Assignment 8: DT

In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os

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

1.1 Loading Data

In [2]:

```
project_data = pd.read_csv('../train_data.csv')
resource_data = pd.read_csv('../resources.csv')
```

In [3]:

```
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 (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix'
'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

```
print("Number of data points in train data", 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[4]:

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

1.2 Preprocessing Categorical Data

1.2.1 preprocessing `project_subject_categories`

In [5]:

```
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 & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are 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]))
```

In [6]:

```
sorted_cat_dict.keys()
```

Out[6]:

```
dict_keys(['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'Appli
edLearning', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_La
nguage'])
```

1.2.2 preprocessing of `project_subject_subcategories`

In [7]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-stri
ng
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-pyth
on
sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace
 it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"M
ath & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_') # we are replacing the & value into
    sub_cat_list.append(temp.strip())

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

from collections import Counter
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]))
```

In [8]:

```
sorted_sub_cat_dict.keys()
```

Out[8]:

```
dict_keys(['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentIn
volvement', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'N
utritionEducation', 'Warmth', 'Care_Hunger', 'SocialSciences', 'Performing
Arts', 'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep',
'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'E
SL', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellnes
s', 'AppliedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematic
s', 'Literacy'])
```

1.2.3 preprocessing of `School State`

In [9]:

```
project_data['school_state'].unique()
```

Out[9]:

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

In [10]:

```
project_data['school_state'][project_data['school_state'].isnull()==True]
```

Out[10]:

```
Series([], Name: school_state, dtype: object)
```

In [11]:

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

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

In [12]:

```
sorted_school_state_dict.keys()
```

Out[12]:

```
dict_keys(['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'W
V', 'ME', 'HI', 'DC', 'NM', 'KS', 'IA', 'ID', 'AR', 'CO', 'MN', 'OR', 'K
Y', 'MS', 'NV', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ', 'NJ', 'O
K', 'WA', 'MA', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'N
C', 'FL', 'NY', 'TX', 'CA'])
```

1.2.4 preprocessing of `Teacher Prefix`

In [13]:

```
project_data.groupby(['teacher_prefix'])['teacher_prefix'].count()
```

Out[13]:

```
teacher_prefix
Dr.            13
Mr.         10648
Mrs.        57269
Ms.         38955
Teacher      2360
Name: teacher_prefix, dtype: int64
```

In [14]:

```
project_data['teacher_prefix'][project_data['teacher_prefix'].isnull()==True]
```

Out[14]:

```
7820     NaN
30368    NaN
57654    NaN
Name: teacher_prefix, dtype: object
```

In [15]:

```
project_data['teacher_prefix'].fillna(project_data['teacher_prefix'].mode()[0],inplace=
True)
```

In [16]:

```
project_data['teacher_prefix'][project_data['teacher_prefix'].isnull()==True]
```

Out[16]:

```
Series([], Name: teacher_prefix, dtype: object)
```

In [17]:

```
project_data['teacher_prefix'].unique()
```

Out[17]:

```
array(['Mrs.', 'Mr.', 'Ms.', 'Teacher', 'Dr.'], dtype=object)
```

In [18]:

```
teacher_prefix = list(project_data['teacher_prefix'].values)

teacher_prefix_list = []
for i in teacher_prefix:
    temp = ""
    temp = i.split('.')
    temp = i.replace('.','')
    teacher_prefix_list.append(temp)

project_data['clean_teacher_prefix'] = teacher_prefix_list
project_data.drop(['teacher_prefix'], 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_teacher_prefix'].values:
    my_counter.update(word.split())

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

In [19]:

```
sorted_teacher_prefix_dict.keys()
```

Out[19]:

```
dict_keys(['Dr', 'Teacher', 'Mr', 'Ms', 'Mrs'])
```

In [20]:

```
project_data.groupby(['clean_teacher_prefix'])['clean_teacher_prefix'].count()
```

Out[20]:

```
clean_teacher_prefix
Dr            13
Mr         10648
Mrs        57272
Ms         38955
Teacher     2360
Name: clean_teacher_prefix, dtype: int64
```

1.2.5 preprocessing of `Project Grade Category`

In [21]:

```
project_data.groupby(['project_grade_category'])['project_grade_category'].count()
```

Out[21]:

```
project_grade_category
Grades 3-5       37137
Grades 6-8       16923
Grades 9-12      10963
Grades PreK-2    44225
Name: project_grade_category, dtype: int64
```

In [22]:

```
project_data['project_grade_category'][project_data['project_grade_category'].isnull()==True]
```

Out[22]:

```
Series([], Name: project_grade_category, dtype: object)
```

In [23]:

```
project_grade_category = list(project_data['project_grade_category'].values)

project_grade_category_list = []
for i in project_grade_category:
    temp = ""
    temp = i.split(' ')
    temp = i.replace('Grades ','')
    project_grade_category_list.append(temp)

project_data['clean_project_grade_category'] = project_grade_category_list
project_data.drop(['project_grade_category'], 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_project_grade_category'].values:
    my_counter.update(word.split())

project_grade_category_dict = dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), k
ey=lambda kv: kv[1]))
```

In [24]:

```
sorted_project_grade_category_dict.keys()
```

Out[24]:

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

In [25]:

```
project_data.groupby(['clean_project_grade_category'])['clean_project_grade_category'].
count()
```

Out[25]:

```
clean_project_grade_category
3-5       37137
6-8       16923
9-12      10963
PreK-2    44225
Name: clean_project_grade_category, dtype: int64
```

1.3 Text Preprocessing of project_essay

In [26]:

```
# merge two column text 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 [27]:

```
project_data.head(1)
```

Out[27]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_dat
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:

In [28]:

```
# 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 [29]:

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

```
My kindergarten students have varied disabilities ranging from speech and
language delays, cognitive delays, gross/fine motor delays, to autism. The
y are eager beavers and always strive to work their hardest working past t
heir limitations. \r\n\r\nThe materials we have are the ones I seek out fo
r my students. I teach in a Title I school where most of the students rece
ive free or reduced price lunch.  Despite their disabilities and limitatio
ns, 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 groov
e and move as you were in a meeting? This is how my kids feel all the tim
e. 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 develop their core, which enha
nces gross motor and in Turn fine motor skills. \r\nThey also want to lear
n through games, my kids do not want to sit and do worksheets. They want t
o learn to count by jumping and playing. Physical engagement is the key to
our success. The number toss and color and shape mats can make that happe
n. My students will forget they are doing work and just have the fun a 6 y
ear old deserves.nannan
==================================================
```

In [30]:

```
# \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, cognitive delays, gross/fine motor delays, to autism. The
y are eager beavers and always strive to work their hardest working past t
heir 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 f
ree or reduced price lunch.  Despite their disabilities and limitations, m
y 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 groove 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 develop their core, which enhances gro
ss 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. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My stude
nts will forget they are doing work and just have the fun a 6 year old des
erves.nannan
```

In [31]:

```
#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 cognitive delays gross fine motor delays to autism They ar
e 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 students
I teach in a Title I school where most of the students receive free or red
uced price lunch Despite their disabilities and limitations my students lo
ve 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 groove and move as you w
ere 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 lo
ve then because they develop their core which enhances gross motor and in
Turn fine motor skills They also want to learn through games my kids do no
t 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 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 [32]:

```
# 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'r
e", "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', 't
hey', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "th
at'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'ha
d', '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', 'ov
er', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'an
y', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too'
, 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'no
w', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't",
'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'migh
tn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'w
asn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [33]:

```
# 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%|██████████| 109248/109248 [01:22<00:00, 1331.27it/s]
```

In [34]:

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

Out[34]:

```
'my kindergarten students varied disabilities ranging speech language dela
ys cognitive delays gross fine motor delays autism they eager beavers alwa
ys strive work hardest working past limitations the materials ones i seek
students i teach title i school students receive free reduced price lunch
despite disabilities limitations students love coming school come eager le
arn explore have ever felt like ants pants needed groove move meeting this
kids feel time the want able move learn say wobble chairs answer i love de
velop core enhances gross motor turn fine motor skills they also want lear
n games kids not want sit worksheets they want learn count jumping playing
physical engagement key success the number toss color shape mats make happ
en my students forget work fun 6 year old deserves nannan'
```

In [35]:

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

1.4 Preprocessing of `project_title`

In [36]:

```
project_data['project_title'][2000:2010]
```

Out[36]:

```
2000                       Steady Stools for Active Learning
2001                                      Classroom Supplies
2002    Kindergarten Students Deserve Quality  Books a...
2003                                   Listen to Understand!
2004                                iPads to iGnite Learning
2005                                    Tablets For Learning
2006                                                Go P.E.!
2007                                    Making Learning Fun!
2008    Empowerment Through Silk Screen Designed Tee S...
2009                                    Let's Play Together!
Name: project_title, dtype: object
```

In [37]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_titles = []
# 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_titles.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:03<00:00, 28485.48it/s]
```

In [38]:

```
preprocessed_titles[2000:2010]
```

Out[38]:

```
['steady stools active learning',
 'classroom supplies',
 'kindergarten students deserve quality books vibrant rug',
 'listen understand',
 'ipads ignite learning',
 'tablets for learning',
 'go p e',
 'making learning fun',
 'empowerment through silk screen designed tee shirts',
 'let play together']
```

In [39]:

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

1.5 Merging Numerical data in Resources to project_data

In [40]:

```
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')
```

2. Decision Tree

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**

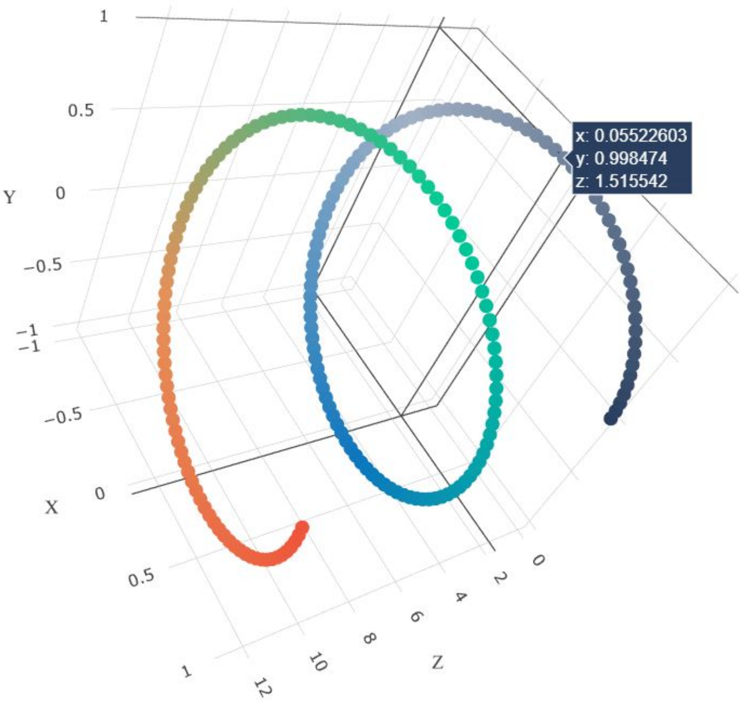
   - Set 1: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   - Set 2: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (best `depth` in range [1, 5, 10, 50], and the best `min_samples_split` in range [5, 10, 100, 500])**

   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - find the best hyper paramter using k-fold cross validation(use gridsearch cv or randomsearch cv)/simple cross validation data(you can write your own for loops refer sample solution)

3. **Representation of results**

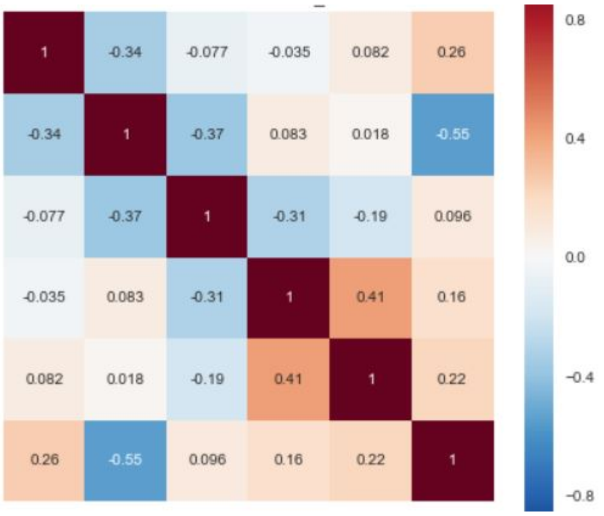
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



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

or

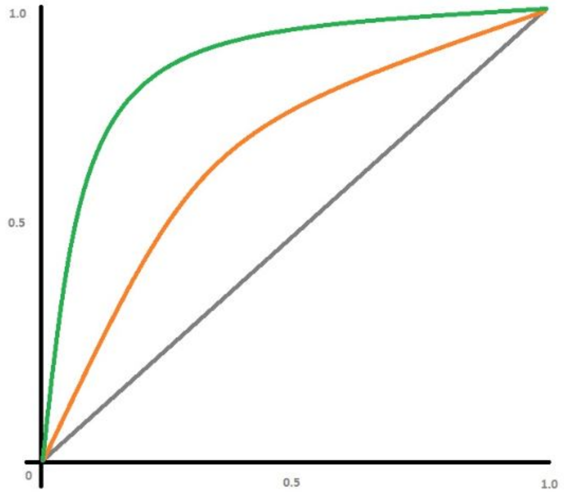
- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



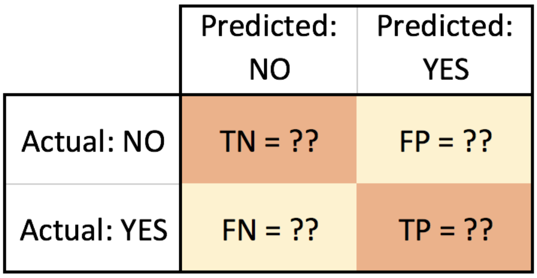
1	-0.34	-0.077	-0.035	0.082	0.26
-0.34	1	-0.37	0.083	0.018	-0.55
-0.077	-0.37	1	-0.31	-0.19	0.096
-0.035	0.083	-0.31	1	0.41	0.16
0.082	0.018	-0.19	0.41	1	0.22
0.26	-0.55	0.096	0.16	0.22	1

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

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



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



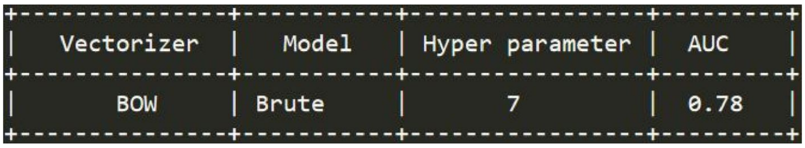
	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

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

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

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

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



```
+---------------+-----------+-----------------+---------+
|   Vectorizer  |   Model   | Hyper parameter |  AUC    |
+---------------+-----------+-----------------+---------+
|      BOW      | Brute     |        7        | 0.78    |
+---------------+-----------+-----------------+---------+
```

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

In [41]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# 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 [42]:

```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 109248 entries, 0 to 109247
Data columns (total 20 columns):
 #   Column                                        Non-Null Count   Dtype 
---  ------                                        --------------   ----- 
 0   Unnamed: 0                                    109248 non-null  int64 
 1   id                                            109248 non-null  object
 2   teacher_id                                    109248 non-null  object
 3   school_state                                  109248 non-null  object
 4   project_submitted_datetime                    109248 non-null  object
 5   project_essay_1                               109248 non-null  object
 6   project_essay_2                               109248 non-null  object
 7   project_essay_3                               3758 non-null    object
 8   project_essay_4                               3758 non-null    object
 9   project_resource_summary                      109248 non-null  object
 10  teacher_number_of_previously_posted_projects  109248 non-null  int64 
 11  project_is_approved                           109248 non-null  int64 
 12  clean_categories                              109248 non-null  object
 13  clean_subcategories                           109248 non-null  object
 14  clean_teacher_prefix                          109248 non-null  object
 15  clean_project_grade_category                  109248 non-null  object
 16  preprocessed_essays                           109248 non-null  object
 17  preprocessed_titles                           109248 non-null  object
 18  price                                         109248 non-null  float6
4
 19  quantity                                      109248 non-null  int64 
dtypes: float64(1), int64(4), object(15)
memory usage: 17.5+ MB
```

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
    - Essay : text data

    - quantity : numerical
    - teacher_number_of_previously_posted_projects : numerical
    - price : numerical
```

In [43]:

```
data1 = project_data.drop(['Unnamed: 0', 'id','project_submitted_datetime','project_ess
ay_1','project_essay_2','project_essay_3','project_essay_4','project_resource_summary',
'teacher_id'], axis = 1)
```

In [44]:

```
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 109248 entries, 0 to 109247
Data columns (total 11 columns):
 #   Column                                        Non-Null Count   Dtype  
---  ------                                        --------------   -----  
 0   school_state                                  109248 non-null  object 
 1   teacher_number_of_previously_posted_projects  109248 non-null  int64  
 2   project_is_approved                           109248 non-null  int64  
 3   clean_categories                              109248 non-null  object 
 4   clean_subcategories                           109248 non-null  object 
 5   clean_teacher_prefix                          109248 non-null  object 
 6   clean_project_grade_category                  109248 non-null  object 
 7   preprocessed_essays                           109248 non-null  object 
 8   preprocessed_titles                           109248 non-null  object 
 9   price                                         109248 non-null  float6
4
 10  quantity                                      109248 non-null  int64  
dtypes: float64(1), int64(3), object(7)
memory usage: 10.0+ MB
```

In [45]:

```
data1 = data1[:50000]
```

In [46]:

```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data1, data1['project_is_approved'
], test_size=0.33, stratify=data1['project_is_approved'])
```

In [47]:

```
#Features
X_train.drop(['project_is_approved'], axis=1, inplace=True)

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

In [48]:

```
X_train.head()
```

Out[48]:

	school_state	teacher_number_of_previously_posted_projects	clean_categories	clean_
40589	NC	10	History_Civics	
41099	AZ	4	Math_Science SpecialNeeds	
7747	IN	34	Math_Science	A
1057	OK	0	Health_Sports	H
19857	CA	0	History_Civics Literacy_Language	Histo Lit

2.2 Make Data Model Ready: encoding essay, and project_title

In [49]:

```
# 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
```

Encoding Essay and Project title

```
2.2.1 TFIDF
2.2.2 TFIDF W2V
```

2.2.1 TF IDF Essay and Title

2.2.1.1 TF IDF Essay

In [50]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)

print("="*100)


vectorizer = TfidfVectorizer()
vectorizer.fit(X_train['preprocessed_essays'].values) # fit has to happen only on train
data

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

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
```

```
(33500, 10) (33500,)
(16500, 10) (16500,)
==========================================================================
==========================
After vectorizations
(33500, 35439) (33500,)
(16500, 35439) (16500,)
==========================================================================
==========================
```

2.2.1.2 TF IDF Title

In [51]:

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

print("="*100)


vectorizer = TfidfVectorizer()
vectorizer.fit(X_train['preprocessed_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['preprocessed_titles'].values)
X_test_title_tfidf = vectorizer.transform(X_test['preprocessed_titles'].values)

print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_test_title_tfidf.shape, y_test.shape)
print("="*100)
```

```
(33500, 10) (33500,)
(16500, 10) (16500,)
==========================================================================
==========================
After vectorizations
(33500, 9707) (33500,)
(16500, 9707) (16500,)
==========================================================================
==========================
```

2.2.2 TF IDF W2V Essay and Title

2.2.2.1 TF IDF W2V Essay

In [52]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-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 [53]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_essays'].values)
# 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 [54]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # 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 tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

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

```
100%|██████████| 33500/33500 [01:27<00:00, 381.72it/s]

33500
300
```

In [55]:

```
tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # 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 tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)
```

```
100%|██████████| 16500/16500 [00:47<00:00, 346.57it/s]
```

2.2.2.2 TF IDF W2V Title

In [56]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_titles'].values)
# 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 [57]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_titles'].values): # 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 tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train_title.append(vector)

print(len(tfidf_w2v_vectors_train_title))
print(len(tfidf_w2v_vectors_train_title[0]))
```

```
100%|██████████| 33500/33500 [00:01<00:00, 22967.68it/s]

33500
300
```

In [58]:

```
tfidf_w2v_vectors_test_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_titles'].values): # 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 tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test_title.append(vector)
```

```
100%|██████████| 16500/16500 [00:00<00:00, 20628.35it/s]
```

2.3 Make Data Model Ready: encoding numerical, categorical features

In [59]:

```
# 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
```

2.3.1 Numerical features

1. teacher_number_of_previously_posted_projects
2. price
3. quantity

2.3.1.1 Teacher number of previously posted projects

In [60]:

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

X_train_TPPP_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
X_test_TPPP_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

print("After vectorizations")
print(X_train_TPPP_norm.shape, y_train.shape)
print(X_test_TPPP_norm.shape, y_test.shape)
print("="*100)
```

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

In [61]:

```
print("Transpose of teacher number of previously posted projects")

X_train_TPPP_norm = X_train_TPPP_norm.transpose()
X_test_TPPP_norm = X_test_TPPP_norm.transpose()

print("After transpose")
print(X_train_TPPP_norm.shape, y_train.shape)
print(X_test_TPPP_norm.shape, y_test.shape)
print("="*100)
```

```
Transpose of teacher number of previously posted projects
After transpose
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

2.3.1.2 price

In [62]:

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

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

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

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

In [63]:

```python
print("Transpose of price")

X_train_price_norm = X_train_price_norm.transpose()
X_test_price_norm = X_test_price_norm.transpose()


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

```
Transpose of price
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

2.3.1.3 quantity

In [64]:

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

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

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

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

In [65]:

```
print("Transpose of Quantity")

X_train_quantity_norm = X_train_quantity_norm.transpose()
X_test_quantity_norm = X_test_quantity_norm.transpose()


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

```
Transpose of Quantity
After vectorizations
(33500, 1) (33500,)
(16500, 1) (16500,)
==========================================================================
==========================
```

2.3.2 Categorical Data

Categorical Features for vectorization

1. Clean Categories
2. Clean Sub Categories
3. School State
4. Teacher Prefix
5. Project grade category

2.3.2.1 Clean Categories

In [66]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
vectorizer.fit(X_train['clean_categories'].values) # fit has to happen only on train data

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

print("After vectorizations")
print(X_train_CC_ohe.shape, y_train.shape)
print(X_test_CC_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(33500, 9) (33500,)
(16500, 9) (16500,)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearnin
g', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
==========================================================================
==========================
```

2.3.2.2 Clean Sub Categories

In [67]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only on train data

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

print("After vectorizations")
print(X_train_CSC_ohe.shape, y_train.shape)
print(X_test_CSC_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(33500, 30) (33500,)
(16500, 30) (16500,)
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvemen
t', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'Nutrition
Education', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts',
'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Musi
c', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL',
'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'A
ppliedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Lit
eracy']
==========================================================================
==========================
```

2.3.2.3 School State

In [68]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercas
e=False, binary=True)
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on train data

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

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

```
After vectorizations
(33500, 51) (33500,)
(16500, 51) (16500,)
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME',
'HI', 'DC', 'NM', 'KS', 'IA', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'N
V', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ', 'NJ', 'OK', 'WA', 'M
A', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'N
Y', 'TX', 'CA']
==========================================================================
==========================
```

2.3.2.4 Teacher prefix

In [69]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowerc
ase=False, binary=True)
vectorizer.fit(X_train['clean_teacher_prefix'].values) # fit has to happen only on trai
n data

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

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

```
After vectorizations
(33500, 5) (33500,)
(16500, 5) (16500,)
['Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
==========================================================================
==========================
```

2.3.2.5 Project Grade category

In [70]:

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

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

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

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

Concatinating all the features

1. SET 1 TF IDF

In [71]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_TFIDF = hstack((X_train_essay_tfidf, X_train_title_tfidf, X_train_state_ohe, X_tra
in_teacher_ohe, X_train_grade_ohe, X_train_CSC_ohe, X_train_CC_ohe, X_train_price_norm,
X_train_quantity_norm, X_train_TPPP_norm)).tocsr()
X_te_TFIDF = hstack((X_test_essay_tfidf, X_test_title_tfidf, X_test_state_ohe, X_test_t
eacher_ohe, X_test_grade_ohe, X_test_CSC_ohe, X_test_CC_ohe, X_test_price_norm, X_test_
quantity_norm, X_test_TPPP_norm)).tocsr()

print("Final Data matrix")
print(X_tr_TFIDF.shape, y_train.shape)
print(X_te_TFIDF.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(33500, 45248) (33500,)
(16500, 45248) (16500,)
==========================================================================
==========================
```

2. SET 2 TF IDF W2V

In [72]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_TFIDF_W2V = hstack((tfidf_w2v_vectors_train, tfidf_w2v_vectors_train_title, X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe, X_train_CSC_ohe, X_train_CC_ohe, X_train_price_norm, X_train_quantity_norm, X_train_TPPP_norm)).tocsr()
X_te_TFIDF_W2V = hstack((tfidf_w2v_vectors_test, tfidf_w2v_vectors_test_title, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe, X_test_CSC_ohe, X_test_CC_ohe, X_test_price_norm, X_test_quantity_norm, X_test_TPPP_norm)).tocsr()

print("Final Data matrix")
print(X_tr_TFIDF_W2V.shape, y_train.shape)
print(X_te_TFIDF_W2V.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(33500, 702) (33500,)
(16500, 702) (16500,)
====================================================================================================
```

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 [73]:

```
# 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 Descision Tree on TFIDF, SET 1

In [74]:

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

#best depth in range [1, 5, 10, 50], and the best min_samples_split in range [5, 10, 10
0, 500]

DT = DecisionTreeClassifier(class_weight = 'balanced')

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=Tr
ue)
classifier.fit(X_tr_TFIDF, y_train)
```

Out[74]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
                                              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='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [75]:

```
print(classifier.cv_results_)
```

```
{'mean_fit_time': array([ 1.19697762,  1.1872309 ,  1.27083842,  1.1872177
9,  2.76168402,
        2.83821297,  2.7757384 ,  2.71962905,  6.43627787,  6.79943999,
        5.96889106,  4.94655538, 25.00706434, 24.25506107, 18.65241567,
       11.60350418]), 'std_fit_time': array([1.01216474e-02, 1.89951773e-0
5, 4.08471086e-02, 2.13544032e-06,
       1.15325652e-02, 1.01782971e-01, 1.05859297e-01, 5.20713854e-02,
       1.47107082e-01, 1.46260285e-01, 2.95122336e-01, 1.51591973e-01,
       2.60197336e-01, 1.74145455e+00, 1.35052353e+00, 1.11017038e+00]),
'mean_score_time': array([0.02083254, 0.01562309, 0.02804812, 0.02083063,
0.02082586,
       0.01907142, 0.02459645, 0.02227068, 0.01561952, 0.02235166,
       0.02365541, 0.01885605, 0.01953435, 0.02080353, 0.02377144,
       0.02252587]), 'std_score_time': array([7.36305444e-03, 3.37174788e-
07, 9.12298790e-03, 7.36339162e-03,
       7.36001987e-03, 4.87667141e-03, 6.58673931e-03, 6.58396731e-03,
       6.74349576e-07, 5.79997232e-04, 6.85221826e-03, 2.58235882e-03,
       5.50726350e-03, 7.35475629e-03, 9.14454957e-04, 4.21629414e-04]),
'param_max_depth': masked_array(data=[1, 1, 1, 1, 5, 5, 5, 5, 10, 10, 10,
10, 50, 50, 50, 50],
             mask=[False, False, False, False, False, False, False, False,
                   False, False, False, False, False, False, False, Fals
e],
       fill_value='?',
            dtype=object), 'param_min_samples_split': masked_array(data=
[5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5,
                   10, 100, 500],
             mask=[False, False, False, False, False, False, False, False,
                   False, False, False, False, False, False, False, Fals
e],
       fill_value='?',
            dtype=object), 'params': [{'max_depth': 1, 'min_samples_spli
t': 5}, {'max_depth': 1, 'min_samples_split': 10}, {'max_depth': 1, 'min_s
amples_split': 100}, {'max_depth': 1, 'min_samples_split': 500}, {'max_dep
th': 5, 'min_samples_split': 5}, {'max_depth': 5, 'min_samples_split': 1
0}, {'max_depth': 5, 'min_samples_split': 100}, {'max_depth': 5, 'min_samp
les_split': 500}, {'max_depth': 10, 'min_samples_split': 5}, {'max_depth':
10, 'min_samples_split': 10}, {'max_depth': 10, 'min_samples_split': 100},
{'max_depth': 10, 'min_samples_split': 500}, {'max_depth': 50, 'min_sample
s_split': 5}, {'max_depth': 50, 'min_samples_split': 10}, {'max_depth': 5
0, 'min_samples_split': 100}, {'max_depth': 50, 'min_samples_split': 50
0}], 'split0_test_score': array([0.56708553, 0.56708553, 0.56708553, 0.567
08553, 0.6433874 ,
       0.64340295, 0.64183139, 0.64231319, 0.64904847, 0.6480415 ,
       0.64960685, 0.65821943, 0.57115085, 0.57431211, 0.61026307,
       0.6356654 ]), 'split1_test_score': array([0.5691283 , 0.5691283 ,
0.5691283 , 0.5691283 , 0.63601191,
       0.63648493, 0.63919588, 0.63919588, 0.64656049, 0.6454377 ,
       0.65129435, 0.65932228, 0.5654676 , 0.56714781, 0.59437502,
       0.6079892 ]), 'split2_test_score': array([0.56877475, 0.56877475,
0.56877475, 0.56877475, 0.65396449,
       0.65407007, 0.65423954, 0.65440495, 0.65074655, 0.64930775,
       0.65709887, 0.67184395, 0.57740038, 0.58704443, 0.60367772,
       0.63452589]), 'mean_test_score': array([0.56832952, 0.56832952, 0.5
6832952, 0.56832952, 0.6444546 ,
       0.64465265, 0.64508893, 0.64530467, 0.64878517, 0.64759565,
       0.65266669, 0.66312855, 0.57133961, 0.57616812, 0.60277194,
       0.62606016]), 'std_test_score': array([0.0008914 , 0.0008914 , 0.00
08914 , 0.0008914 , 0.00736786,
       0.00723328, 0.0065593 , 0.00655951, 0.00171906, 0.00161109,
       0.00320885, 0.00617914, 0.00487337, 0.0082281 , 0.00651781,
       0.01278657]), 'rank_test_score': array([13, 13, 13, 13,  8,  7,  6,
5,  3,  4,  2,  1, 12, 11, 10,  9]), 'split0_train_score': array([0.567404
2 , 0.5674042 , 0.5674042 , 0.5674042 , 0.69029877,
       0.68999236, 0.68857901, 0.68493793, 0.80462559, 0.80206143,
       0.77706031, 0.75069358, 0.98339479, 0.97596978, 0.92798266,
       0.83922934]), 'split1_train_score': array([0.57539165, 0.57539165,
0.57539165, 0.57539165, 0.68651639,
       0.68651639, 0.68382529, 0.68382529, 0.81141301, 0.80851871,
       0.77992512, 0.7471068 , 0.98892526, 0.9847337 , 0.932285  ,
       0.85269529]), 'split2_train_score': array([0.56656008, 0.56656008,
0.56656008, 0.56656008, 0.68327323,
       0.68327323, 0.68188013, 0.68074039, 0.81560513, 0.81244169,
       0.78871479, 0.75408551, 0.99014915, 0.9848015 , 0.92418874,
       0.83252282]), 'mean_train_score': array([0.56978531, 0.56978531, 0.
56978531, 0.56978531, 0.68669613,
       0.68659399, 0.68476148, 0.68316787, 0.81054791, 0.80767394,
       0.78190007, 0.75062863, 0.98748973, 0.98183499, 0.92815213,
       0.84148248]), 'std_train_score': array([0.00397923, 0.00397923, 0.0
0397923, 0.00397923, 0.00287098,
       0.00274362, 0.00281378, 0.00177557, 0.00452393, 0.00427961,
       0.00495863, 0.00284942, 0.00293836, 0.00414742, 0.00330746,
       0.00838807])}
```

In [129]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_min_samples_split',
'param_max_depth']).max().unstack()
max_scores1
```

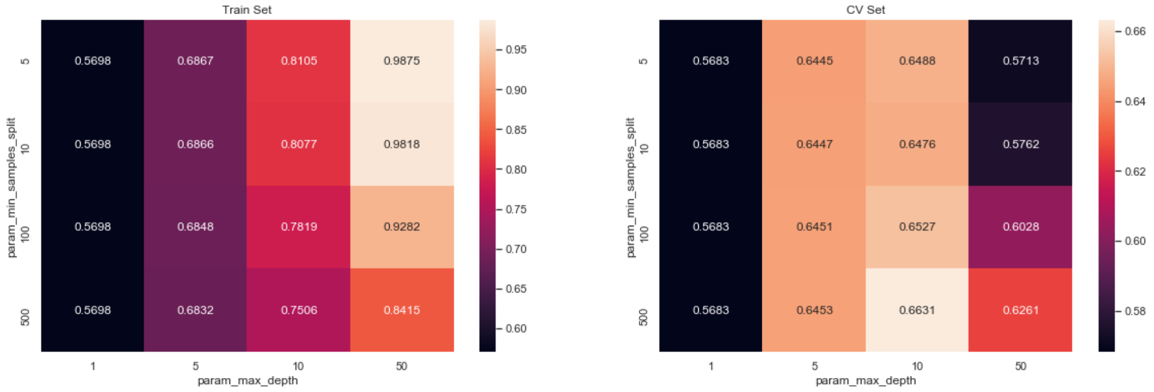
Out[129]:

	mean_fit_time				**std_fit_time**		
param_max_depth	**1**	**5**	**10**	**50**	**1**	**5**	**10**
param_min_samples_split							
5	0.120719	0.606974	1.464321	4.590692	0.007324	0.072612	0.1198
10	0.143564	0.695861	1.422847	4.148889	0.011753	0.024142	0.0136
100	0.177640	0.682927	1.229325	2.486934	0.026490	0.120333	0.0589
500	0.131868	0.693345	1.007352	1.175724	0.007017	0.174597	0.0774

4 rows × 64 columns

In [77]:

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



In [ ]:

```

```

In [ ]:

```

```

In [78]:

```
print(classifier.best_estimator_)
#Mean cross-validated score of the best_estimator
print(classifier.best_params_)
print(classifier.best_score_)
max_d = classifier.best_params_['max_depth']
min_samp_splt = classifier.best_params_['min_samples_split']
```

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight='balanced', criterion
='gini',
                       max_depth=10, max_features=None, max_leaf_nodes=Non
e,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=None, splitter='best')
{'max_depth': 10, 'min_samples_split': 500}
0.6631285546067064
```

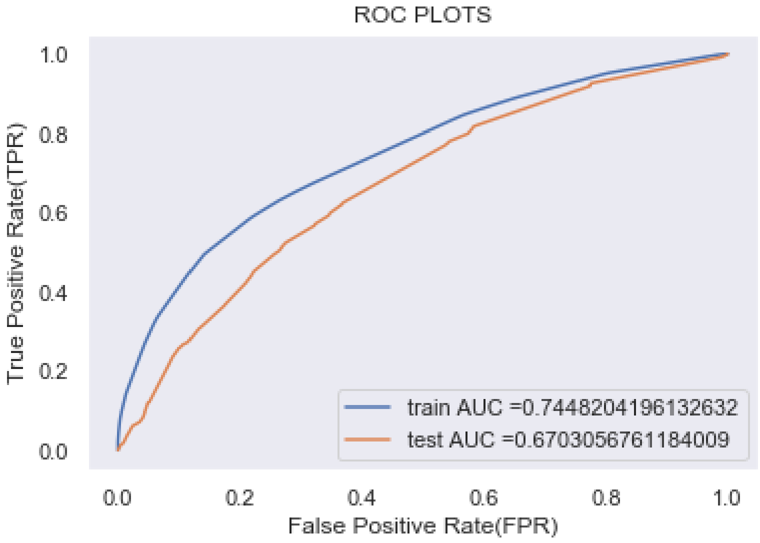
In [ ]:

```

```

In [146]:

```
##Fitting Model to Hyper-Parameter Curve
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
best_clf_TFIDF = DecisionTreeClassifier(class_weight = 'balanced',max_depth=max_d,min_s
amples_split=min_samp_splt)
best_clf_TFIDF.fit(X_tr_TFIDF ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs
train_fpr, train_tpr, thresholds = roc_curve(y_train, best_clf_TFIDF.predict_proba(X_tr
_TFIDF)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_test, best_clf_TFIDF.predict_proba(X_te_TF
IDF)[:,1])
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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid(False)
plt.show()
```



In [147]:

```
abc = best_clf_TFIDF.predict_proba(X_tr_TFIDF)
abc[:5,:]
```

Out[147]:

```
array([[0.58975653, 0.41024347],
       [0.70614275, 0.29385725],
       [0.19413914, 0.80586086],
       [0.58975653, 0.41024347],
       [0.34039767, 0.65960233]])
```

In [148]:

```
abc = best_clf_TFIDF.predict(X_tr_TFIDF)
abc[:5]
```

Out[148]:

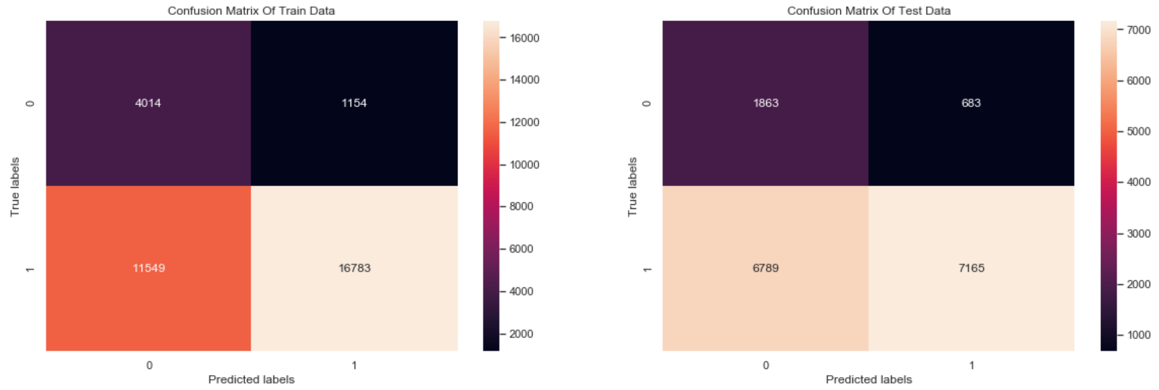
```
array([0, 0, 1, 0, 1], dtype=int64)
```

In [149]:

```
X_train_pred=best_clf_TFIDF.predict(X_tr_TFIDF)
X_test_pred=best_clf_TFIDF.predict(X_te_TFIDF)
```

In [150]:

```
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(confusion_matrix(y_train,X_train_pred), annot=True, ax = ax[0],fmt='g');
#annot=True to annotate cells
# labels, title and ticks
ax[0].set_xlabel('Predicted labels');
ax[0].set_ylabel('True labels');
ax[0].set_title('Confusion Matrix Of Train Data');
#ax.xaxis.set_ticklabels(['business', 'health']); ax.yaxis.set_ticklabels(['health', 'business']);
sns.heatmap(confusion_matrix(y_test, X_test_pred), annot=True, ax = ax[1],fmt='g');
ax[1].set_xlabel('Predicted labels');
ax[1].set_ylabel('True labels');
ax[1].set_title('Confusion Matrix Of Test Data');
```



WordCloud plot with Words of essay of false positive data

In [151]:

```
#Actual vs predicted class labels in Test Data
act_vs_predicted = pd.DataFrame({'index':y_test.index, 'actual':y_test.values,'predicted':X_test_pred})
act_vs_predicted.head()
```

Out[151]:

	index	actual	predicted
0	24742	0	1
1	11195	1	1
2	37213	1	0
3	43645	1	0
4	20176	1	1

In [152]:

```
fpi = []
for i in tqdm(range(len(act_vs_predicted))):
    if(act_vs_predicted['actual'][i]==0 and act_vs_predicted['predicted'][i]==1 ):
        fpi.append(act_vs_predicted['index'][i])

len(fpi)
```

```
100%|██████████| 16500/16500 [00:00<00:00, 19906.36it/s]
```

Out[152]:

```
683
```

In [153]:

```
fpi[0:10]
```

Out[153]:

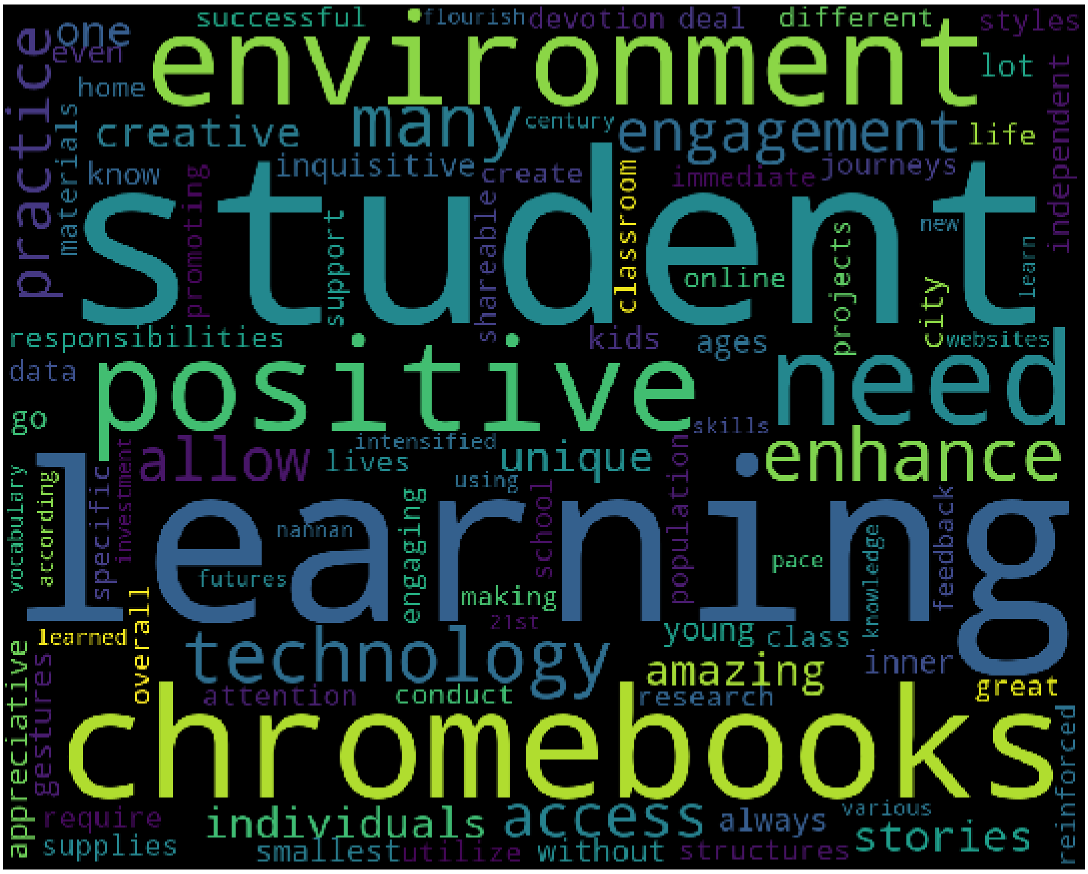
```
[24742, 11185, 15678, 22520, 6812, 11217, 7591, 43709, 17165, 31742]
```

In [154]:

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

In [87]:

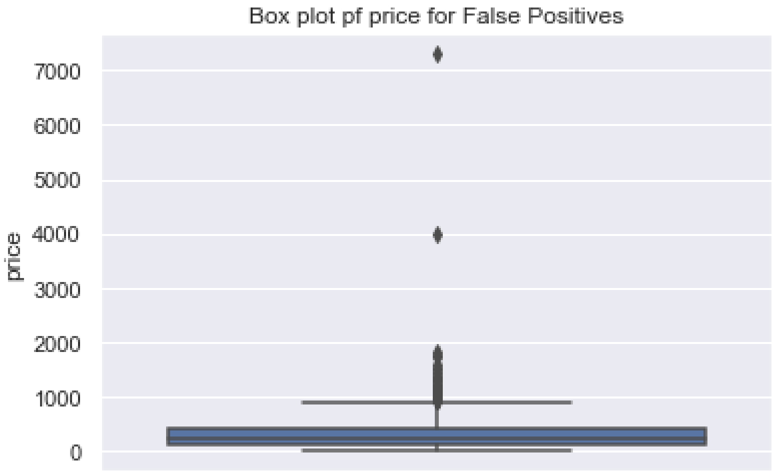
```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in X_test_falsePos['preprocessed_essays'] :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '
wordcloud = WordCloud(width = 1000, height = 800, background_color ='black', stopwords
= stopwords,min_font_size = 10).generate(comment_words)
plt.figure(figsize = (10, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



Boxplot with price of false positive data

In [88]:

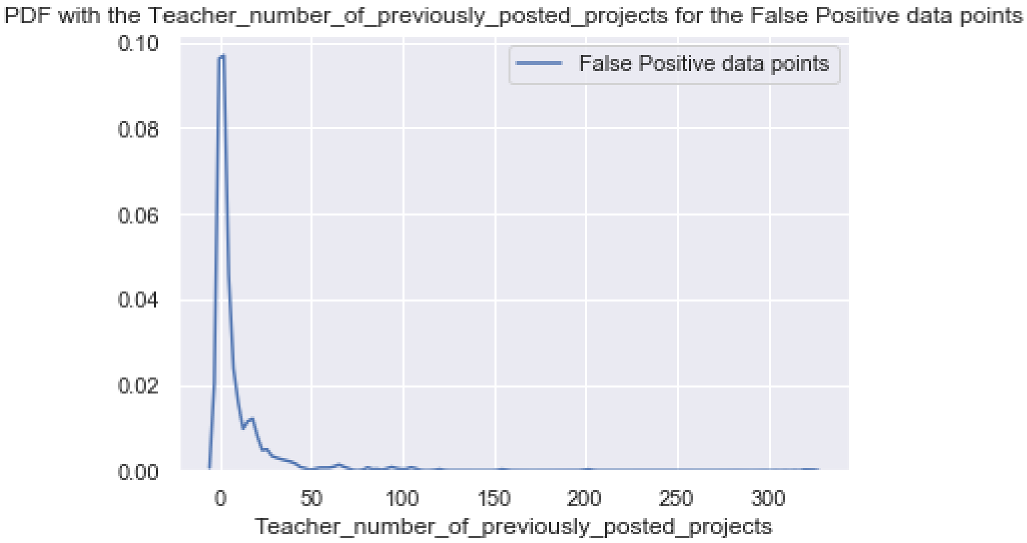
```
sns.boxplot(y=X_test_falsePos['price'])
plt.title("Box plot pf price for False Positives")
plt.show()
```



PDF curve with Teacher_number_of_previously_posted_projects of false positive data

In [89]:

```
sns.distplot(X_test_falsePos['teacher_number_of_previously_posted_projects'], hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```



2.4.2 Applying Descision Tree on TFIDF W2V, SET 2

In [90]:

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

#best depth in range [1, 5, 10, 50], and the best min_samples_split in range [5, 10, 10
0, 500]

DT = DecisionTreeClassifier(class_weight = 'balanced')

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=Tr
ue)
classifier.fit(X_tr_TFIDF_W2V, y_train)
```

Out[90]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
                                              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='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [91]:

```
print(classifier.cv_results_)
```

```
{'mean_fit_time': array([  2.98435028,   3.00028125,   2.95882956,   2.819
12573,
        12.69195708,  14.42411677,  14.17324225,  12.51055018,
        38.03548288,  38.98941596,  36.63751189,  22.35750008,
       101.57982302,  98.1078035 ,  85.43425814,  29.14148847]), 'std_fit_
time': array([0.05786985, 0.01573334, 0.35728953, 0.13502495, 0.46018537,
       0.88804934, 1.79560244, 0.45890078, 2.35153218, 1.24230068,
       1.02040202, 0.38675319, 7.64264055, 3.48911415, 7.24345282,
       1.23071333]), 'mean_score_time': array([0.07313832, 0.07511957, 0.0
8510717, 0.07047979, 0.07446694,
       0.09808477, 0.0701472 , 0.07447251, 0.0747985 , 0.08328493,
       0.07663353, 0.0787921 , 0.10091456, 0.097591  , 0.09958736,
       0.08814422]), 'std_score_time': array([0.00448315, 0.00617113, 0.01
404173, 0.0026176 , 0.00367181,
       0.01687758, 0.00169409, 0.00678428, 0.00215516, 0.01340939,
       0.00084654, 0.00281929, 0.00295964, 0.01492494, 0.02072768,
       0.00053347]), 'param_max_depth': masked_array(data=[1, 1, 1, 1, 5,
5, 5, 5, 10, 10, 10, 10, 50, 50, 50, 50],
             mask=[False, False, False, False, False, False, False, False,
                   False, False, False, False, False, False, False, Fals
e],
       fill_value='?',
            dtype=object), 'param_min_samples_split': masked_array(data=
[5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5,
                   10, 100, 500],
             mask=[False, False, False, False, False, False, False, False,
                   False, False, False, False, False, False, False, Fals
e],
       fill_value='?',
            dtype=object), 'params': [{'max_depth': 1, 'min_samples_spli
t': 5}, {'max_depth': 1, 'min_samples_split': 10}, {'max_depth': 1, 'min_s
amples_split': 100}, {'max_depth': 1, 'min_samples_split': 500}, {'max_dep
th': 5, 'min_samples_split': 5}, {'max_depth': 5, 'min_samples_split': 1
0}, {'max_depth': 5, 'min_samples_split': 100}, {'max_depth': 5, 'min_samp
les_split': 500}, {'max_depth': 10, 'min_samples_split': 5}, {'max_depth':
10, 'min_samples_split': 10}, {'max_depth': 10, 'min_samples_split': 100},
{'max_depth': 10, 'min_samples_split': 500}, {'max_depth': 50, 'min_sample
s_split': 5}, {'max_depth': 50, 'min_samples_split': 10}, {'max_depth': 5
0, 'min_samples_split': 100}, {'max_depth': 50, 'min_samples_split': 50
0}], 'split0_test_score': array([0.56708553, 0.56708553, 0.56708553, 0.567
08553, 0.63822151,
       0.63822151, 0.63822151, 0.63831089, 0.59136175, 0.59161267,
       0.6122678 , 0.63570857, 0.53596731, 0.54030869, 0.57305802,
       0.62930156]), 'split1_test_score': array([0.5691283 , 0.5691283 ,
0.5691283 , 0.5691283 , 0.63738224,
       0.63685342, 0.63685342, 0.63563074, 0.59541783, 0.59216605,
       0.60687916, 0.62888372, 0.52720066, 0.5248504 , 0.55277405,
       0.61182081]), 'split2_test_score': array([0.56877475, 0.56877475,
0.56877475, 0.56877475, 0.63879432,
       0.63879432, 0.63686728, 0.63886844, 0.60365251, 0.60528746,
       0.61228033, 0.62799264, 0.53082865, 0.53264315, 0.56123888,
       0.61590393]), 'mean_test_score': array([0.56832952, 0.56832952, 0.5
6832952, 0.56832952, 0.63813269,
       0.63795641, 0.63731407, 0.63760336, 0.5968107 , 0.59635539,
       0.61047576, 0.63086164, 0.53133221, 0.53260075, 0.56235699,
       0.61900876]), 'std_test_score': array([0.0008914 , 0.0008914 , 0.00
08914 , 0.0008914 , 0.00057989,
       0.00081424, 0.00064168, 0.0014133 , 0.00511343, 0.00631997,
       0.00254319, 0.00344655, 0.00359664, 0.00631089, 0.00831855,
       0.00746656]), 'rank_test_score': array([10, 10, 10, 10,  1,  2,  4,
3,  8,  9,  7,  5, 16, 15, 14,  6]), 'split0_train_score': array([0.567404
2 , 0.5674042 , 0.5674042 , 0.5674042 , 0.70256778,
       0.70256778, 0.70256778, 0.6977114 , 0.89270445, 0.89075325,
       0.84344242, 0.75840783, 0.99968166, 0.99850588, 0.91855443,
       0.76721641]), 'split1_train_score': array([0.57539165, 0.57539165,
0.57539165, 0.57539165, 0.69701769,
       0.69691188, 0.69691188, 0.69297988, 0.87141718, 0.86844159,
       0.82996234, 0.75278013, 0.99957324, 0.99899044, 0.92939382,
       0.76910622]), 'split2_train_score': array([0.56656008, 0.56656008,
0.56656008, 0.56656008, 0.69492563,
       0.69492563, 0.69237756, 0.68976187, 0.87938377, 0.8763779 ,
       0.82934193, 0.75389075, 0.99945418, 0.99828137, 0.92563613,
       0.7713938 ]), 'mean_train_score': array([0.56978531, 0.56978531, 0.
56978531, 0.56978531, 0.69817037,
       0.6981351 , 0.69728574, 0.69348438, 0.88116847, 0.87852424,
       0.8342489 , 0.75502624, 0.99956969, 0.99859256, 0.92452813,
       0.76923881]), 'std_train_score': array([3.97923154e-03, 3.97923154e
-03, 3.97923154e-03, 3.97923154e-03,
       3.22460149e-03, 3.23756899e-03, 4.16852821e-03, 3.26492671e-03,
       8.78163905e-03, 9.23427140e-03, 6.50573696e-03, 2.43375667e-03,
       9.29037809e-05, 2.95897315e-04, 4.49398784e-03, 1.70798843e-03])}
```

In [92]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_min_samples_split',
'param_max_depth']).max().unstack()
max_scores1
```

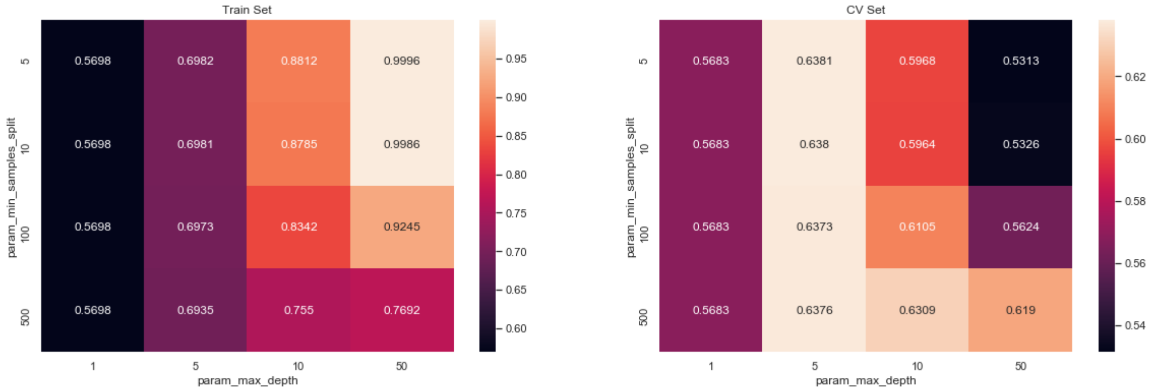
Out[92]:

	mean_fit_time				**std_fit_time**		
param_max_depth	**1**	**5**	**10**	**50**	**1**	**5**	**1(**
param_min_samples_split							
5	2.984350	12.691957	38.035483	101.579823	0.057870	0.460185	2.
10	3.000281	14.424117	38.989416	98.107804	0.015733	0.888049	1.
100	2.958830	14.173242	36.637512	85.434258	0.357290	1.795602	1.
500	2.819126	12.510550	22.357500	29.141488	0.135025	0.458901	0.

4 rows × 64 columns

In [93]:

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



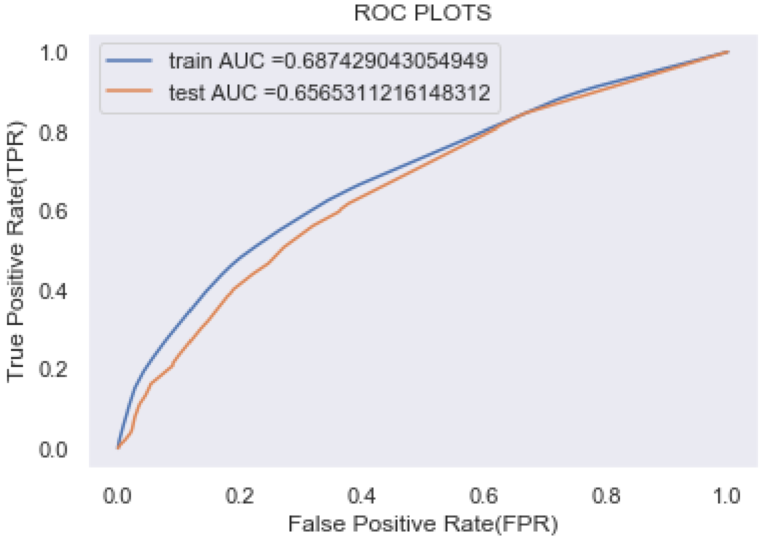
In [94]:

```
print(classifier.best_estimator_)
#Mean cross-validated score of the best_estimator
print(classifier.best_params_)
print(classifier.best_score_)
max_d_w2v = classifier.best_params_['max_depth']
min_samp_splt_w2v = classifier.best_params_['min_samples_split']
```

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight='balanced', criterion
='gini',
                       max_depth=5, max_features=None, max_leaf_nodes=Non
e,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=5,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=None, splitter='best')
{'max_depth': 5, 'min_samples_split': 5}
0.6381326880683054
```

In [95]:

```
##Fitting Model to Hyper-Parameter Curve
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
best_clf = DecisionTreeClassifier(class_weight = 'balanced',max_depth=max_d_w2v,min_sam
ples_split=min_samp_splt_w2v)
best_clf.fit(X_tr_TFIDF_W2V ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs
train_fpr, train_tpr, thresholds = roc_curve(y_train, best_clf.predict_proba(X_tr_TFIDF
_W2V)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_test, best_clf.predict_proba(X_te_TFIDF_W2
V)[:,1])
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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid(False)
plt.show()
```

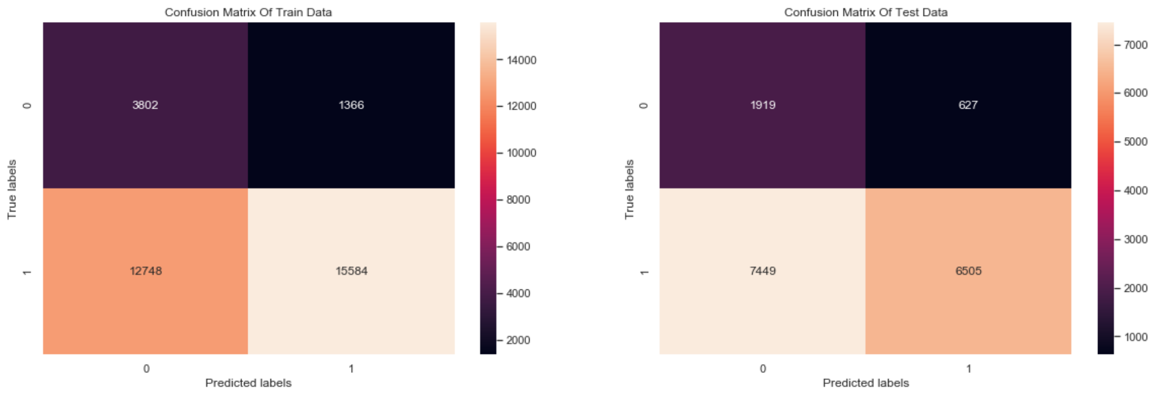


In [96]:

```
X_train_pred=best_clf.predict(X_tr_TFIDF_W2V)
X_test_pred=best_clf.predict(X_te_TFIDF_W2V)
```

In [97]:

```
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(confusion_matrix(y_train, X_train_pred), annot=True, ax = ax[0],fmt='g');
#annot=True to annotate cells
# labels, title and ticks
ax[0].set_xlabel('Predicted labels');
ax[0].set_ylabel('True labels');
ax[0].set_title('Confusion Matrix Of Train Data');
#ax.xaxis.set_ticklabels(['business', 'health']); ax.yaxis.set_ticklabels(['health', 'business']);
sns.heatmap(confusion_matrix(y_test, X_test_pred), annot=True, ax = ax[1],fmt='g');
ax[1].set_xlabel('Predicted labels');
ax[1].set_ylabel('True labels');
ax[1].set_title('Confusion Matrix Of Test Data');
```



WordCloud plot with Words of essay of false positive data

In [98]:

```
#Actual vs predicted class labels in Test Data
act_vs_predicted = pd.DataFrame({'index':y_test.index, 'actual':y_test.values,'predicted':X_test_pred})
act_vs_predicted.head()
```

Out[98]:

	index	actual	predicted
0	24742	0	1
1	11195	1	0
2	37213	1	0
3	43645	1	0
4	20176	1	0

In [99]:

```
fpi = []
for i in tqdm(range(len(act_vs_predicted))):
    if(act_vs_predicted['actual'][i]==0 and act_vs_predicted['predicted'][i]==1 ):
        fpi.append(act_vs_predicted['index'][i])

len(fpi)
```

```
100%|██████████| 16500/16500 [00:00<00:00, 21169.51it/s]
```

Out[99]:

```
627
```

In [100]:

```
fpi[0:10]
```

Out[100]:

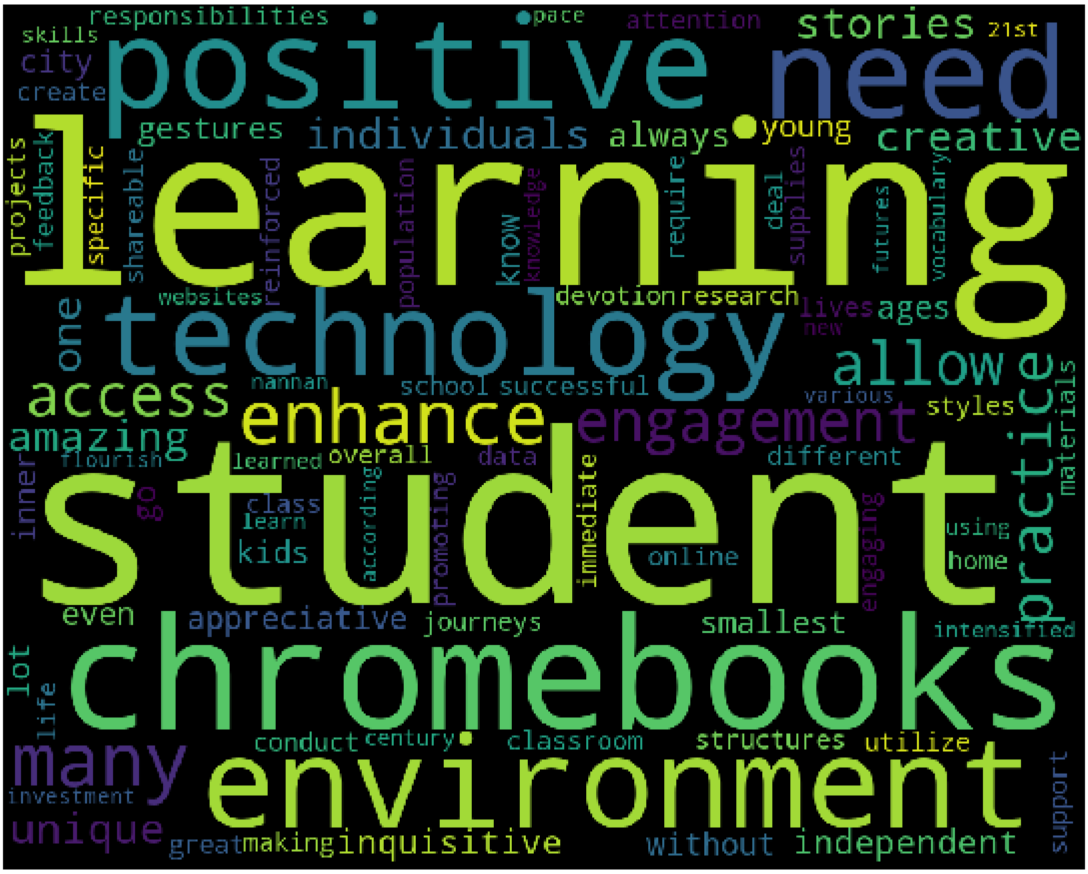
```
[24742, 15678, 22520, 7591, 43709, 37673, 31742, 9797, 14001, 43486]
```

In [101]:

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

In [102]:

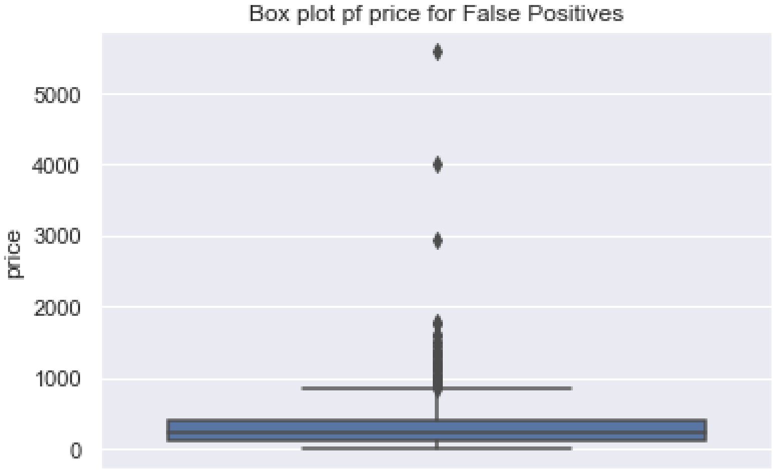
```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in X_test_falsePos['preprocessed_essays'] :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '
wordcloud = WordCloud(width = 1000, height = 800, background_color ='black', stopwords
= stopwords,min_font_size = 10).generate(comment_words)
plt.figure(figsize = (10, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



Boxplot with price of false positive data

In [103]:

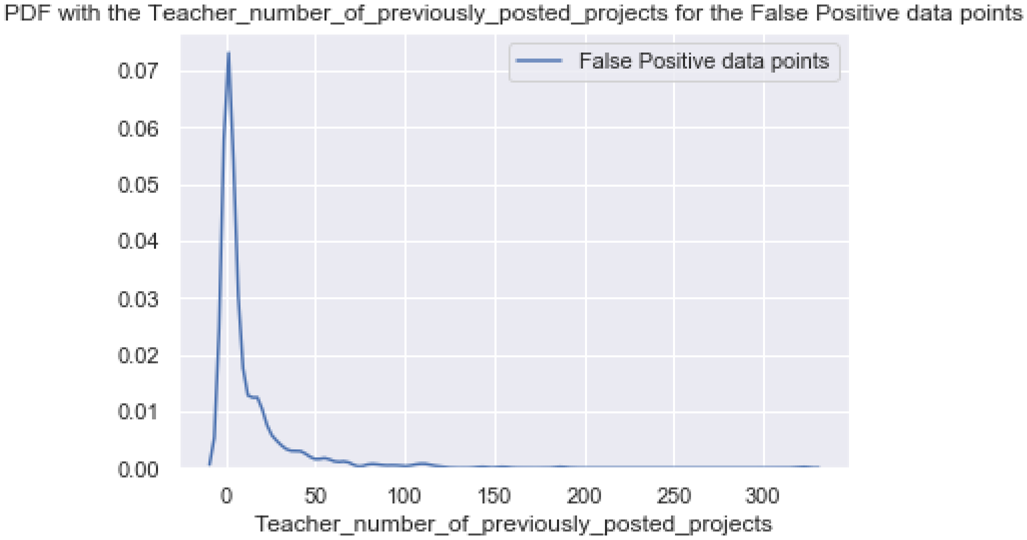
```
sns.boxplot(y=X_test_falsePos['price'])
plt.title("Box plot pf price for False Positives")
plt.show()
```



PDF curve with Teacher_number_of_previously_posted_projects of false positive data

In [104]:

```
sns.distplot(X_test_falsePos['teacher_number_of_previously_posted_projects'], hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```



2.5 Getting top features using `feature_importances_`

In [105]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# 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 [171]:

```
from sklearn.feature_selection import SelectFromModel
selector = SelectFromModel(estimator=best_clf_TFIDF, threshold = 0.001).fit(X_tr_TFIDF,
y_train)
```

In [172]:

```
selector.threshold_
```

Out[172]:

```
0.001
```

In [173]:

```
X_tr_TFIDF_updated=selector.transform(X_tr_TFIDF)
```

In [174]:

```
X_tr_TFIDF_updated.shape
```

Out[174]:

```
(33500, 81)
```

In [175]:

```
X_te_TFIDF_updated=selector.transform(X_te_TFIDF)

X_te_TFIDF_updated.shape
```

Out[175]:

```
(16500, 81)
```

In [176]:

```
len(best_clf_TFIDF.feature_importances_[best_clf_TFIDF.feature_importances_[:]!=0])
```

Out[176]:

```
81
```

In [111]:

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

#best depth in range [1, 5, 10, 50], and the best min_samples_split in range [5, 10, 10
0, 500]

DT = DecisionTreeClassifier(class_weight = 'balanced')

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

classifier = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=Tr
ue)
classifier.fit(X_tr_TFIDF_updated, y_train)
```

Out[111]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
                                              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='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [112]:

```
print(classifier.cv_results_)
```

```
{'mean_fit_time': array([0.12071935, 0.14356351, 0.17763956, 0.13186757,
0.60697389,
       0.69586126, 0.68292745, 0.69334515, 1.46432145, 1.42284695,
       1.22932482, 1.0073518 , 4.59069228, 4.14888851, 2.48693371,
       1.17572355]), 'std_fit_time': array([0.00732422, 0.01175314, 0.0264
9023, 0.00701675, 0.07261233,
       0.02414188, 0.12033267, 0.17459707, 0.1198064 , 0.01360725,
       0.05898492, 0.07747608, 0.70357609, 0.22955403, 0.23073929,
       0.0257237 ]), 'mean_score_time': array([0.01253144, 0.01098053, 0.0
1664782, 0.0123148 , 0.01301694,
       0.01602944, 0.01335637, 0.0170087 , 0.01599979, 0.01364772,
       0.01566291, 0.0151693 , 0.01196909, 0.01597579, 0.01063927,
       0.01462873]), 'std_score_time': array([0.00174047, 0.00354177, 0.00
126033, 0.00249216, 0.00283598,
       0.00219624, 0.00206775, 0.00717339, 0.00285221, 0.00169745,
       0.00337032, 0.00134472, 0.00081517, 0.00645432, 0.00094032,
       0.00329071]), 'param_max_depth': masked_array(data=[1, 1, 1, 1, 5,
5, 5, 5, 10, 10, 10, 10, 50, 50, 50, 50],
             mask=[False, False, False, False, False, False, False, False,
                   False, False, False, False, False, False, False, Fals
e],
       fill_value='?',
            dtype=object), 'param_min_samples_split': masked_array(data=
[5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5,
                   10, 100, 500],
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e],
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            dtype=object), 'params': [{'max_depth': 1, 'min_samples_spli
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amples_split': 100}, {'max_depth': 1, 'min_samples_split': 500}, {'max_dep
th': 5, 'min_samples_split': 5}, {'max_depth': 5, 'min_samples_split': 1
0}, {'max_depth': 5, 'min_samples_split': 100}, {'max_depth': 5, 'min_samp
les_split': 500}, {'max_depth': 10, 'min_samples_split': 5}, {'max_depth':
10, 'min_samples_split': 10}, {'max_depth': 10, 'min_samples_split': 100},
{'max_depth': 10, 'min_samples_split': 500}, {'max_depth': 50, 'min_sample
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0}], 'split0_test_score': array([0.56708553, 0.56708553, 0.56708553, 0.567
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       0.64146877, 0.64085941, 0.64335179, 0.65807169, 0.65560052,
       0.65986198, 0.67501898, 0.55927654, 0.55620218, 0.60768063,
       0.65899309]), 'split1_test_score': array([0.5691283 , 0.5691283 ,
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       0.66259277, 0.66822216, 0.5531516 , 0.56161352, 0.60903323,
       0.64914038]), 'split2_test_score': array([0.56877475, 0.56877475,
0.56877475, 0.56877475, 0.65681057,
       0.65691464, 0.65692574, 0.65628998, 0.66561545, 0.66574953,
       0.67608341, 0.68012183, 0.55815198, 0.57174251, 0.63027626,
       0.67595038]), 'mean_test_score': array([0.56832952, 0.56832952, 0.5
6832952, 0.56832952, 0.6472492 ,
       0.64721355, 0.64722044, 0.64775538, 0.65987759, 0.65900766,
       0.66617939, 0.67445432, 0.55686004, 0.56318607, 0.61566337,
       0.66136128]), 'std_test_score': array([0.0008914 , 0.0008914 , 0.00
08914 , 0.0008914 , 0.00681001,
       0.00689846, 0.00697232, 0.0060359 , 0.00414908, 0.00476731,
       0.00709139, 0.0048744 , 0.00266215, 0.00644102, 0.01034761,
       0.0110725 ]), 'rank_test_score': array([11, 11, 11, 11,  7,  9,  8,
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       0.78490545]), 'split2_train_score': array([0.56656008, 0.56656008,
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       0.76758492, 0.74090229, 0.99825829, 0.99105913, 0.88709846,
       0.78066268]), 'mean_train_score': array([0.56978531, 0.56978531, 0.
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       0.77162302, 0.74178093, 0.99827639, 0.99107379, 0.89001471,
       0.7800415 ]), 'std_train_score': array([0.00397923, 0.00397923, 0.0
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       0.00785898, 0.00361868, 0.00029184, 0.00035117, 0.00223959,
       0.00424777])}
```

In [113]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_min_samples_split',
'param_max_depth']).max().unstack()
max_scores1
```

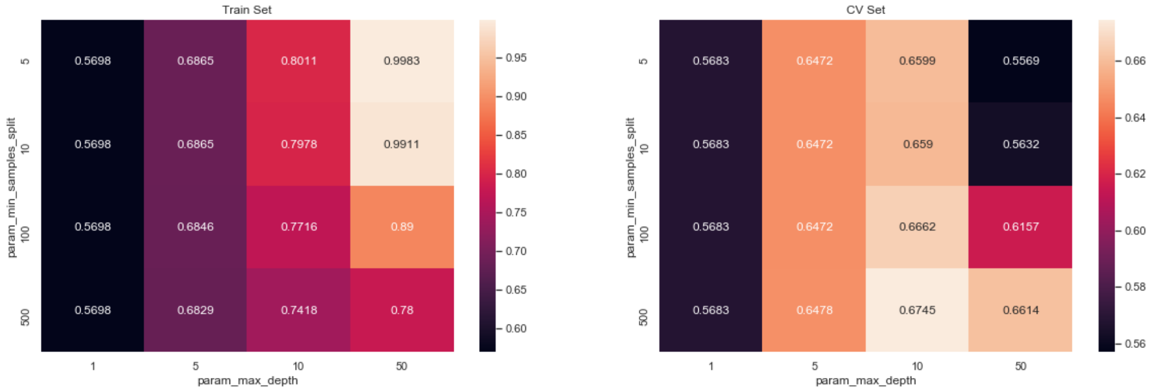
Out[113]:

	mean_fit_time				std_fit_time		
param_max_depth	**1**	**5**	**10**	**50**	**1**	**5**	**10**
param_min_samples_split							
5	0.120719	0.606974	1.464321	4.590692	0.007324	0.072612	0.1198
10	0.143564	0.695861	1.422847	4.148889	0.011753	0.024142	0.0136
100	0.177640	0.682927	1.229325	2.486934	0.026490	0.120333	0.0589
500	0.131868	0.693345	1.007352	1.175724	0.007017	0.174597	0.0774

4 rows × 64 columns

In [114]:

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



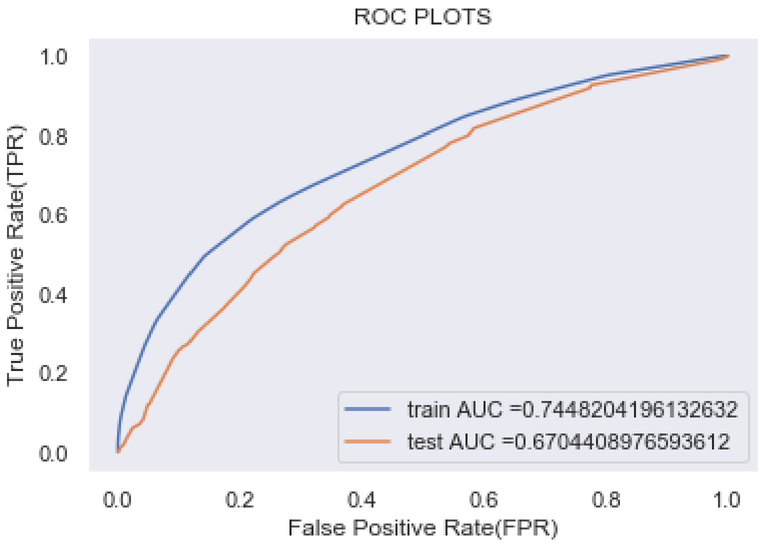
In [115]:

```
print(classifier.best_estimator_)
#Mean cross-validated score of the best_estimator
print(classifier.best_params_)
print(classifier.best_score_)
max_d_impft = classifier.best_params_['max_depth']
min_samp_splt_impft = classifier.best_params_['min_samples_split']
```

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight='balanced', criterion
='gini',
                       max_depth=10, max_features=None, max_leaf_nodes=Non
e,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=None, splitter='best')
{'max_depth': 10, 'min_samples_split': 500}
0.6744543242011188
```

In [116]:

```
##Fitting Model to Hyper-Parameter Curve
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
best_clf_TFIDF = DecisionTreeClassifier(class_weight = 'balanced',max_depth=max_d_impft
,min_samples_split=min_samp_splt_impft)
best_clf_TFIDF.fit(X_tr_TFIDF_updated ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs
train_fpr, train_tpr, thresholds = roc_curve(y_train, best_clf_TFIDF.predict_proba(X_tr
_TFIDF_updated)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_test, best_clf_TFIDF.predict_proba(X_te_TF
IDF_updated)[:,1])
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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid(False)
plt.show()
```

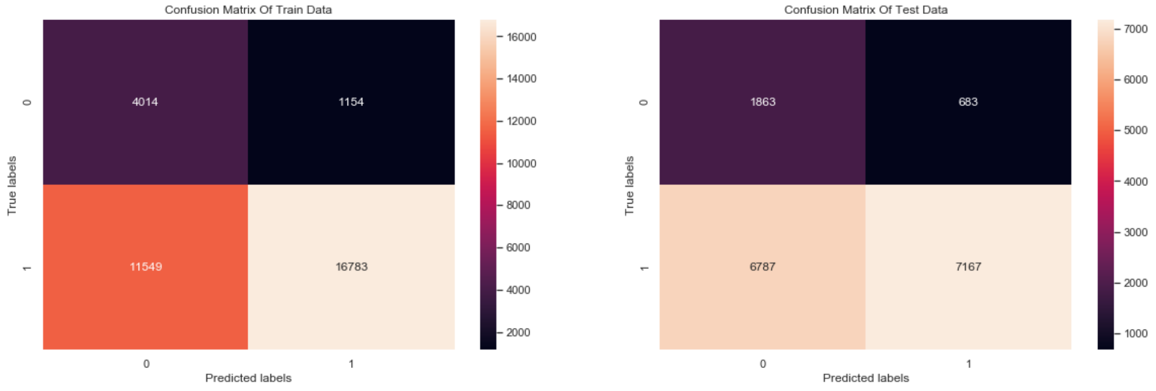


In [117]:

```
X_train_pred=best_clf_TFIDF.predict(X_tr_TFIDF_updated)
X_test_pred=best_clf_TFIDF.predict(X_te_TFIDF_updated)
```

In [118]:

```
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(confusion_matrix(y_train, X_train_pred), annot=True, ax = ax[0],fmt='g');
#annot=True to annotate cells
# labels, title and ticks
ax[0].set_xlabel('Predicted labels');
ax[0].set_ylabel('True labels');
ax[0].set_title('Confusion Matrix Of Train Data');
#ax.xaxis.set_ticklabels(['business', 'health']); ax.yaxis.set_ticklabels(['health', 'b
usiness']);
sns.heatmap(confusion_matrix(y_test, X_test_pred), annot=True, ax = ax[1],fmt='g');
ax[1].set_xlabel('Predicted labels');
ax[1].set_ylabel('True labels');
ax[1].set_title('Confusion Matrix Of Test Data');
```



WordCloud plot with Words of essay of false positive data

In [119]:

```
#Actual vs predicted class labels in Test Data
act_vs_predicted = pd.DataFrame({'index':y_test.index, 'actual':y_test.values,'predicte
d':X_test_pred})
act_vs_predicted.head()
```

Out[119]:

	index	actual	predicted
0	24742	0	1
1	11195	1	1
2	37213	1	0
3	43645	1	0
4	20176	1	1

In [120]:

```
fpi = []
for i in tqdm(range(len(act_vs_predicted))):
    if(act_vs_predicted['actual'][i]==0 and act_vs_predicted['predicted'][i]==1 ):
        fpi.append(act_vs_predicted['index'][i])

len(fpi)
```

```
100%|██████████| 16500/16500 [00:00<00:00, 19812.57it/s]
```

Out[120]:

```
683
```

In [121]:

```
fpi[0:10]
```

Out[121]:

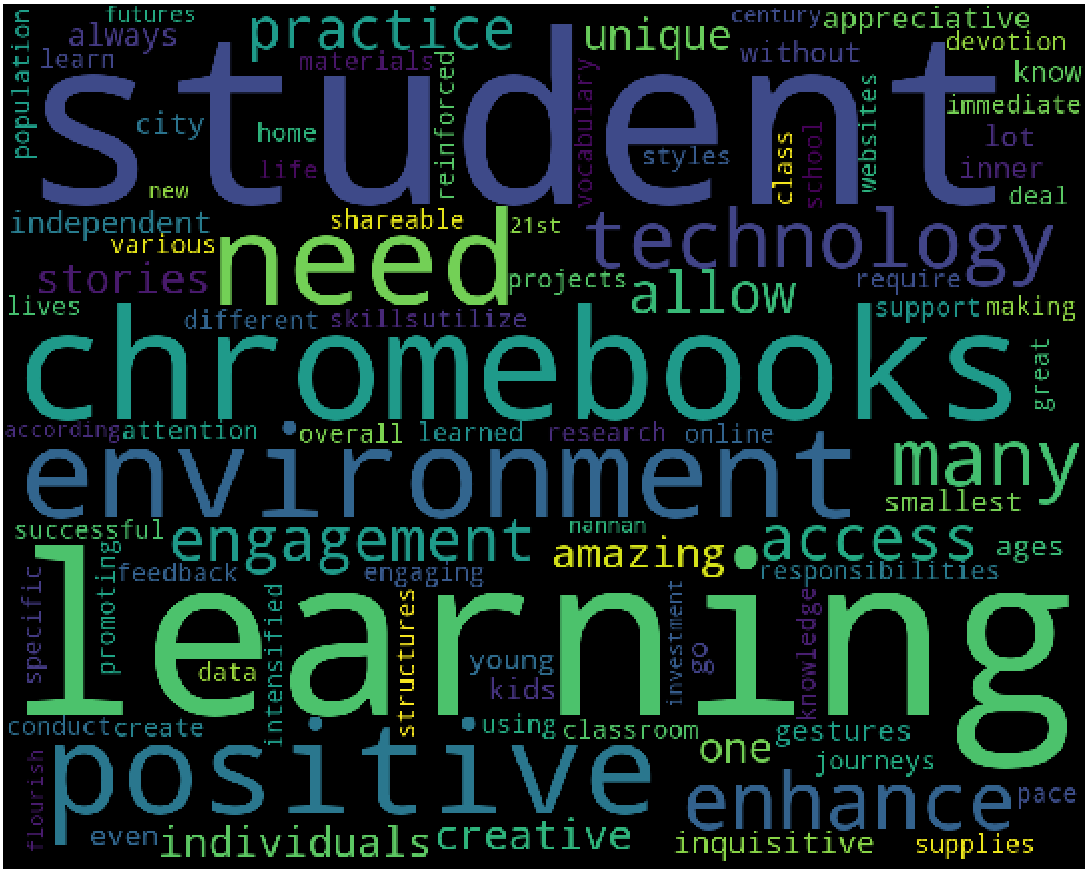
```
[24742, 11185, 15678, 22520, 6812, 11217, 7591, 43709, 17165, 31742]
```

In [122]:

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

In [123]:

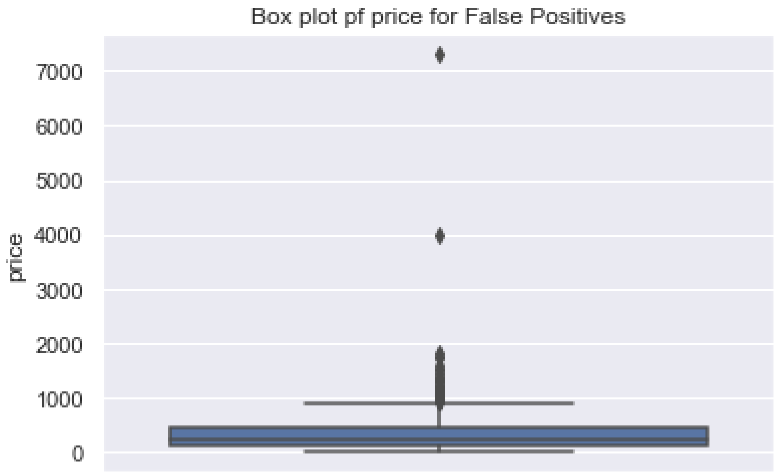
```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in X_test_falsePos['preprocessed_essays'] :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '
wordcloud = WordCloud(width = 1000, height = 800, background_color ='black', stopwords
= stopwords,min_font_size = 10).generate(comment_words)
plt.figure(figsize = (10, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



Boxplot with price of false positive data

In [124]:

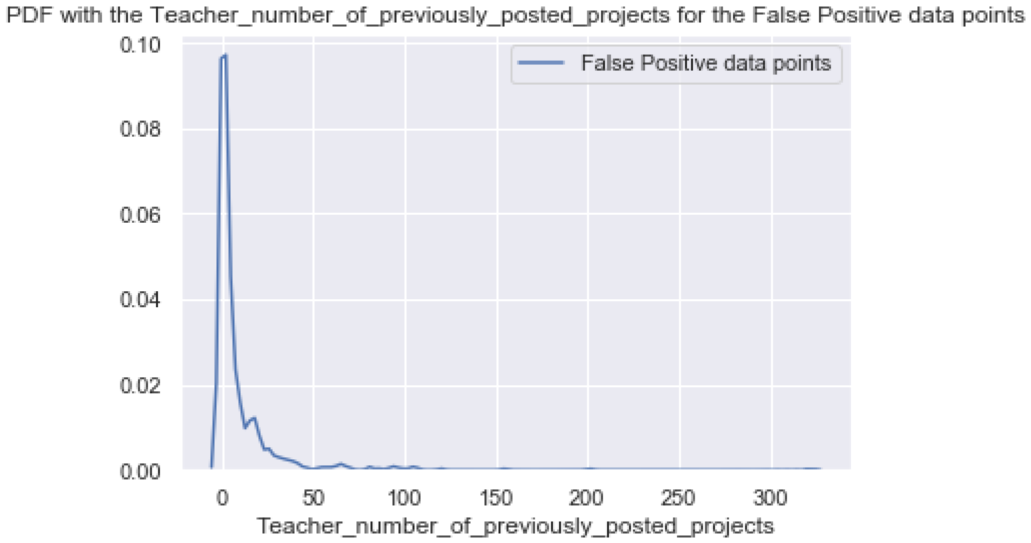
```
sns.boxplot(y=X_test_falsePos['price'])
plt.title("Box plot pf price for False Positives")
plt.show()
```



PDF curve with Teacher_number_of_previously_posted_projects of false positive data

In [125]:

```
sns.distplot(X_test_falsePos['teacher_number_of_previously_posted_projects'], hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```



3. Summary

In [155]:

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prett
ytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameters(max depth,min samples split)",
"AUC"]
x.add_row(["TFIDF", "Decision Tree", (10,500), 0.67])
x.add_row(["TFIDF W2V", "Decision Tree", (5,5), 0.65])
x.add_row(["TFIDF WITH FEATURE IMPORTANCE", "Decision Tree", (10,500), 0.67])
print(x)
```

```
+-------------------------------+---------------+-------------------------
---------------------+------+
|           Vectorizer          |     Model     | Hyperparameters(max dept
h,min samples split) | AUC  |
+-------------------------------+---------------+-------------------------
---------------------+------+
|             TFIDF             | Decision Tree |                   (10, 50
0)                   | 0.67 |
|           TFIDF W2V           | Decision Tree |                     (5,
5)                    | 0.65 |
| TFIDF WITH FEATURE IMPORTANCE | Decision Tree |                   (10, 50
0)                   | 0.67 |
+-------------------------------+---------------+-------------------------
---------------------+------+
```

Observation

1.With 50k data, we can see that Normal TFIDF and TFIDF WITH FEATURE IMPORTANCE has given highest AUC score

In [ ]:

```
```