Mean : 5.2118787878787876, Standard deviation : 27.30705061932881
Mean : 5.2236996834011755, Standard deviation : 27.30705061932881
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [117]:

```
#standerise the essay wordcount
```

In [109]:

```
essay_scalar = StandardScaler()

essay_scalar.fit(x_train['essay_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
train_essay_word_count_standar = essay_scalar.transform(x_train['essay_word_count'].values.reshape
(-1, 1))

essay_scalar.fit(x_train['essay_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
test_essay_word_count_standar = essay_scalar.transform(x_test['essay_word_count'].values.reshape(-1
, 1))

essay_scalar.fit(x_cv['essay_word_count'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
cv_essay_word_count_standar = essay_scalar.transform(x_cv['essay_word_count'].values.reshape(-1, 1)
)

print(train_essay_word_count_standar.shape, y_train.shape)
print(test_essay_word_count_standar.shape, y_test.shape)
print(cv_essay_word_count_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [119]:

```
#standerise  Positive Intensity
```

In [110]:

```
essay_scalar.fit(x_train['positive'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
train_positive_standar = essay_scalar.transform(x_train['positive'].values.reshape(-1, 1))

essay_scalar.fit(x_train['positive'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
test_positive_standar = essay_scalar.transform(x_test['positive'].values.reshape(-1, 1))

essay_scalar.fit(x_cv['positive'].values.reshape(-1,1)) # finding the mean and standard deviation
of this data
cv_positive_standar = essay_scalar.transform(x_cv['positive'].values.reshape(-1, 1))

print(train_positive_standar.shape, y_train.shape)
print(test_positive_standar.shape, y_test.shape)
print(cv_positive_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [111]:

```
#standerise  negative Intensity
```

In [112]:

```
essay_scalar.fit(x_train['negitive'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
train_negitive_standar = essay_scalar.transform(x_train['negitive'].values.reshape(-1, 1))

essay_scalar.fit(x_train['negitive'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
test_negitive_standar = essay_scalar.transform(x_test['negitive'].values.reshape(-1, 1))

essay_scalar.fit(x_cv['negitive'].values.reshape(-1,1)) # finding the mean and standard deviation
of this data
cv_negitive_standar = essay_scalar.transform(x_cv['negitive'].values.reshape(-1, 1))

print(train_negitive_standar.shape, y_train.shape)
print(test_negitive_standar.shape, y_test.shape)
print(cv_negitive_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [123]:

```
#Standardize Neutral Intensity
```

In [113]:

```
essay_scalar.fit(x_train['neutral'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
train_neutral_standar = essay_scalar.transform(x_train['neutral'].values.reshape(-1, 1))

essay_scalar.fit(x_train['neutral'].values.reshape(-1,1))
test_neutral_standar = essay_scalar.transform(x_test['neutral'].values.reshape(-1, 1))

essay_scalar.fit(x_cv['neutral'].values.reshape(-1,1)) # finding the mean and standard deviation o
f this data
cv_neutral_standar = essay_scalar.transform(x_cv['neutral'].values.reshape(-1, 1))

print(train_neutral_standar.shape, y_train.shape)
print(test_neutral_standar.shape, y_test.shape)
print(cv_neutral_standar.shape, y_cv.shape)
```

```
(22445, 1) (22445,)
(16500, 1) (16500,)
(11055, 1) (11055,)
```

In [125]:

```
#merging all data together
```

In [114]:

```
print("Shape of train matrix after one hot encodig ",train_categories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_categories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_categories_one_hot.shape)

print("Shape of train matrix after one hot encodig ",train_subcategories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_subcategories_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_subcategories_one_hot.shape)
```

```
print("Shape of train matrix after one hot encodig ",train_state_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_state_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_state_one_hot.shape)

print("Shape of train matrix after one hot encodig ",train_grade_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_grade_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_grade_one_hot.shape)

print("Shape of train matrix after one hot encodig ",train_teacher_prefix_one_hot.shape)
print("Shape of train matrix after one hot encodig ",cv_teacher_prefix_one_hot.shape)
print("Shape of train matrix after one hot encodig ",test_teacher_prefix_one_hot.shape)

print("Shape of matrix after one hot encodig ",text_bow_essays_train.shape)
print("Shape of matrix after one hot encodig ",text_bow_essays_cv.shape)
print("Shape of matrix after one hot encodig ",text_bow_essays_test.shape)

print("Shape of matrix after one hot encodig ",text_bow_title_train.shape)
print("Shape of matrix after one hot encodig ",text_bow_title_cv.shape)
print("Shape of matrix after one hot encodig ",text_bow_title_test.shape)

print("Shape of matrix after one hot encodig ",text_tfidf_title_train.shape)
print("Shape of matrix after one hot encodig ",text_tfidf_title_cv.shape)
print("Shape of matrix after one hot encodig ",text_tfidf_title_test.shape)

print("Shape of matrix after one hot encodig ",tfidf_essay_train.shape)
print("Shape of matrix after one hot encodig ",tfidf_essay_cv.shape)
print("Shape of matrix after one hot encodig ",tfidf_essay_test.shape)
```

```
Shape of train matrix after one hot encodig  (22445, 9)
Shape of train matrix after one hot encodig  (11055, 9)
Shape of train matrix after one hot encodig  (16500, 9)
Shape of train matrix after one hot encodig  (22445, 30)
Shape of train matrix after one hot encodig  (11055, 30)
Shape of train matrix after one hot encodig  (16500, 30)
Shape of train matrix after one hot encodig  (22445, 51)
Shape of train matrix after one hot encodig  (11055, 51)
Shape of train matrix after one hot encodig  (16500, 51)
Shape of train matrix after one hot encodig  (22445, 4)
Shape of train matrix after one hot encodig  (11055, 4)
Shape of train matrix after one hot encodig  (16500, 4)
Shape of train matrix after one hot encodig  (22445, 5)
Shape of train matrix after one hot encodig  (11055, 5)
Shape of train matrix after one hot encodig  (16500, 5)
Shape of matrix after one hot encodig  (22445, 8869)
Shape of matrix after one hot encodig  (11055, 8869)
Shape of matrix after one hot encodig  (16500, 8869)
Shape of matrix after one hot encodig  (22445, 1229)
Shape of matrix after one hot encodig  (11055, 1229)
Shape of matrix after one hot encodig  (16500, 1229)
Shape of matrix after one hot encodig  (22445, 1229)
Shape of matrix after one hot encodig  (11055, 1229)
Shape of matrix after one hot encodig  (16500, 1229)
Shape of matrix after one hot encodig  (22445, 8869)
Shape of matrix after one hot encodig  (11055, 8869)
Shape of matrix after one hot encodig  (16500, 8869)
```

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 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

2. Decision Tree

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

In [127]:

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

2.2 Make Data Model Ready: encoding numerical, categorical features

In [128]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [129]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

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

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

In [130]:

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

2.4.1 Applying Decision Trees on BOW, SET 1

In [131]:

```
# Please write all the code with proper documentation
```

In [132]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train1 =
hstack((train_categories_one_hot,train_subcategories_one_hot,train_state_one_hot,train_grade_one_hot,
                  train_teacher_prefix_one_hot,text_bow_essays_train, text_bow_title_train, train_quantity_standar,
                  train_prev_proj_standar, train_price_standar,train_title_word_count_standar,
                  train_essay_word_count_standar, train_positive_standar, train_negitive_standar,
                  train_neutral_standar)).tocsr()
print(X_train1.shape, y_train.shape)
print(type(X_train1))
```

```
(22445, 10205) (22445,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [133]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_cv1 = hstack((cv_categories_one_hot,cv_subcategories_one_hot,cv_state_one_hot,cv_grade_one_hot,
                  cv_teacher_prefix_one_hot,text_bow_essays_cv, text_bow_title_cv,
```

```
cv_quantity_standar,
                  cv_prev_proj_standar, cv_price_standar, cv_title_word_count_standar,
                  cv_essay_word_count_standar, cv_positive_standar, cv_negitive_standar,
                  cv_neutral_standar)).tocsr()
print(X_cv1.shape, y_cv.shape)
print(type(X_cv1))
```

```
(11055, 10205) (11055,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [134]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_test1 =
hstack((test_categories_one_hot,test_subcategories_one_hot,test_state_one_hot,test_grade_one_hot,
                  test_teacher_prefix_one_hot,text_bow_essays_test, text_bow_title_test,
test_quantity_standar,
                  test_prev_proj_standar, test_price_standar, test_title_word_count_standar,
                  test_essay_word_count_standar, test_positive_standar, test_negitive_standar,
                  test_neutral_standar)).tocsr()
print(X_test1.shape, y_test.shape)
print(type(X_test1))
```

```
(16500, 10205) (16500,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [135]:

```
#HYperparamter tunning using Gridesearch
```

In [136]:

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
import seaborn as sea
```

In [137]:

```
DT = DecisionTreeClassifier( class_weight = 'balanced',random_state=0)

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc', n_jobs=-1, verbose=1)
classifier.fit(X_train1, y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits
```

```
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed:    9.3s
[Parallel(n_jobs=-1)]: Done  72 out of  72 | elapsed:  1.3min finished
```

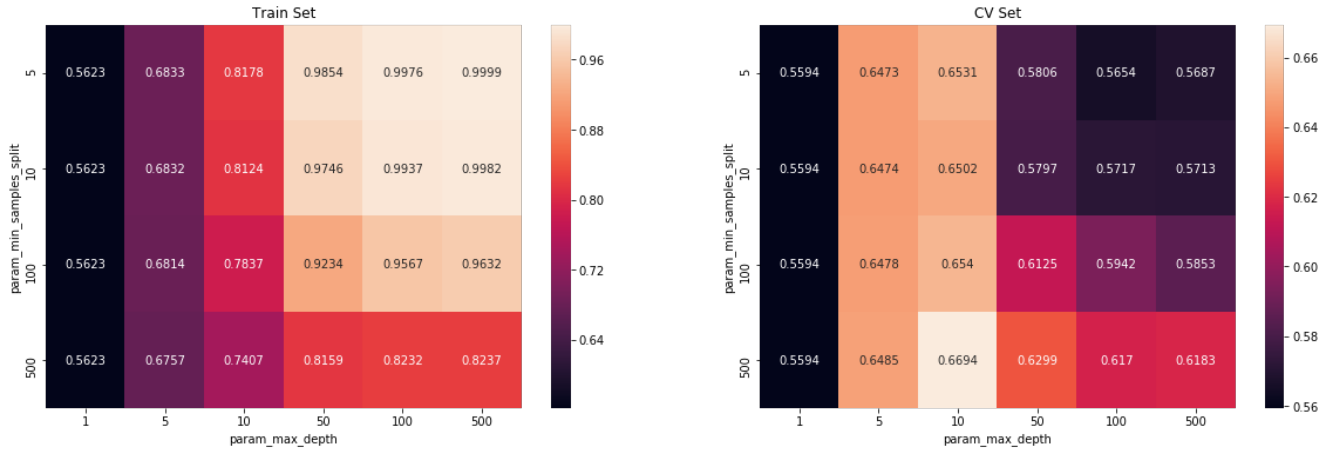
Out[137]:

```
GridSearchCV(cv=3, error_score='raise',
       estimator=DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=None, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=0,
            splitter='best'),
       fit_params=None, iid=True, n_jobs=-1,
       param_grid={'max_depth': [1, 5, 10, 50, 100, 500], 'min_samples_split': [5, 10, 100, 500]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='roc_auc', verbose=1)
```

In [138]:

```
max_scores = pd.DataFrame(classifier.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))

sea.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sea.heatmap(max_scores.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 [139]:

```
#traning the model using best hyper paramter
```

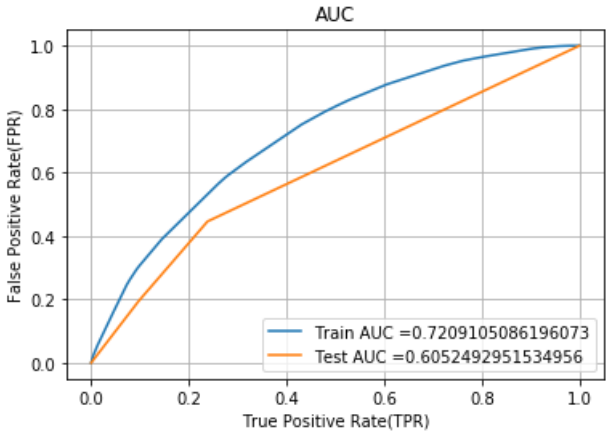
In [140]:

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

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [141]:

```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(max_depth = 10, min_samples_split = 500)
classifier_viz = DecisionTreeClassifier(max_depth = 2, min_samples_split = 500)

classifier.fit(X_train1, y_train)
classifier_viz.fit(X_train1, y_train)

y_train_pred = batch_predict(classifier,X_train1)
y_test_pred = batch_predict(classifier_viz,X_test1)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
```

```
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



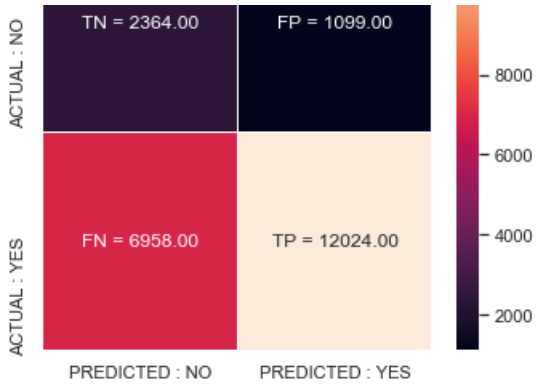
In [142]:

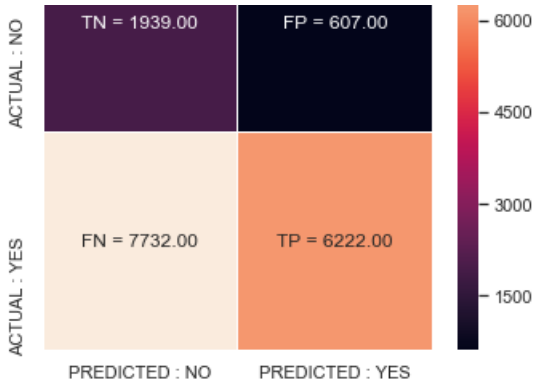
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [143]:

```
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.43241622312342776 for threshold 0.861
the maximum value of tpr*(1-fpr) 0.33958671973596105 for threshold 0.887
```





In [144]:

```
#false positive rate
```

In [145]:

```
BOW_essay_text=text_bow_essays_test.todense()
print(BOW_essay_text.shape)
len(bow_eassay_feature)
```

```
(16500, 8869)
```

Out[145]:

```
8869
```

In [146]:

```
y_test_data = list(y_test[::])
len(y_test_data)
```

Out[146]:

```
16500
```

In [147]:

```
fp_index = []
fp_count = 0

for i in range(len(y_test_pred)):
    if y_test_data[i] == 0 and y_test_pred[i] <= 0.9:
        fp_index.append(i)
        fp_count = fp_count + 1
    else :
        pass
print(fp_count)
```

```
2546
```

In [148]:

```
fp_index[0:10]
```

Out[148]:

```
[0, 2, 3, 9, 14, 15, 20, 23, 26, 43]
```

In [149]:

```
df1 = pd.DataFrame(BOW_essay_text)
```

In [150]:

In [150]:

```
df1_final = df1.iloc[fp_index,:]
print(df1_final.shape)
```

```
(2546, 8869)
```

In [151]:

```
best_indices = []

for j in range(8869):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
```

In [152]:

```
len(best_indices)
```

Out[152]:

```
598
```

In [153]:

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

Out[153]:

```
[3, 45, 105, 161, 162, 163, 182, 183, 194, 234]
```

In [156]:

```
%%script false
fp_words = []

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

In [159]:

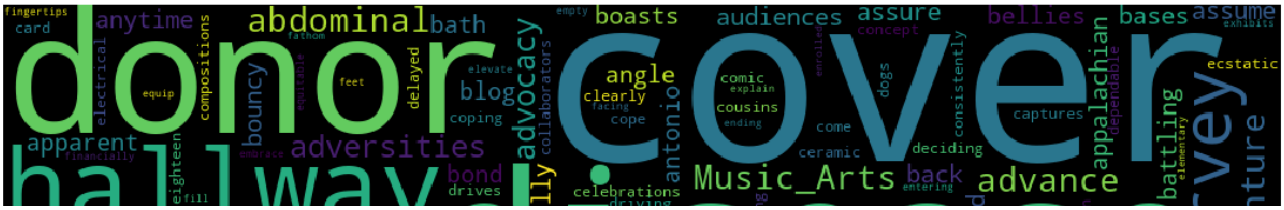
```
fp_words[0:10]
```

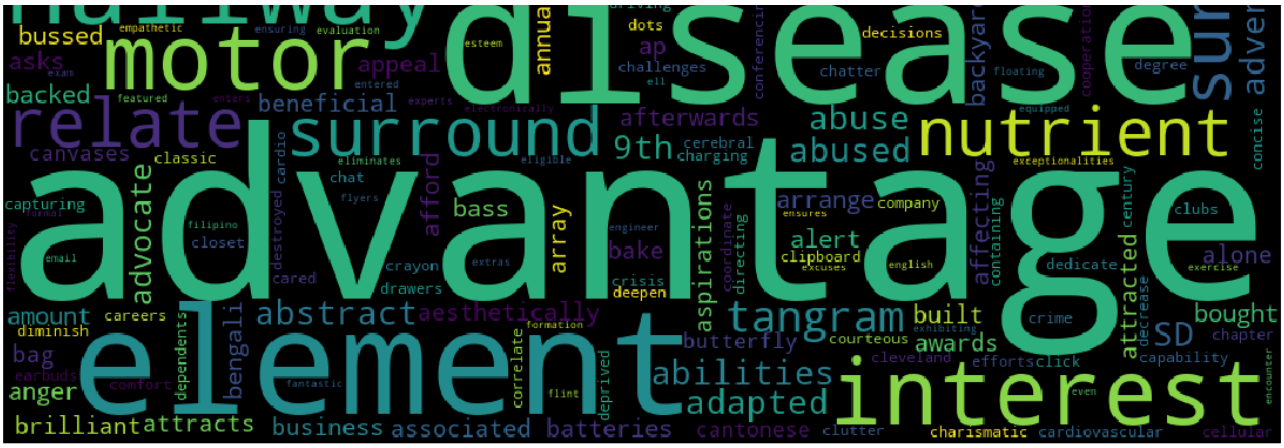
Out[159]:

```
['Music_Arts', 'SD', '11', '32', '320', '33', '44', '45', '51', '82']
```

In [163]:

```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```





BOX & PDF plot of false postive rate

In [160]:

```
df = pd.DataFrame(x_test['price'])
print(df.head(2))
```

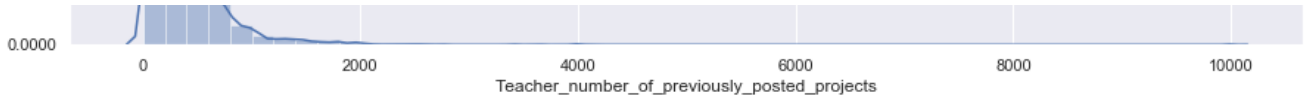
```
    price
0  337.18
1   89.49
```

In [161]:

```
plt.figure(figsize=(15,3))
df1 = df.iloc[fp_index, : ]
sea.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positive data points")
plt.xlabel("Price")
plt.show()
```

In [162]:

```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```



2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [139]:

```
BOW_feature=cat_feature+subcat_feature+state_feature+grade_feature+teacher_feature+bow_eassay_featu
re+bow_title_feature
```

In [140]:

```
len(BOW_feature)
```

Out[140]:

```
10197
```

In [159]:

```
BOW_feature.append('price')
BOW_feature.append('teacher_number_of_previously_posted_projects')
BOW_feature.append('quantity')
BOW_feature.append('title_word_count')
BOW_feature.append('essay_word_count')
BOW_feature.append('positive')
BOW_feature.append('negitive')
BOW_feature.append('neutral')
```

In [160]:

```
len(BOW_feature)
```

Out[160]:

```
10205
```

In [161]:

```
print(classifier_viz.n_features_)
```

```
10205
```

In [162]:

```
import graphviz
from sklearn import tree
from graphviz import Source

dot_data = tree.export_graphviz(classifier_viz, out_file=None, feature_names=BOW_feature)
graph = graphviz.Source(dot_data)
graph.render("Bow tree",view = True)
```

Out[162]:

```
'Bow tree.pdf'
```

In [164]:

```
# Please write all the code with proper documentation
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus

dot_data = StringIO()
```

```
export_graphviz(classifier_viz, out_file=dot_data, filled=True, rounded=True, special_characters=Tr
ue, feature_names=BOW_feature)

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
graph.write_pdf('graph1.pdf')
```

Out[164]:

```
True
```

2.4.2 Applying Decision Trees on TFIDF, SET 2

In [165]:

```
# Please write all the code with proper documentation
```

In [166]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train2 = hstack((train_categories_one_hot,train_subcategories_one_hot,train_state_one_hot,
                   train_grade_one_hot,train_teacher_prefix_one_hot,tfidf_essay_train,
                   text_tfidf_title_train, train_quantity_standar,
                   train_prev_proj_standar, train_price_standar, train_title_word_count_standar,
                   train_essay_word_count_standar, train_positive_standar, train_negitive_standar,
                   train_neutral_standar)).tocsr()
print(X_train2.shape, y_train.shape)
print(type(X_train2))
```

```
(22445, 10205) (22445,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [167]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_cv2 = hstack((cv_categories_one_hot,cv_subcategories_one_hot,cv_state_one_hot,
                cv_grade_one_hot,cv_teacher_prefix_one_hot,tfidf_essay_cv,
                text_tfidf_title_cv, cv_quantity_standar,
                cv_prev_proj_standar, cv_price_standar, cv_title_word_count_standar,
                cv_essay_word_count_standar, cv_positive_standar, cv_negitive_standar,
                cv_neutral_standar)).tocsr()
print(X_cv2.shape, y_cv.shape)
print(type(X_cv2))
```

```
(11055, 10205) (11055,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [168]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_test2 = hstack((test_categories_one_hot,test_subcategories_one_hot,test_state_one_hot,
                  test_grade_one_hot,test_teacher_prefix_one_hot,text_tfidf_title_test,
                  tfidf_essay_test, test_quantity_standar,
                  test_prev_proj_standar, test_price_standar, test_title_word_count_standar,
                  test_essay_word_count_standar, test_positive_standar, test_negitive_standar,
                  test_neutral_standar)).tocsr()
print(X_test2.shape, y_test.shape)
print(type(X_test2))
```

```
(16500, 10205) (16500,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [169]:

```
from sklearn.model_selection import train_test_split
```

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
import seaborn as sea
```

In [171]:

```
DT = DecisionTreeClassifier(class_weight='balanced',random_state=0)

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc', verbose=1, n_jobs=-1)
classifier.fit(X_train2, y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits

[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed:   16.0s
[Parallel(n_jobs=-1)]: Done  72 out of  72 | elapsed:  1.7min finished
```

Out[171]:

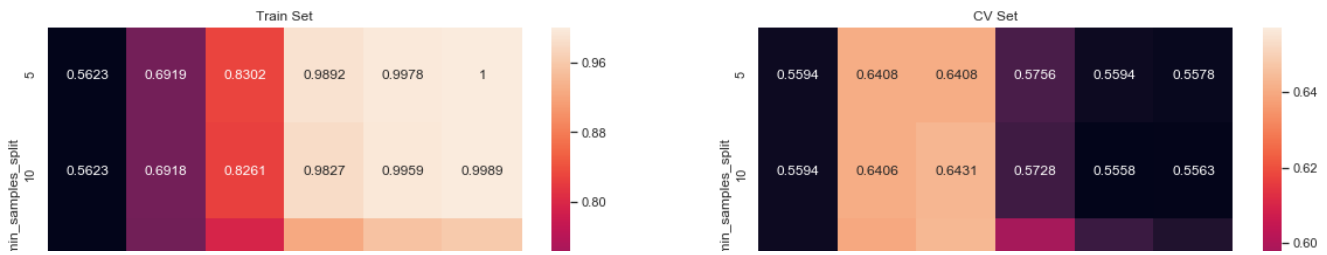
```
GridSearchCV(cv=3, error_score='raise',
       estimator=DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=None, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=0,
            splitter='best'),
       fit_params=None, iid=True, n_jobs=-1,
       param_grid={'max_depth': [1, 5, 10, 50, 100, 500], 'min_samples_split': [5, 10, 100, 500]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='roc_auc', verbose=1)
```

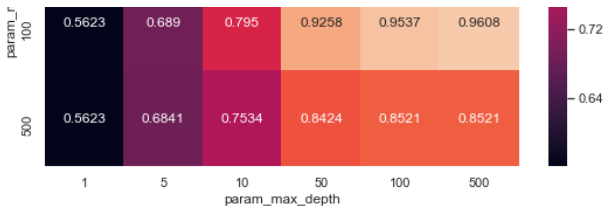
In [172]:

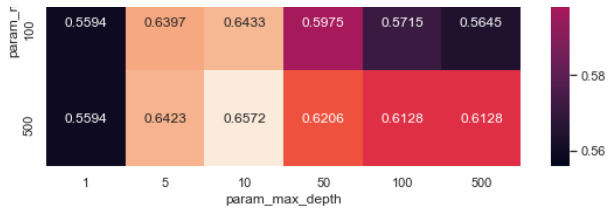
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [173]:

```
max_scores = pd.DataFrame(classifier.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))

sea.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sea.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```





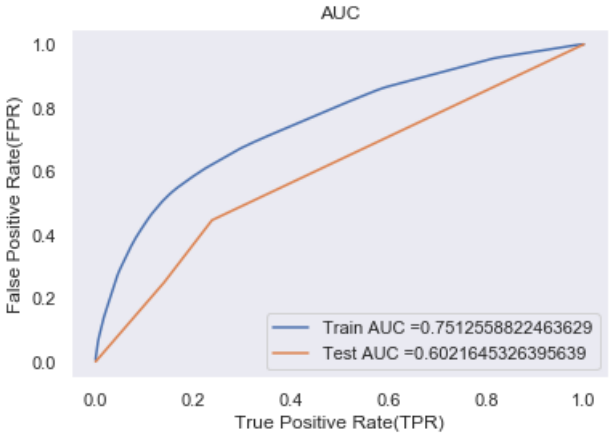


In [174]:

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

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [177]:

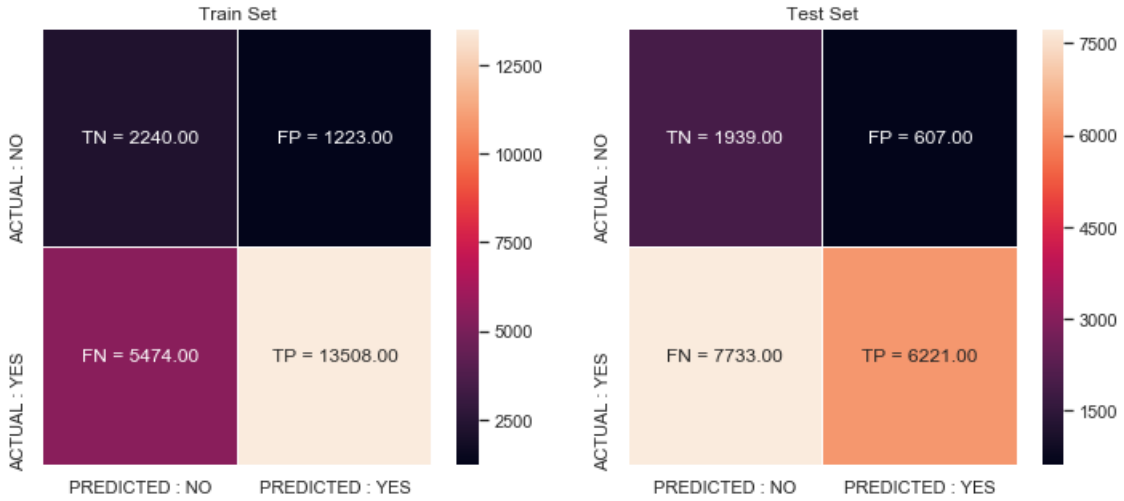
```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier2 = DecisionTreeClassifier(max_depth = 5, min_samples_split = 500)
classifier_viz2 = DecisionTreeClassifier(max_depth = 2, min_samples_split = 500)

classifier2.fit(X_train2, y_train)
classifier_viz2.fit(X_train2, y_train)

y_train_pred = batch_predict(classifier,X_train2)
y_test_pred = batch_predict(classifier_viz,X_test2)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [178]:

```
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4725274788800174 for threshold 0.405
the maximum value of tpr*(1-fpr) 0.33953214134963255 for threshold 0.899
```



In [179]:

```
#find the false postive data points
```

In [180]:

```
BOW_essay_text=text_bow_essays_test.todense()
print(BOW_essay_text.shape)
len(bow_eassay_feature)
```

```
(16500, 8869)
```

Out[180]:

```
8869
```

In [181]:

```
y_test_data = list(y_test[::])
len(y_test_data)
```

Out[181]:

```
16500
```

In [182]:

```
fp_index = []
fp_count = 0

for i in range(len(y_test_pred)):
    if y_test_data[i] == 0 and y_test_pred[i] <= 0.9:
        fp_index.append(i)
        fp_count = fp_count + 1
    else :
        pass
print(fp_count)
```

```
2188
```

In [183]:

```
df1 = pd.DataFrame(BOW_essay_text)
```

In [184]:

```
df1_final = df1.iloc[fp_index,:]
print(df1_final.shape)
```

```
(2188, 8869)
```

In [185]:

```
for j in range(8869):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
len(best_indices)
```

Out[185]:

```
1135
```

In [186]:

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

Out[186]:

```
[3, 45, 105, 161, 162, 163, 182, 183, 194, 234]
```

In [187]:

```
fp_words = []

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

fp_words[0:10]
```

Out[187]:

```
['Music_Arts', 'SD', '11', '32', '320', '33', '44', '45', '51', '82']
```

In [ ]:

```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
```

```
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```

In [ ]:

```
df = pd.DataFrame(x_test['price'])
print(df.head(2))
```

In [ ]:

```
plt.figure(figsize=(20,4))
df1 = df.iloc[fp_index, : ]
sea.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positive data points")
plt.xlabel("Price")
plt.show()
```

In [ ]:

```
plt.figure(figsize=(20,4))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```

2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [ ]:

```
# Please write all the code with proper documentation
```

In [188]:

```
tfidf_feature=cat_feature+subcat_feature+state_feature+grade_feature+teacher_feature+title_tfidf_fe
ature+tfidf_essay_feature
len(tfidf_feature)
```

Out[188]:

10197

In [189]:

```
tfidf_feature.append('price')
tfidf_feature.append('teacher_number_of_previously_posted_projects')
tfidf_feature.append('quantity')
tfidf_feature.append('title_word_count')
tfidf_feature.append('essay_word_count')
tfidf_feature.append('positive')
tfidf_feature.append('negitive')
tfidf_feature.append('neutral')
```

In [190]:

```
len(tfidf_feature)
```

Out[190]:

10205

In [191]:

```
print(classifier_viz2.n_features_)
```

```
print(classifier_viz2.n_features_)
```

```
10205
```

In [193]:

```
import graphviz
from sklearn import tree
from graphviz import Source

dot_data = tree.export_graphviz(classifier_viz2, out_file=None, feature_names=tfidf_feature)
graph = graphviz.Source(dot_data)
graph.render("TFIDF tree",view = True)
```

Out[193]:

```
'TFIDF tree.pdf'
```

In [194]:

```
# Please write all the code with proper documentation
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus

dot_data = StringIO()

export_graphviz(classifier_viz2, out_file=dot_data, filled=True, rounded=True, special_characters=T
rue, feature_names=tfidf_feature)

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
graph.write_pdf('graph2.pdf')
```

Out[194]:

```
True
```

2.4.3 Applying Decision Trees on AVG W2V, SET 3

In [ ]:

```
# Please write all the code with proper documentation
```

In [115]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train3 = hstack((train_categories_one_hot,train_subcategories_one_hot,train_state_one_hot,
                   train_grade_one_hot,train_teacher_prefix_one_hot,avg_w2v_essay_train_data,
                   avg_w2v_project_title_train_data, train_quantity_standar,
                   train_prev_proj_standar, train_price_standar, train_title_word_count_standar,
                   train_essay_word_count_standar, train_positive_standar, train_negitive_standar,
                   train_neutral_standar)).tocsr()
print(X_train3.shape, y_train.shape)
print(type(X_train3))
```

```
(22445, 707) (22445,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [116]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_cv3= hstack((cv_categories_one_hot,cv_subcategories_one_hot,cv_state_one_hot,
               cv_grade_one_hot,cv_teacher_prefix_one_hot,avg_w2v_essay_cv_data,
               avg_w2v_project_title_cv_data, cv_quantity_standar,
               cv_prev_proj_standar, cv_price_standar, cv_title_word_count_standar,
               cv_essay_word_count_standar, cv_positive_standar, cv_negitive_standar,
               cv_neutral_standar)).tocsr()
```

```
                cv_neutral_standar)).tocsr()
print(X_cv3.shape, y_cv.shape)
print(type(X_cv3))
```

```
(11055, 707) (11055,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [117]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_test3 = hstack((test_categories_one_hot,test_subcategories_one_hot,test_state_one_hot,
                  test_grade_one_hot,test_teacher_prefix_one_hot,avg_w2v_essay_test_data,
                  avg_w2v_project_title_test_data, test_quantity_standar,
                  test_prev_proj_standar, test_price_standar, test_title_word_count_standar,
                  test_essay_word_count_standar, test_positive_standar, test_negitive_standar,
                  test_neutral_standar)).tocsr()
print(X_test3.shape, y_test.shape)
print(type(X_test3))
```

```
(16500, 707) (16500,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [119]:

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
import seaborn as sea
```

In [120]:

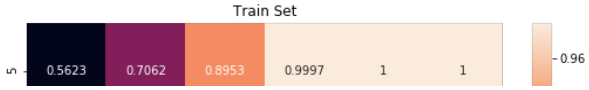
```
DT = DecisionTreeClassifier(class_weight = 'balanced',random_state=0)

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc')
classifier.fit(X_train3, y_train)
```

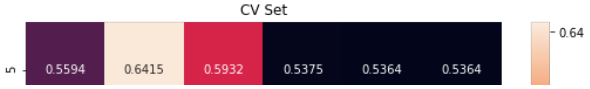
Out[120]:

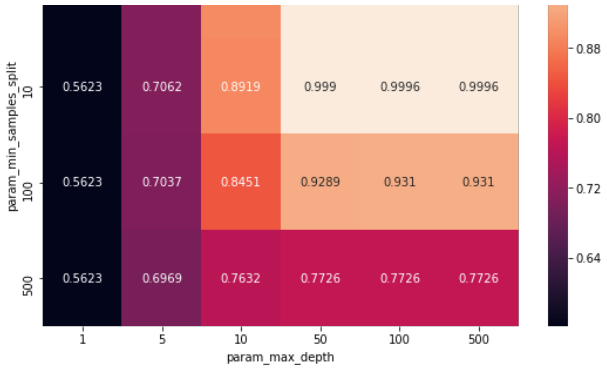
```
GridSearchCV(cv=3, error_score='raise-deprecating',
       estimator=DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=None, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=0,
            splitter='best'),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid={'max_depth': [1, 5, 10, 50, 100, 500], 'min_samples_split': [5, 10, 100, 500]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='roc_auc', verbose=0)
```

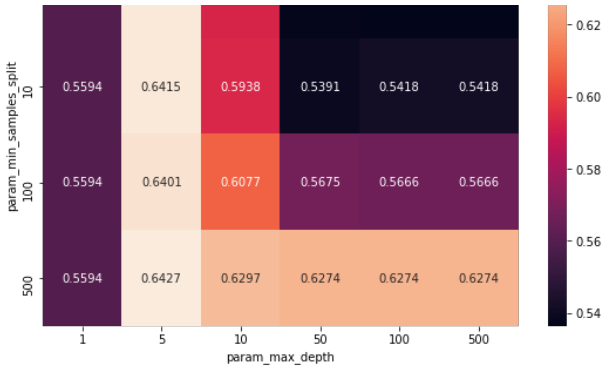
In [121]:

```
max_scores = pd.DataFrame(classifier.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))

sea.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sea.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```







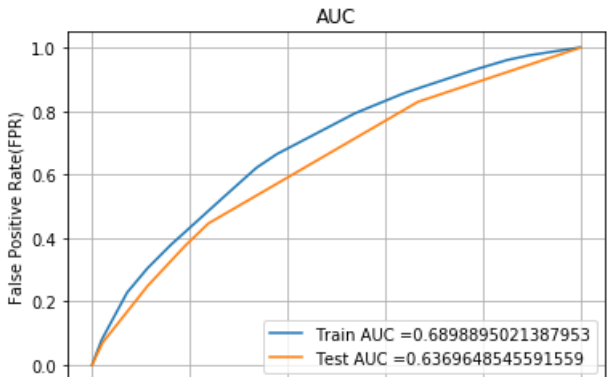


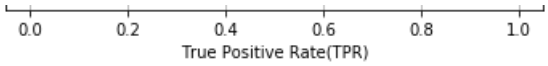
In [122]:

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

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [123]:

```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(max_depth =5, min_samples_split = 500)
classifier_viz = DecisionTreeClassifier(max_depth = 3, min_samples_split = 500)

classifier.fit(X_train3, y_train)
classifier_viz.fit(X_train3, y_train)

y_train_pred = batch_predict(classifier,X_train3)
y_test_pred = batch_predict(classifier_viz,X_test3)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```





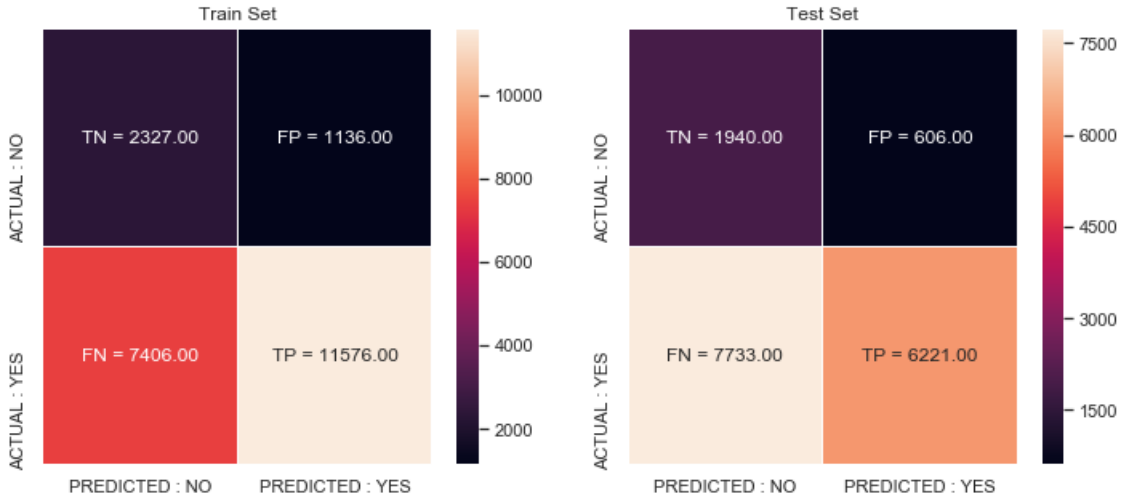
In [124]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [125]:

```
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4131448998310876 for threshold 0.883
the maximum value of tpr*(1-fpr) 0.3397072481785906 for threshold 0.867
```



In [126]:

```
BOW_essay_text=text_bow_essays_test.todense()
print(BOW_essay_text.shape)
len(bow_eassay_feature)
```

```
len(BOW_essay_features)
```

```
(16500, 8869)
```

Out[126]:

```
8869
```

In [127]:

```
y_test_data = list(y_test[::])
len(y_test_data)
```

Out[127]:

```
16500
```

In [129]:

```
FP_index = []
FP_count = 0

for i in range(len(y_test_pred)):
    if y_test_data[i] == 0 and y_test_pred[i] <= 0.9:
        FP_index.append(i)
        FP_count = FP_count + 1
    else :
        pass
print(FP_count)

FP_index[0:10]
```

```
2256
```

Out[129]:

```
[0, 3, 9, 14, 15, 20, 23, 26, 43, 48]
```

In [131]:

```
df1 = pd.DataFrame(BOW_essay_text)

df1_final = df1.iloc[FP_index,:]
print(df1_final.shape)
```

```
(2256, 8869)
```

In [135]:

```
best_indices=[]
```

In [136]:

```
for j in range(8869):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
len(best_indices)
```

Out[136]:

```
554
```

In [137]:

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

Out[137]:

```
[3, 105, 161, 162, 163, 182, 194, 234, 255, 259]
```

In [141]:

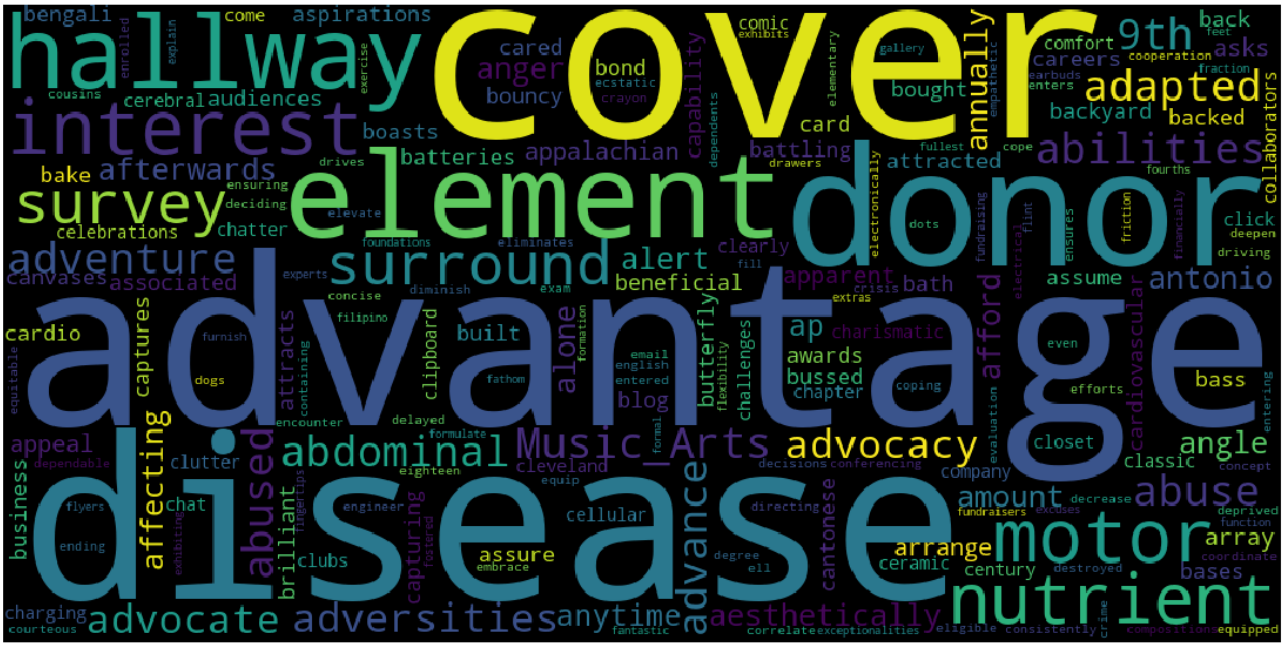
```
fp_words = []

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

fp_words[0:10]
```

Out[141]:

```
['Music_Arts', '11', '32', '320', '33', '44', '51', '82', '9th', 'abdominal']
```

In [142]:

```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```



In [143]:

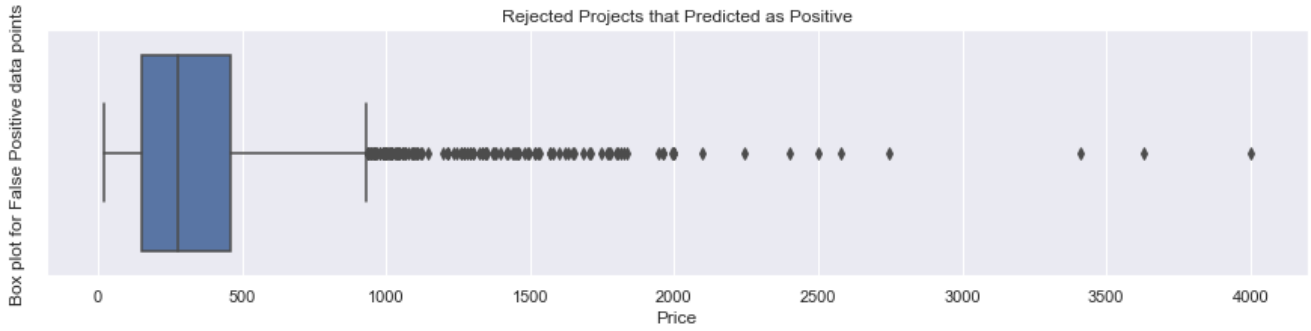
```
df = pd.DataFrame(x_test['price'])
print(df.head(2))
```

```
    price
0  337.18
1   89.49
```

In [145]:

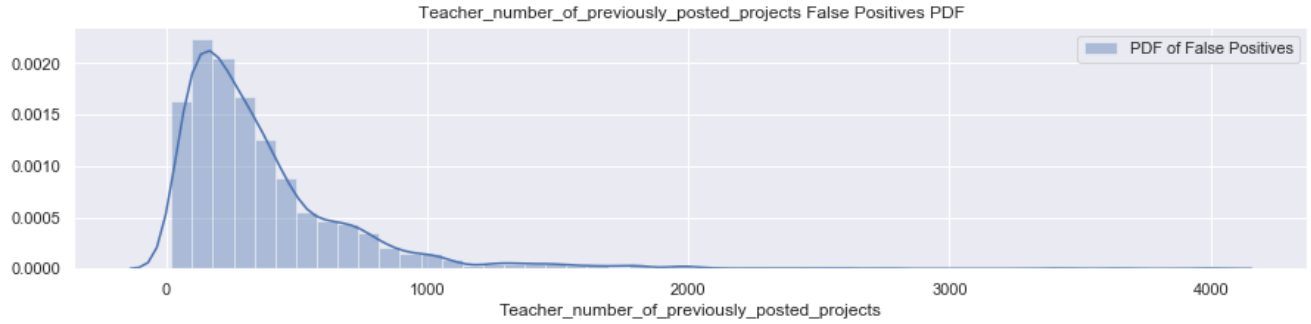
```
plt.figure(figsize=(15,3))
df1 = df.iloc[FP_index, : ]
sea.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positive data points")
```

```
plt.xlabel("Price")
plt.show()
```



In [146]:

```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```



2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

In [ ]:

```
# Please write all the code with proper documentation
```

In [147]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train4 = hstack((train_categories_one_hot,train_subcategories_one_hot,train_state_one_hot,
                   train_grade_one_hot,train_teacher_prefix_one_hot,tfidf_w2v_essay_train_data,
                   tfidf_w2v_project_title_train_data, train_quantity_standar,
                   train_prev_proj_standar, train_price_standar, train_title_word_count_standar,
                   train_essay_word_count_standar, train_positive_standar, train_negitive_standar,
                   train_neutral_standar)).tocsr()
print(X_train4.shape, y_train.shape)
print(type(X_train4))
```

```
(22445, 707) (22445,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [148]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_cv4= hstack((cv_categories_one_hot,cv_subcategories_one_hot,cv_state_one_hot,
               cv_grade_one_hot,cv_teacher_prefix_one_hot,tfidf_w2v_essay_cv_data,
               tfidf_w2v_project_title_cv_data, cv_quantity_standar,
               cv_prev_proj_standar, cv_price_standar, cv_title_word_count_standar,
               cv_essay_word_count_standar, cv_positive_standar, cv_negitive_standar,
```

```
                cv_neutral_standar)).tocsr()
print(X_cv4.shape, y_cv.shape)
print(type(X_cv4))
```

```
(11055, 707) (11055,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [149]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_test4 = hstack((test_categories_one_hot,test_subcategories_one_hot,test_state_one_hot,
                  test_grade_one_hot,test_teacher_prefix_one_hot,tfidf_w2v_essay_test_data,
                  tfidf_w2v_project_title_test_data, test_quantity_standar,
                  test_prev_proj_standar, test_price_standar, test_title_word_count_standar,
                  test_essay_word_count_standar, test_positive_standar, test_negitive_standar,
                  test_neutral_standar)).tocsr()
print(X_test4.shape, y_test.shape)
print(type(X_test4))
```

```
(16500, 707) (16500,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [150]:

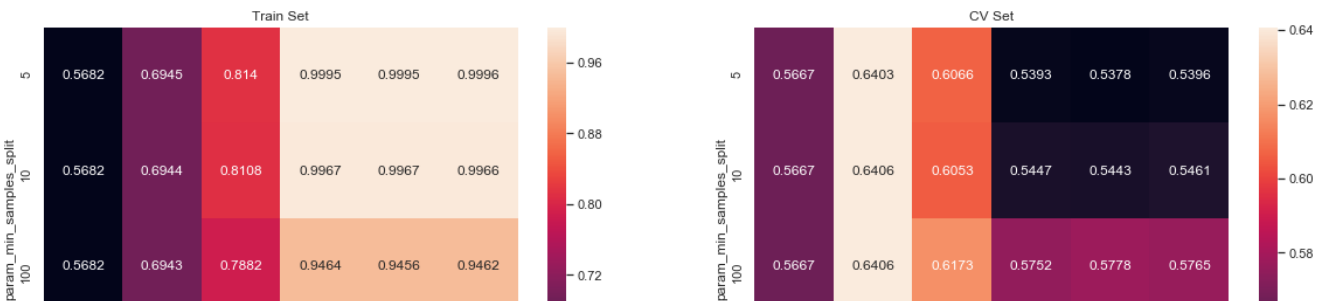
```
DT = DecisionTreeClassifier()

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc')
classifier.fit(X_train4, y_train)
```

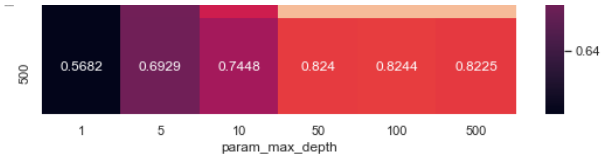
Out[150]:

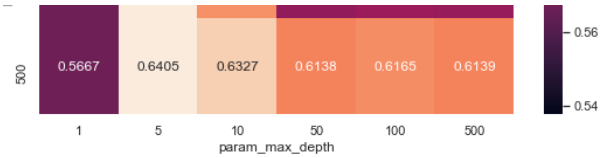
```
GridSearchCV(cv=3, error_score='raise-deprecating',
       estimator=DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best'),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid={'max_depth': [1, 5, 10, 50, 100, 500], 'min_samples_split': [5, 10, 100, 500]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='roc_auc', verbose=0)
```

In [151]:

```
max_scores = pd.DataFrame(classifier.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))

sea.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sea.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```





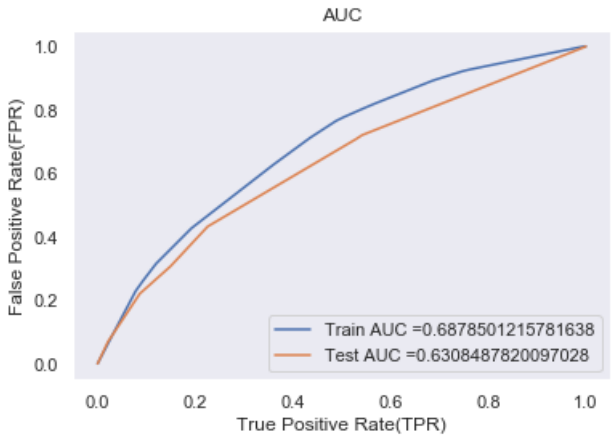


In [152]:

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

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [153]:

```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(max_depth = 5, min_samples_split = 500)
classifier_viz = DecisionTreeClassifier(max_depth = 3, min_samples_split = 500)

classifier.fit(X_train4, y_train)
classifier_viz.fit(X_train4, y_train)

y_train_pred = batch_predict(classifier,X_train4)
y_test_pred = batch_predict(classifier_viz,X_test4)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

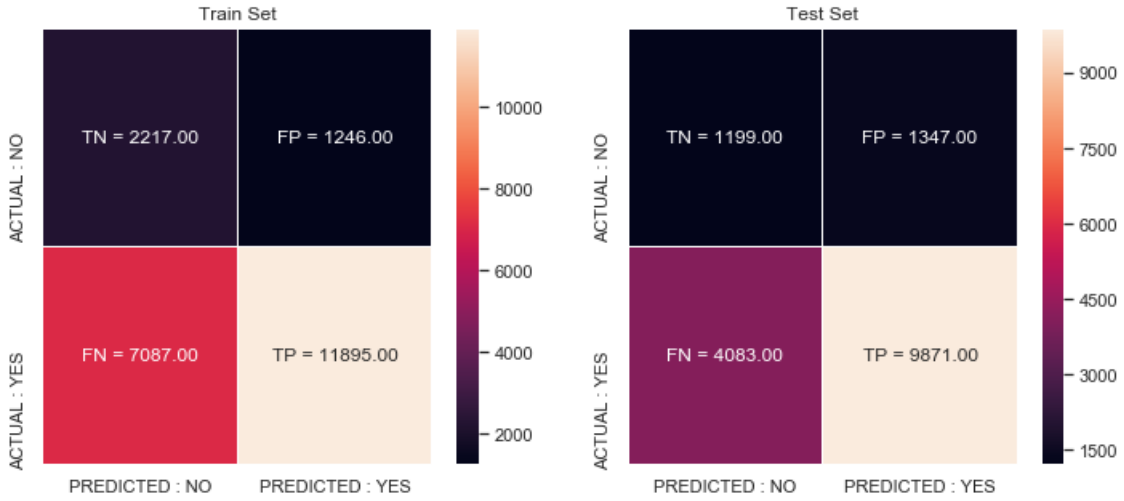


In [154]:

```
import seaborn as sns; sns.set()
```

```
con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.40194389973777306 for threshold 0.867
the maximum value of tpr*(1-fpr) 0.33470877997631315 for threshold 0.839
```



In [155]:

```
BOW_essay_text=text_bow_essays_test.todense()
print(BOW_essay_text.shape)
len(bow_eassay_feature)
```

```
(16500, 8869)
```

Out[155]:

```
8869
```

In [156]:

```
y_test_data = list(y_test[::])
len(y_test_data)
```

Out[156]:

```
16500
```

In [157]:

```
FP_index = []
FP_count = 0
```

```
for i in range(len(y_test_pred)):
    if y_test_data[i] == 0 and y_test_pred[i] <= 0.9:
        FP_index.append(i)
        FP_count = FP_count + 1
    else :
        pass
print(FP_count)
```

```
2326
```

In [158]:

```
FP_index[0:10]
```

Out[158]:

```
[0, 3, 9, 14, 15, 20, 23, 26, 43, 51]
```

In [160]:

```
df1 = pd.DataFrame(BOW_essay_text)

df1_final = df1.iloc[FP_index,:]
print(df1_final.shape)
```

```
(2326, 8869)
```

In [161]:

```
best_indices = []

for j in range(8869):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
len(best_indices)
```

Out[161]:

```
566
```

In [162]:

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

Out[162]:

```
[3, 45, 105, 161, 162, 163, 182, 183, 194, 234]
```

In [163]:

```
fp_words = []

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

fp_words[0:10]
```

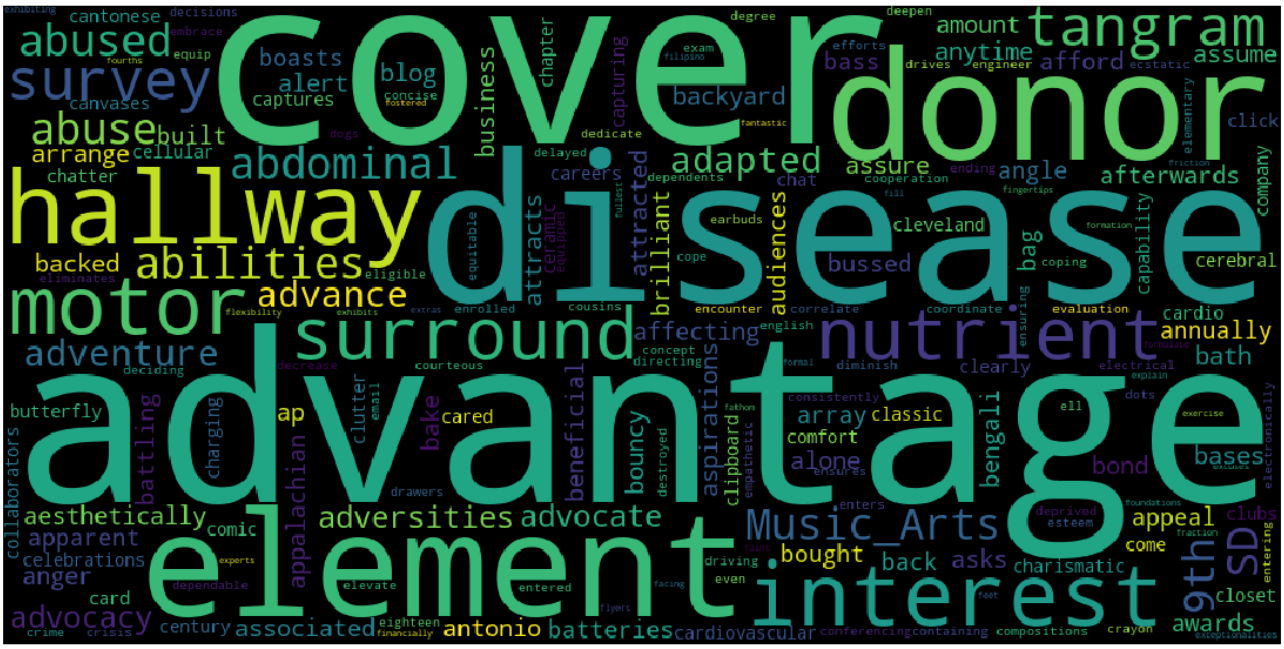
Out[163]:

```
['Music_Arts', 'SD', '11', '32', '320', '33', '44', '45', '51', '82']
```

In [164]:

```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
```

```
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```



In [165]:

```
df = pd.DataFrame(x_test['price'])
print(df.head(2))
```

```
    price
0  337.18
1   89.49
```

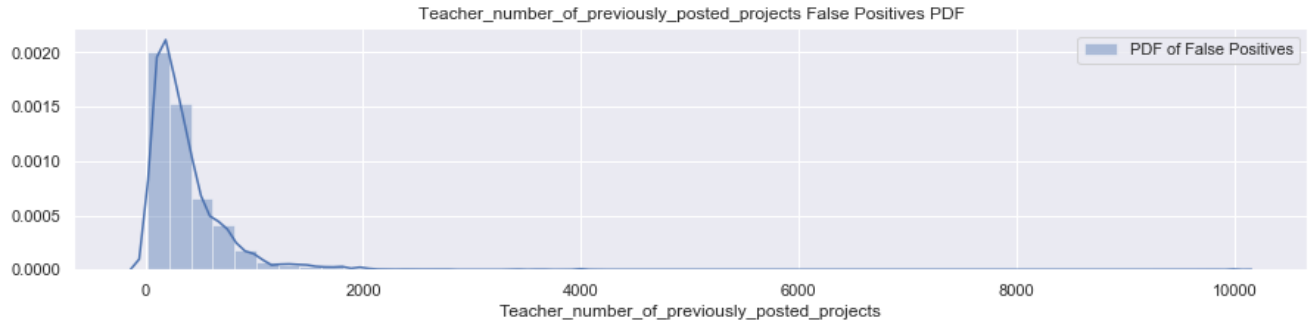
In [167]:

```
plt.figure(figsize=(15,3))
df1 = df.iloc[FP_index, : ]
sea.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positive data points")
plt.xlabel("Price")
plt.show()
```

In [168]:

```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
```

```
plt.legend()
plt.show()
```



2.5 [Task-2]Getting top 5k features using `feature_importances_`

In [ ]:

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

In [169]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train5 = hstack((train_categories_one_hot,train_subcategories_one_hot,train_state_one_hot,
                   train_grade_one_hot,train_teacher_prefix_one_hot,tfidf_essay_train,
                   text_tfidf_title_train, train_quantity_standar,
                   train_prev_proj_standar, train_price_standar, train_title_word_count_standar,
                   train_essay_word_count_standar, train_positive_standar, train_negitive_standar,
                   train_neutral_standar)).tocsr()
print(X_train5.shape, y_train.shape)
print(type(X_train5))
```

```
(22445, 10205) (22445,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [170]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_cv5 = hstack((cv_categories_one_hot,cv_subcategories_one_hot,cv_state_one_hot,
                cv_grade_one_hot,cv_teacher_prefix_one_hot,tfidf_essay_cv,
                text_tfidf_title_cv, cv_quantity_standar,
                cv_prev_proj_standar, cv_price_standar, cv_title_word_count_standar,
                cv_essay_word_count_standar, cv_positive_standar, cv_negitive_standar,
                cv_neutral_standar)).tocsr()
print(X_cv5.shape, y_cv.shape)
print(type(X_cv5))
```

```
(11055, 10205) (11055,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [171]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_test5 = hstack((test_categories_one_hot,test_subcategories_one_hot,test_state_one_hot,
                  test_grade_one_hot,test_teacher_prefix_one_hot,text_tfidf_title_test,
                  tfidf_essay_test, test_quantity_standar,
                  test_prev_proj_standar, test_price_standar, test_title_word_count_standar,
```

```
                    test_essay_word_count_standar, test_positive_standar, test_negitive_standar,
                    test_neutral_standar)).tocsr()
print(X_test5.shape, y_test.shape)
print(type(X_test5))
```

```
(16500, 10205) (16500,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [172]:

```
#https://datascience.stackexchange.com/questions/6683/feature-selection-using-feature-importances-in-random-forests-with-scikit-learn
def selectKImportance(model, X, k=5):
     return X[:,model.feature_importances_.argsort()[::-1][:k]]
```

In [173]:

```
X_train_best5k=selectKImportance(classifier,X_train5,5000)
X_test_best5k=selectKImportance(classifier,X_test5,5000)
X_cv_best5k=selectKImportance(classifier,X_cv5,5000)
```

In [174]:

```
print(X_train_best5k.shape)
print(X_test_best5k.shape)
print(X_cv_best5k.shape)
```

```
(22445, 707)
(16500, 707)
(11055, 707)
```

In [175]:

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

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [176]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.linear_model import SGDClassifier

train_auc = []
cv_auc = []
alpha= [10**-4, 10**-3, 10**-2, 10**-1, 1 , 10**1, 10**2, 10**3, 10**4]
for i in alpha:
    model = SGDClassifier(alpha=i,loss='hinge', penalty='l2',random_state=0)
    model.fit(X_train_best5k, y_train)

    y_train_pred = model.decision_function(X_train_best5k)
    y_cv_pred = model.decision_function(X_cv_best5k)

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

```
plt.plot(alpha, train_auc, label='Train AUC')
plt.plot(alpha, cv_auc, label='CV AUC')

plt.scatter(alpha, train_auc, label='Train AUC points')
plt.scatter(alpha, cv_auc, label='CV AUC points')

plt.legend()
plt.xscale('log')
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

In [182]:

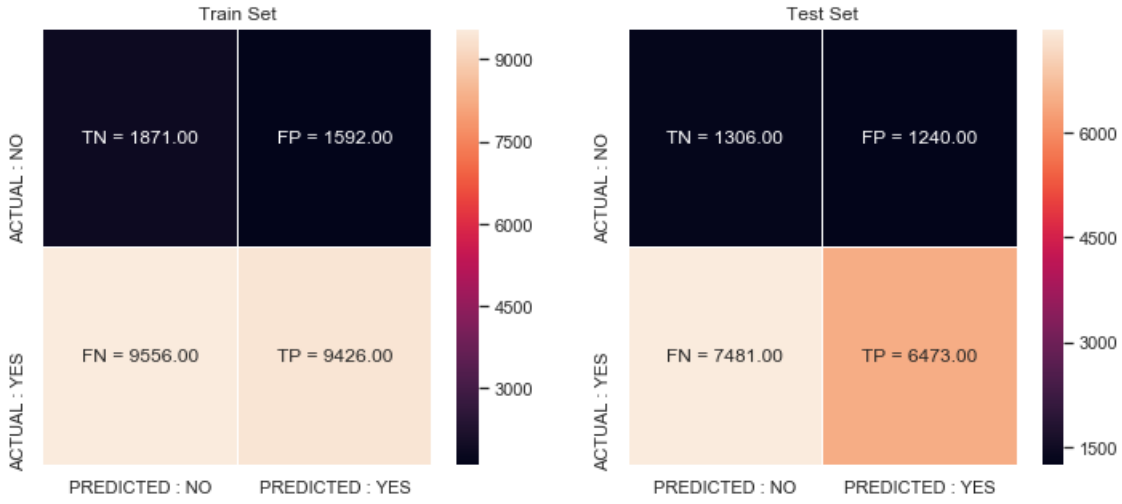
```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model=SGDClassifier(alpha=0.001,loss='hinge', penalty='l2',random_state=0)
model.fit(X_train_best5k, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_train_best5k)
y_test_pred = model.decision_function(X_test_best5k)

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

alpha: hyperparameter

In [183]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.2724101617858681 for threshold 1.018
the maximum value of tpr*(1-fpr) 0.24348591900150884 for threshold 1.018
```



3. Conclusion

In [189]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer","Model","max_depth","min_samples_split","Train AUC","Test AUC"]


x.add_row(["BOW","Decision Tree","10","500","0.72","0.60"])

x.add_row(["TFIDF","Decision Tree","5","500","0.75","0.60 "])

x.add_row(["AVGW2V","Decision Tree","5","500","0.68","0.63"])

x.add_row(["TFIF-w2V","Decision Tree","5","500 ","0.68","0.63 "])

x.add_row(["SET5","Using  best 5k feature","best aplha=0.001"," ","0.53","0.48"])
print(x)
```

Vectorizer	Model	max_depth	min_samples_split	Train AUC	Test AUC
BOW	Decision Tree	10	500	0.72	0.60
TFIDF	Decision Tree	5	500	0.75	0.60
AVGW2V	Decision Tree	5	500	0.68	0.63
TFIF-w2V	Decision Tree	5	500	0.68	0.63
SET5	Using best 5k feature	best aplha=0.001		0.53	0.48

Decision trees are easy to interpret and visualize. It can easily capture Non-linear patterns. It requires fewer data preprocessing from the user, for example, there is no need to normalize columns. It can be used for feature engineering such as predicting missing values, suitable for variable selection. Decision trees are biased with imbalance dataset, so it is recommended that balance out the dataset before creating the decision tree.