Decision Trees on Donor Choose Dataset

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

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)
project_data.project_is_approved.value_counts()
```

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

Out[3]:
```
1    92706
0    16542
Name: project_is_approved, dtype: int64
```

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 of `project_subject_categories`

In [5]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.co

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-i
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", "
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the traili
        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
```

Out[6]:
```
{'Warmth': 1388,
 'Care_Hunger': 1388,
 'History_Civics': 5914,
 'Music_Arts': 10293,
 'AppliedLearning': 12135,
 'SpecialNeeds': 13642,
 'Health_Sports': 14223,
 'Math_Science': 41421,
 'Literacy_Language': 52239}
```

1.3 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.co

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

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", "
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the traili
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4
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
```

Out[8]:
```
{'Economics': 269,
 'CommunityService': 441,
 'FinancialLiteracy': 568,
 'ParentInvolvement': 677,
 'Extracurricular': 810,
 'Civics_Government': 815,
 'ForeignLanguages': 890,
 'NutritionEducation': 1355,
 'Warmth': 1388,
 'Care_Hunger': 1388,
 'SocialSciences': 1920,
 'PerformingArts': 1961,
 'CharacterEducation': 2065,
 'TeamSports': 2192,
 'Other': 2372,
 'College_CareerPrep': 2568,
 'Music': 3145,
 'History_Geography': 3171,
 'Health_LifeScience': 4235,
 'EarlyDevelopment': 4254,
 'ESL': 4367,
 'Gym_Fitness': 4509,
 'EnvironmentalScience': 5591,
 'VisualArts': 6278,
 'Health_Wellness': 10234,
 'AppliedSciences': 10816,
 'SpecialNeeds': 13642,
 'Literature_Writing': 22179,
 'Mathematics': 28074,
 'Literacy': 33700}
```

1.4 preprocessing of project grade categories

In [9]:
```
project_data['project_grade_category'].value_counts()
```

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

In [10]:
```
preprocessed_project_grade_categories= []
for grade_cat in tqdm(project_data["project_grade_category"]):
    grade_cat = grade_cat.replace('-', '_')  #Replacing(-) with(_)
    grade_cat = grade_cat.replace('Grades', '') #Removing grades as it is redunda
    grad_cat = ' '.join(f for f in grade_cat.split())
    preprocessed_project_grade_categories.append(grad_cat.strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 10
9248/109248 [00:00<00:00, 622904.75it/s]
```

In [11]:
```
print(preprocessed_project_grade_categories[12])
print("="*50)
print(preprocessed_project_grade_categories[502])
print("="*50)
print(preprocessed_project_grade_categories[5002])
print("="*50)
print(preprocessed_project_grade_categories[50002])
print("="*50)
print(preprocessed_project_grade_categories[100013])
print("="*50)
```

```
6_8
==================================================
6_8
==================================================
6_8
==================================================
3_5
==================================================
PreK_2
==================================================
```

1.5 preprocessing of teacher prefix

In [12]:
```
project_data['teacher_prefix'].value_counts()
```

Out[12]:
```
Mrs.       57269
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

Replacing Nan Values with maximum frequencies values i.e Mrs.

In [13]:
```
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna('Mrs.')
```

In [14]:
```
def replace_cate(lst):          # Removing (.) in Mrs.
    return lst.replace('.','')
project_data['teacher_prefix']= project_data['teacher_prefix'].apply(replace_cate
```

In [15]:
```
preprocessed_teacher_prefix = []
for teach_prefix in tqdm(project_data["teacher_prefix"]):
    preprocessed_teacher_prefix.append(teach_prefix.strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109
248/109248 [00:00<00:00, 2278156.69it/s]
```

In [16]:
```
print(preprocessed_teacher_prefix[1])
print("="*50)
print(preprocessed_teacher_prefix[50])
print("="*50)
project_data.teacher_prefix.value_counts()
```

```
Mr
==================================================
Mrs
==================================================
```

Out[16]:
```
Mrs        57272
Ms         38955
Mr         10648
Teacher     2360
Dr            13
Name: teacher_prefix, dtype: int64
```

1.6 Adding a new feature

Introducing New Features Consider these set of features for Set 5 in Assignment:

categorical dataschool_state
clean_categories....clean_subcategories....project_grade_category....teacher_prefix

numerical data quantity....teacher_number_of_previously_posted_projects....price

New Features

sentiment score's of each of the essay : numerical data number of words in the title : numerical data number of words in the combine essays : numerical data

In [17]:
```
title_word_count = []
```

In [18]:
```
for a in project_data["project_title"] :
    b = len(a.split())
    title_word_count.append(b)
```

In [19]:
```
project_data["title_word_count"] = title_word_count
```

In [20]:
```
project_data.head(5)
```

Out[20]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sub
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	20
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms	AZ	20
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs	KY	20
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs	TX	20

combining 4 essays into 1 essay

In [21]:
```
# 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)
```

Adding a new feature Number of words in essay

In [22]:
```
essay_word_count=[]
```

In [23]:
```
for ess in project_data["essay"] :
    c = len(ess.split())
    essay_word_count.append(c)
```

In [24]:
```
project_data["essay_word_count"] = essay_word_count
```

Computing Sentiment Score

In [25]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
import nltk
nltk.download('vader_lexicon')
# import nltk
#nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the sm
ss = sid.polarity_scores(for_sentiment)

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

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

```
C:\Anaconda3\lib\site-packages\nltk\twitter\__init__.py:20: UserWarning:

The twython library has not been installed. Some functionality from the twitter
package will not be available.


[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\honey\AppData\Roaming\nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
neg: 0.109, neu: 0.693, pos: 0.198, compound: 0.2023,
```

In [26]:
```
SID = SentimentIntensityAnalyzer()
#There is NEGITIVE and POSITIVE and NEUTRAL and COMPUND SCORES
#http://www.nltk.org/howto/sentiment.html

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

```
100%|██████████████████████████████████████████████████████████████████████████|
109248/109248 [16:08<00:00, 112.78it/s]
```

In [27]:
```
project_data['negitive'] = negitive
project_data['positive'] = positive
project_data['neutral'] = neutral
project_data['compound'] = compound
```

In [28]:
```
project_data.head(2)
```

Out[28]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sub
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	20

2 rows × 24 columns

In [29]:
```
project_data.columns.values
```

Out[29]:
```
array(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects',
       'project_is_approved', 'clean_categories', 'clean_subcategories',
       'title_word_count', 'essay', 'essay_word_count', 'negitive',
       'positive', 'neutral', 'compound'], dtype=object)
```

Train Test split

In [30]:
```
# train test split using sklearn.model selection
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data, project_data['p
#X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33
```

In [31]:
```
project_data.head()
```

Out[31]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sub
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	20
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms	AZ	20
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs	KY	20
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs	TX	20

5 rows × 24 columns

In [32]:
```
X_train.drop(['project_is_approved'], axis=1, inplace=True)
X_test.drop(['project_is_approved'], axis=1, inplace=True)
#X_cv.drop(['project_is_approved'], axis=1, inplace=True)
```

In [33]:
```
X_train.head(2)
```

Out[33]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	projec
41046	35767	p135014	292857bb10b18b1d61b9f7c2d6f8be41	Mrs	SC	
81320	153328	p082885	83993ecaecbe4670a8836aeab839f3e8	Ms	LA	

2 rows × 23 columns

1.8 Text preprocessing

In [34]:
```
# printing some random reviews

print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[500])
print("="*50)
```

```
I teach in a suburban area of upstate South Carolina at a large primary school
of 740 students! In my classroom, I have 25 motivated and wonderfully unique st
udents who learn in many different ways.\r\n\r\nOur classroom is filled with lo
ve, laughter, and learning. Through small group and whole group lessons, games,
activities, and projects, the students are able to achieve goals based on their
individual needs.\r\n\r\nWe are continuing to integrate technology to provide s
tudents with 21st century skills they will need to be successful in the world.T
here are so many apps available for students at the K-2 level.  For example, th
ere are apps to read books picked specifically for them such as Raz-Kids and Ep
ic!  The students in our class have a wide range of interests and levels and th
ese apps provide another reading opportunity outside of the books in the classr
oom library. Using an app called Seesaw, students will be keeping an online jou
rnal of things completed in class and documenting their learning.  Having anoth
er iPad in the room would allow for more students to work on their journals and
reflect on their work so they can grow as learners.  \r\n\r\nIn today's world,
technology is integrated into every aspect of life.\r\nWe must prepare students
by exposing them to technology and utilitizing it in a productive way. Having a
n iPad mini will allow the students to show what they've learned by using what
they love!\r\n\r\n\r\nnannan
==================================================
The students of MS258 are a fantastic group of fun loving, determined and brigh
t young men and women. They work hard in Physical Education and Health classes
to get the most out of their bodies. In nearly all of their classroom settings
they have been provided with tools that can help them succeed. In physical educ
ation however, their equipment is deteriorating and students are forced to work
in a gym that has splintering backboards and dis functional water fountains. We
need help to be the best that we can be. The students of MS258 are ready to tak
e it to the next level!!These basketball backboards and rims will increase stud
ent moral more then you might imagine. Not only will students be able to partic
ipate in one of their favorite activities, but our boys' and girls' basketball
teams will have equipment that is safe. Right now we have 20 year old wooden ba
ckboards that have begun to splinter and break. The rims have been bent, and ar
e barely usable. With these pieces of equipment, we will be able to run safe af
ter school programs that will help keep our students out of trouble both after
school and during the summer. Living a healthy and active childhood is not some
thing these students should be denied because of unsafe equipment. We need your
help! Thank you, thank you, thank you!!!nannan
==================================================
```

In [35]:
```
# 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 [36]:
```
sent = decontracted(X_train['essay'].values[20000])
print(sent)
print("="*50)
```

```
My students are awesome! They are working so hard this year to complete all of
their projects.  Our community is classified as high poverty; our students do n
ot have many resources outside of the school doors. They are very grateful for
any technology or helpful aides supplied to them to enhance their learning envi
ronment.  \r\n\r\nOur Business & Technology classes, as well as the high school
Yearbook staff, are talented kiddos who, when given the right tools, can be ver
y creative with their designs! They have fantastic ideas and share many \"aha\"
moments in the classroom.My classroom is in desperate need of help with hearing
sound related to our graphic design projects. Our projector system is not the b
est, and it is nearly impossible for students to hear the audio that they arran
ge with their designs when presenting to the class. They become discouraged, th
inking they did not successfully complete their project when it comes time to s
hare with their classmates and the audio is very low. Currently, we have volume
on all computers and projectors turned up to the maximum volume and we are stil
l having to stand at the very front of the room to hear anything.nannan
==================================================
```

In [37]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-bre
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My students are awesome! They are working so hard this year to complete all of
their projects.  Our community is classified as high poverty; our students do n
ot have many resources outside of the school doors. They are very grateful for
any technology or helpful aides supplied to them to enhance their learning envi
ronment.      Our Business & Technology classes, as well as the high school Yea
rbook staff, are talented kiddos who, when given the right tools, can be very c
reative with their designs! They have fantastic ideas and share many  aha  mome
nts in the classroom.My classroom is in desperate need of help with hearing sou
nd related to our graphic design projects. Our projector system is not the bes
t, and it is nearly impossible for students to hear the audio that they arrange
with their designs when presenting to the class. They become discouraged, think
ing they did not successfully complete their project when it comes time to shar
e with their classmates and the audio is very low. Currently, we have volume on
all computers and projectors turned up to the maximum volume and we are still h
aving to stand at the very front of the room to hear anything.nannan
```

In [38]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My students are awesome They are working so hard this year to complete all of t
heir projects Our community is classified as high poverty our students do not h
ave many resources outside of the school doors They are very grateful for any t
echnology or helpful aides supplied to them to enhance their learning environme
nt Our Business Technology classes as well as the high school Yearbook staff ar
e talented kiddos who when given the right tools can be very creative with thei
r designs They have fantastic ideas and share many aha moments in the classroom
My classroom is in desperate need of help with hearing sound related to our gra
phic design projects Our projector system is not the best and it is nearly impo
ssible for students to hear the audio that they arrange with their designs when
presenting to the class They become discouraged thinking they did not successfu
lly complete their project when it comes time to share with their classmates an
d the audio is very low Currently we have volume on all computers and projector
s turned up to the maximum volume and we are still having to stand at the very
front of the room to hear anything nannan
```

In [39]:
```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', '
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itsel
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'th
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all'
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than',
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "di
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn'
            'won', "won't", 'wouldn', "wouldn't"]
```

1.8.1 Preprocessesd training data - Text

In [40]:
```
from tqdm import tqdm
def preprocess_textual(row_value):
    preprocessed_train = []
    for sentences in tqdm(row_value):
        sent = decontracted(sentences)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\"', ' ')
        sent = sent.replace('\\n', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
        # https://gist.github.com/sebleier/554280
        sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
        preprocessed_train.append(sent.lower().strip())
    return preprocessed_train
```

In [41]:
```
preprocessed_essays_train=preprocess_textual(X_train['essay'].values)
```

```
100%|██████████████████████████████████████████████████████████████████████████
| 73196/73196 [00:35<00:00, 2035.61it/s]
```

In [42]:
```
preprocessed_essays_test=preprocess_textual(X_test['essay'].values)
```

```
100%|██████████████████████████████████████████████████████████████████████████
| 36052/36052 [00:17<00:00, 2074.99it/s]
```

In [43]:
```
preprocessed_essays_test
```

Out[43]:
```
['students diverse culturally academically class work community celebrate dif
ferences cultures share ideas traditions cultures work together succeed socia
lly emotionally academically many students english language learners work rea
lly hard achieve individual goals many students families not speak english sc
hool works hard students succeed prepare college school also works parents he
lp children succeed life education students need noise canceling headphones h
elp concentrate students need quiet environment help concentrate work student
s learn multiple environments students like noise others need quiet headphone
s great tool help noise level noise canceling headphones solution help studen
ts focus many students find hard concentrate especially sounds distracting ti
mes using noise cancelling headphones helps students block external noise con
centrate need learn nannan',
 'students 6th 7th 8th graders attending public middle school many recent arr
ivals united states come classroom no english others completely tune presente
d numbers chalkboard experience students jump right hard work hooked interest
ing phenomena every one 46 students teach wants learn wants succeed challenge
showing science relevant lives understand importance topic take responsibilit
y hard work learning gift bring world science september not shop class school
years generations kids missed chances grow refine technical mathematical writ
```

1.8.3 Preprocessed cross validation data

In [44]:
```
#preprocessed_essays_cv=preprocess_textual(X_cv['essay'].values)
```

1.9 preprocessing of project title

In [45]:
```
# printing some randomproject titles.
print(project_data['project_title'].values[1])
print("="*50)
print(project_data['project_title'].values[1501])
print("="*50)
print(project_data['project_title'].values[10001])
print("="*50)
print(project_data['project_title'].values[20001])
print("="*50)
```

```
Wanted: Projector for Hungry Learners
==================================================
Making Every Day at School Count
==================================================
Becoming 'Readerly' Readers
==================================================
The Beautiful Life of a Butterfly
==================================================
```

In [46]:
```
title = decontracted(X_train['project_title'].values[2000])
```

1.9.1 Preprocessing of Project Title(Train)

In [47]:
```
preprocessed_titles_train=preprocess_textual(X_train["project_title"].values)
```

```
100%|████████████████████████████████████████████████████████████████████████████|
73196/73196 [00:01<00:00, 45656.40it/s]
```

1.9.2 Preprocessing of Project Title(Test)

In [48]:
```
preprocessed_titles_test=preprocess_textual(X_test["project_title"])
```

```
100%|████████████████████████████████████████████████████████████████████████████|
36052/36052 [00:00<00:00, 41967.85it/s]
```

In [49]:
```
preprocessed_titles_test[10]
```

Out[49]:
```
'chromebooks empower students 21st century learning'
```

1.9.2 Preprocessing of Project Title(CV)

In [50]:
```
#preprocessed_titles_cv=preprocess_textual(X_cv["project_title"])
```

In [51]:
```
#preprocessed_titles_cv[10]
```

1.5 Preparing data for models

In [52]:
```
project_data.columns
```

Out[52]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count', 'essay',
       'essay_word_count', 'negitive', 'positive', 'neutral', 'compound'],
      dtype='object')
```

we are going to consider

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

- project_title : text data
- text : text data
- project_resource_summary: text data (optinal)

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

In [53]:
```
project_data.head(10)
```

Out[53]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_su
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	2(
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	2(
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms	AZ	2(
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs	KY	2(
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs	TX	2(
5	141660	p154343	a50a390e8327a95b77b9e495b58b9a6e	Mrs	FL	2(
6	21147	p099819	9b40170bfa65e399981717ee8731efc3	Mrs	CT	2(
7	94142	p092424	5bfd3d12fae3d2fe88684bbac570c9d2	Ms	GA	2(
8	112489	p045029	487448f5226005d08d36bdd75f095b31	Mrs	SC	2(

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_su
9	158561	p001713	140eeac1885c820ad5592a409a3a8994	Ms	NC	2(

10 rows × 24 columns

1.5.1 Vectorizing Categorical data

One hot Categorical (train,test,CV)

In [54]:
```
# we use count vectorizer to convert the values into one
# Vectorizing Clean Categories
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=F

vectorizer.fit(X_train['clean_categories'].values)
train_categories_one_hot = vectorizer.fit_transform(X_train['clean_categories'].v
test_categories_one_hot = vectorizer.transform(X_test['clean_categories'].values)
#cv_categories_one_hot = vectorizer.transform(X_cv['clean_categories'].values)

cat_feat = vectorizer.get_feature_names()   #For Decision Tree
print(cat_feat)
print("Shape of  Train matrix after one hot encodig ",train_categories_one_hot.sh
print("Shape of  Test matrix after one hot encodig ",test_categories_one_hot.shap
#print("Shape of  cv  matrix after one hot encodig ",cv_categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'S
pecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of  Train matrix after one hot encodig  (73196, 9)
Shape of  Test matrix after one hot encodig  (36052, 9)
```

one hot vector for clean subcategories (train ,test,cv)

In [55]:
```
# we use count vectorizer to convert the values into one

vectorizer_sub_proj = CountVectorizer(min_df=10,ngram_range=(1,1), max_features=5
vectorizer_sub_proj.fit(X_train['clean_subcategories'].values)

sub_categories_one_hot_train = vectorizer_sub_proj.transform(X_train['clean_subca
sub_categories_one_hot_test = vectorizer_sub_proj.transform(X_test['clean_subcate
#sub_categories_one_hot_cv = vectorizer_sub_proj.transform(X_cv['clean_subcategor
sub_cat_feat = vectorizer_sub_proj.get_feature_names()

print(vectorizer_sub_proj.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_
print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_h
#print("Shape of matrix of Cross Validation data after one hot encoding ",sub_cat
```

```
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'env
ironmentalscience', 'esl', 'extracurricular', 'financialliteracy', 'foreignlang
uages', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_geogra
phy', 'literacy', 'literature_writing', 'mathematics', 'music', 'nutritioneduca
tion', 'other', 'parentinvolvement', 'performingarts', 'socialsciences', 'speci
alneeds', 'teamsports', 'visualarts', 'warmth']
Shape of matrix of Train data after one hot encoding  (73196, 30)
Shape of matrix of Test data after one hot encoding  (36052, 30)
```

In [56]:
```
#sub_categories_one_hot_cv[0].toarray()
```

In [57]:
```
vectorizer_sub_proj.vocabulary_
```

Out[57]:
```
{'literature_writing': 18,
 'parentinvolvement': 23,
 'appliedsciences': 0,
 'mathematics': 19,
 'literacy': 17,
 'charactereducation': 2,
 'college_careerprep': 4,
 'earlydevelopment': 6,
 'environmentalscience': 8,
 'civics_government': 3,
 'history_geography': 16,
 'health_wellness': 15,
 'gym_fitness': 13,
 'teamsports': 27,
 'esl': 9,
 'specialneeds': 26,
 'music': 20,
 'performingarts': 24,
 'health_lifescience': 14,
 'foreignlanguages': 12,
 'visualarts': 28,
 'other': 22,
 'nutritioneducation': 21,
 'socialsciences': 25,
 'financialliteracy': 11,
 'extracurricular': 10,
 'economics': 7,
 'communityservice': 5,
 'warmth': 29,
 'care_hunger': 1}
```

One hot vector for school states(train,test,cv)

In [58]:
```
my_counter = Counter()
for state in project_data['school_state'].values:
    my_counter.update(state.split())
```

In [59]:
```
school_state_cat_dict = dict(my_counter)
sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lam
```

In [60]:
```
## Using count vectorizer to convert the values into one hot encoded features

vectorizer_states = CountVectorizer(min_df=10,ngram_range=(1,1), max_features=500
vectorizer_states.fit(X_train['school_state'].values)

school_state_categories_one_hot_train = vectorizer_states.transform(X_train['scho
school_state_categories_one_hot_test = vectorizer_states.transform(X_test['school
#school_state_categories_one_hot_cv = vectorizer_states.transform(X_cv['school_st
school_feat=vectorizer_states.get_feature_names()
print(vectorizer_states.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",school_state_catego
print("Shape of matrix of Test data after one hot encoding ",school_state_categor
#print("Shape of matrix of Cross Validation data after one hot encoding ",school_
```

```
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia',
'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms',
'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'or', 'pa',
'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
Shape of matrix of Train data after one hot encoding  (73196, 51)
Shape of matrix of Test data after one hot encoding  (36052, 51)
```

one hot vector for Project grade category (train,test,cv)

In [61]:
```
my_counter = Counter()
for project_grade in preprocessed_project_grade_categories:
    my_counter.update(project_grade.split())
```

In [62]:
```
project_grade_cat_dict = dict(my_counter)
sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.items(), key=l
```

In [63]:
```
## we use count vectorizer to convert the values into one hot encoded features
vectorizer_grade = CountVectorizer(min_df=10,ngram_range=(1,1), max_features=5000
vectorizer_grade.fit(X_train['project_grade_category'].values)

project_grade_categories_one_hot_train = vectorizer_grade.transform(X_train['proj
project_grade_categories_one_hot_test = vectorizer_grade.transform(X_test['projec
#project_grade_categories_one_hot_cv = vectorizer_grade.transform(X_cv['project_gr
grade_feat=vectorizer_grade.get_feature_names()
print(vectorizer_grade.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",project_grade_categ
print("Shape of matrix of Test data after one hot encoding ",project_grade_catego
#print("Shape of matrix of Cross Validation data after one hot encoding ",project_
```

```
['12', 'grades', 'prek']
Shape of matrix of Train data after one hot encoding  (73196, 3)
Shape of matrix of Test data after one hot encoding  (36052, 3)
```

One hot vector for teacher

prefix(train,test,cv)

In [64]:
```
vectorizer_teacher = CountVectorizer()
vectorizer_teacher.fit(X_train['teacher_prefix'].values) # fit has to happen only

# we use the fitted CountVectorizer to convert the text to vector
teacher_prefix_categories_one_hot_train = vectorizer_teacher.transform(X_train['t
#teacher_prefix_categories_one_hot_cv = vectorizer_teacher.transform(X_cv['teache
teacher_prefix_categories_one_hot_test = vectorizer_teacher.transform(X_test['tea

print("After vectorizations")
print("Shape of matrix of Train data after one hot encoding",teacher_prefix_categ
#print("Shape of matrix of cv data after one hot encoding",teacher_prefix_categor
print("Shape of matrix of Test data after one hot encoding",teacher_prefix_catego
teacher_feat=vectorizer_teacher.get_feature_names()
print(vectorizer_teacher.get_feature_names())
print("="*100)
```

```
After vectorizations
Shape of matrix of Train data after one hot encoding (73196, 5) (73196,)
Shape of matrix of Test data after one hot encoding (36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================
====================
```

1.11 Vectorizing text data

TFIDF

tfidf(train essays)

In [65]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_essay = TfidfVectorizer(min_df=10,max_features=5000) #Considerin
vectorizer_tfidf_essay.fit(preprocessed_essays_train)

text_tfidf_train = vectorizer_tfidf_essay.transform(preprocessed_essays_train)
print("Shape of matrix after TfidfVectorizer ",text_tfidf_train.shape)
```

```
Shape of matrix after TfidfVectorizer  (73196, 5000)
```

tfidf(test essays)

In [66]:
```
text_tfidf_test = vectorizer_tfidf_essay.transform(preprocessed_essays_test)
print("Shape of matrix after TfidfVectorizer ",text_tfidf_test.shape)
```

```
Shape of matrix after TfidfVectorizer  (36052, 5000)
```

tfidf(cv essays)

In [67]:
```
#text_tfidf_cv = vectorizer_tfidf_essay.transform(preprocessed_essays_cv)
#print("Shape of matrix after TfidfVectorizer ",text_tfidf_cv.shape)
```

tfidf(train Titles)

In [68]:
```
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

vectorizer_tfidf_titles.fit(preprocessed_titles_train)
title_tfidf_train = vectorizer_tfidf_titles.transform(preprocessed_titles_train)
print("Shape of matrix after TfidfVectorizer ",title_tfidf_train.shape)
```

```
Shape of matrix after TfidfVectorizer  (73196, 2546)
```

tfidf(test titles)

In [69]:
```
title_tfidf_test = vectorizer_tfidf_titles.transform(preprocessed_titles_test)
print("Shape of matrix after TfidfVectorizer ",title_tfidf_test.shape)
```

```
Shape of matrix after TfidfVectorizer  (36052, 2546)
```

tfidf(cv titles)

In [70]:
```
#title_tfidf_cv = vectorizer_tfidf_titles.transform(preprocessed_titles_cv)
#print("Shape of matrix after TfidfVectorizer ",title_tfidf_cv.shape)
```

1.5.2.3 Using Pretrained Models: TFIDF Weighted W2V

In [71]:
```

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

train essays

In [72]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [73]:
```
def tfidfWV(preprocessed_data):
    # average Word2Vec
    # compute average word2vec for each review.
    tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in t
    for sentence in tqdm(preprocessed_data): # for each review/sentence
        vector = np.zeros(300) # as word vectors are of zero length
        tf_idf_weight =0; # num of words with a valid vector in the sentence/revi
        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
                tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.spli
                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.append(vector)
    print("The length of TFIDF word to vec is ", len(tfidf_w2v_vectors))
    print("The length of TFIDF word to vec of index 0 is ",len(tfidf_w2v_vectors[
    return tfidf_w2v_vectors
```

In [74]:
```
tfidf_w2v_vectors_train=tfidfWV(preprocessed_essays_train)
```

```
100%|██████████████████████████████████████████████████████████████████████
| 73196/73196 [01:55<00:00, 632.87it/s]

The length of TFIDF word to vec is  73196
The length of TFIDF word to vec of index 0 is  300
```

Test essays

In [75]:
```
tfidf_w2v_vectors_test=tfidfWV(preprocessed_essays_test)
```

```
100%|██████████████████████████████████████████████████████████████████████
| 36052/36052 [00:57<00:00, 626.89it/s]

The length of TFIDF word to vec is  36052
The length of TFIDF word to vec of index 0 is  300
```

cv essays

In [76]:
```
#tfidf_w2v_vectors_cv = tfidfWV(preprocessed_essays_cv)
```

train titles

In [77]:
```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [78]:
```
tfidf_w2v_vectors_titles_train = tfidfWV(preprocessed_titles_train)
```

```
100%|████████████████████████████████████████████████████████████████████████████|
73196/73196 [00:01<00:00, 42979.11it/s]

The length of TFIDF word to vec is  73196
The length of TFIDF word to vec of index 0 is  300
```

test titles

In [79]:
```
tfidf_w2v_vectors_titles_test = tfidfWV(preprocessed_titles_test)
```

```
100%|████████████████████████████████████████████████████████████████████████████|
36052/36052 [00:00<00:00, 43146.44it/s]

The length of TFIDF word to vec is  36052
The length of TFIDF word to vec of index 0 is  300
```

cv titles

In [80]:
```
#tfidf_w2v_vectors_titles_cv = tfidfWV(preprocessed_titles_cv)
```

1.12 Vectorizing Numerical features

Various numerical feautures are :

1.Price

2.Quantity

3.Number of Projects previously proposed by Teacher

4.Title word Count (introduced by us)

5.Essay word Count (introduced by us)

6.Negative Intensity

7.Positive Intensity

8.Neutral Intensity

In [81]:
```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).r
price_data.head(4)
```

Out[81]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21
2	p000003	298.97	4
3	p000004	1113.69	98

In [82]:
```
# join two dataframes in python:
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
#X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [ ]:
```
```

In [83]:
```
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.

price_for_test=X_test['price']    #Box Plot Purpose

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

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

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
====================================================================================
====================
```

2) Quantity

In [84]:
```
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))

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

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
====================================================================================================
```

3) Number of Projects previously proposed by Teacher

In [85]:
```
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.res

prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_
#prev_projects_cv = normalizer.transform(X_cv['teacher_number_of_previously_poste
number_of_previously_posted_projects_dtrees=X_test['teacher_number_of_previously_
prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_po

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
====================================================================================
====================
```

4) title word count

In [86]:
```
normalizer = Normalizer()

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

title_word_count_train = normalizer.transform(X_train['title_word_count'].values.
#title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshap
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.re

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
====================================================================================
====================
```

5) essay word count

In [87]:
```
normalizer = Normalizer()

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

essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.
#essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshap
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.re

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
```

6) Positive Intensity

In [88]:
```
normalizer = Normalizer()

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

positive_intensity_train = normalizer.transform(X_train['positive'].values.reshap
#positive_intensity_cv = normalizer.transform(X_cv['positive'].values.reshape(-1,
positive_intensity_test = normalizer.transform(X_test['positive'].values.reshape(

print("After vectorizations")
print(positive_intensity_train.shape, y_train.shape)
#print(positive_intensity_cv.shape, y_cv.shape)
print(positive_intensity_test.shape, y_test.shape)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
```

7) Negative Intensity

In [89]:
```
normalizer = Normalizer()

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

negative_intensity_train = normalizer.transform(X_train['negitive'].values.reshap
#negative_intensity_cv = normalizer.transform(X_cv['negitive'].values.reshape(-1,1
negative_intensity_test = normalizer.transform(X_test['negitive'].values.reshape(

print("After vectorizations")
print(negative_intensity_train.shape, y_train.shape)
#print(negative_intensity_cv.shape, y_cv.shape)
print(negative_intensity_test.shape, y_test.shape)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
```

8) Neutral Intensity

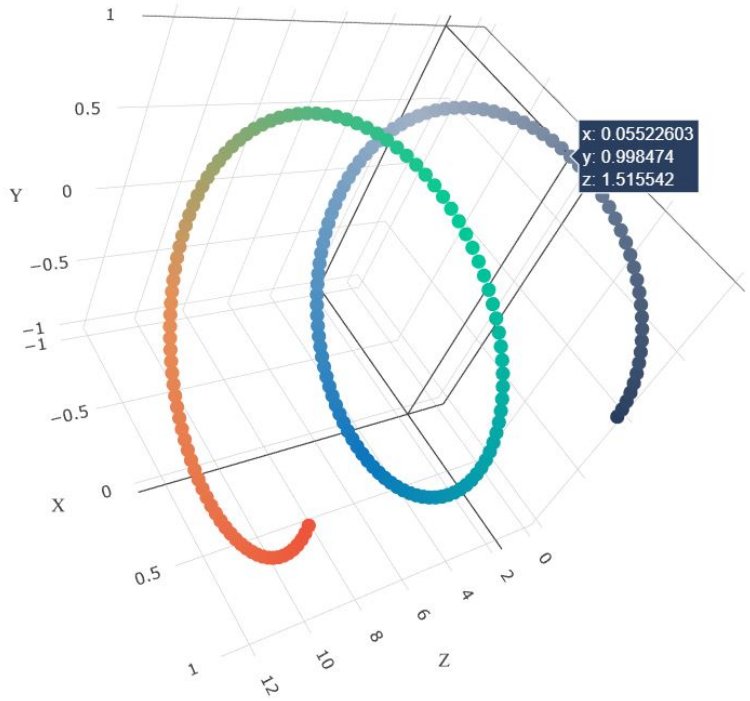
In [90]:
```
normalizer = Normalizer()

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

neutral_intensity_train = normalizer.transform(X_train['neutral'].values.reshape(
#neutral_intensity_cv = normalizer.transform(X_cv['neutral'].values.reshape(-1,1)
neutral_intensity_test = normalizer.transform(X_test['neutral'].values.reshape(-1

print("After vectorizations")
print(neutral_intensity_train.shape, y_train.shape)
#print(neutral_intensity_cv.shape, y_cv.shape)
print(neutral_intensity_test.shape, y_test.shape)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
```

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
   - Set 1: categorical, numerical features + preprocessed_essay (TFIDF) + Sentiment scores(preprocessed_essay)
   - Set 2: categorical, numerical features + preprocessed_essay (TFIDF W2V) + Sentiment scores(preprocessed_essay)
2. **The hyper paramter tuning (best `depth` in range [1, 3, 10, 30], 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**

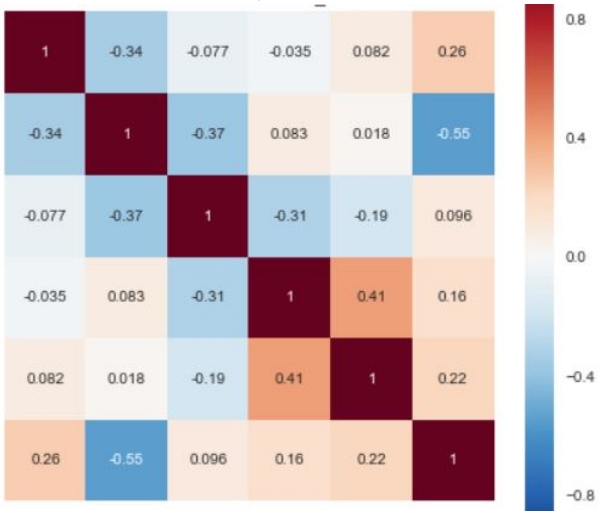
- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



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

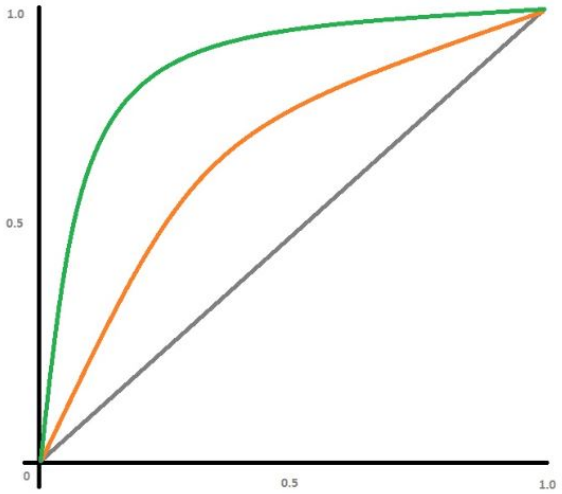
- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **min_sample_split**, 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. Make sure that you are using predict_proba method to calculate AUC curves, because AUC is calcualted on class probabilities and not on class labels.



- 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/ (https://www.geeksforgeeks.org/generating-word-cloud-python/)](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`

In [91]:
```
from scipy.sparse import hstack
X_train = hstack((train_categories_one_hot , sub_categories_one_hot_train, school
                  teacher_prefix_categories_one_hot_train,text_tfidf_train,title_
                  prev_projects_train, price_train,title_word_count_train,
                  essay_word_count_train, positive_intensity_train, negative_inte
                  neutral_intensity_train)).tocsr()
print(X_train.shape, y_train.shape)
print(type(X_train))
```

```
(73196, 7652) (73196,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [92]:
```
X_test = hstack((test_categories_one_hot ,sub_categories_one_hot_test,school_stat
                 teacher_prefix_categories_one_hot_test,text_tfidf_test, title_tf
                  prev_projects_test, price_test,title_word_count_test,
                  essay_word_count_test, title_word_count_test, negative_intensit
                  neutral_intensity_test)).tocsr()
print(X_test.shape, y_test.shape)
print(type(X_test))
```

```
(36052, 7652) (36052,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [93]:
```
print(test_categories_one_hot)
```

```
  (0, 8)        1
  (1, 4)        1
  (1, 7)        1
  (2, 3)        1
  (2, 8)        1
  (3, 8)        1
  (4, 5)        1
  (5, 3)        1
  (6, 7)        1
  (7, 8)        1
  (8, 3)        1
  (9, 4)        1
  (10, 2)       1
  (10, 7)       1
  (11, 7)       1
  (11, 8)       1
  (12, 3)       1
  (12, 8)       1
  (13, 5)       1
  (13, 7)       1
  (14, 6)       1
  (15, 8)       1
  (16, 8)       1
  (17, 7)       1
  (17, 8)       1
  :     :
  (36034, 4)    1
  (36034, 5)    1
  (36035, 8)    1
  (36036, 8)    1
  (36037, 5)    1
  (36037, 6)    1
  (36038, 7)    1
  (36039, 7)    1
  (36040, 7)    1
  (36040, 8)    1
  (36041, 8)    1
  (36042, 8)    1
  (36043, 4)    1
  (36043, 7)    1
  (36044, 8)    1
  (36045, 7)    1
  (36045, 8)    1
  (36046, 8)    1
  (36047, 3)    1
  (36047, 7)    1
  (36048, 6)    1
  (36049, 8)    1
  (36050, 5)    1
  (36050, 7)    1
  (36051, 7)    1
```

We don't need CV data since it is automatically

done by the optimization function of python

In [94]:
```
# X_cv = hstack((cv_categories_one_hot ,sub_categories_one_hot_cv,school_state_ca
#                  teacher_prefix_categories_one_hot_cv,text_tfidf_cv, title_tfid
#                  prev_projects_cv, price_cv, title_word_count_cv,
#                   essay_word_count_cv ,positive_intensity_cv, negative_intensit
#                   neutral_intensity_cv)).tocsr()
# print(X_cv.shape, y_cv.shape)
# print(type(X_cv))
```

Hyperparameter Tuning

In [95]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
DT = DecisionTreeClassifier()

parameters = {'max_depth': [1, 3, 10, 30], 'min_samples_split':  [5, 10, 100, 500

classifier_5 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',verbose=10,n_
classifier_5.fit(X_train, y_train)
```

```
C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:
```

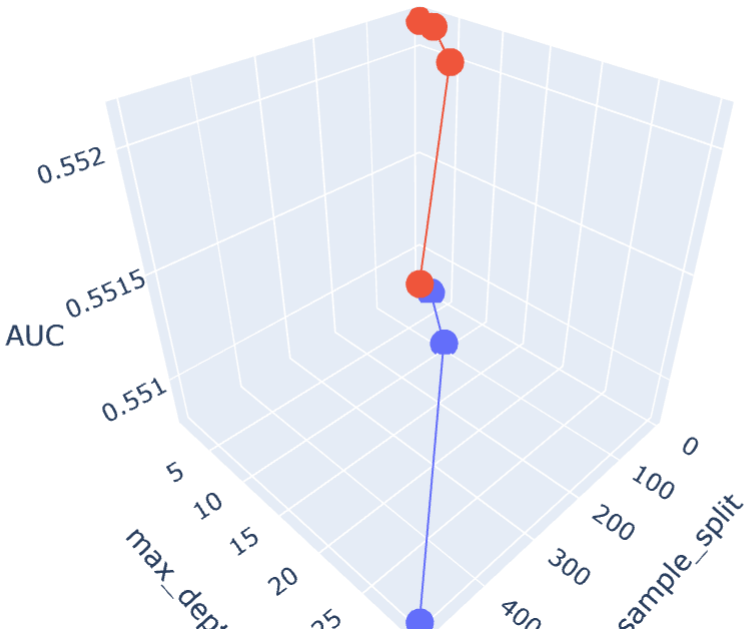
In [96]:
```
max_depth_best_param=classifier_5.best_params_['max_depth']
min_samples_split_best_param=classifier_5.best_params_['min_samples_split']
print(classifier_5.best_params_)
```

```
{'max_depth': 10, 'min_samples_split': 500}
```

In [97]:
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [98]:
```
x1 = [5, 10, 100, 500] #min_sample_split
y1 = [1, 3, 10, 30]#max_depth
z1 = classifier_5.cv_results_['mean_test_score']

x2 = [5, 10, 100, 500] #min_sample_split
y2 = [1, 3, 10, 30] #max_depth
z2 = classifier_5.cv_results_['mean_train_score']
```

In [99]:
```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'Cross Validation')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Train')
data = [trace1, trace2]

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

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



In [100]:
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # not the predicted outputs

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

    return y_data_pred
```

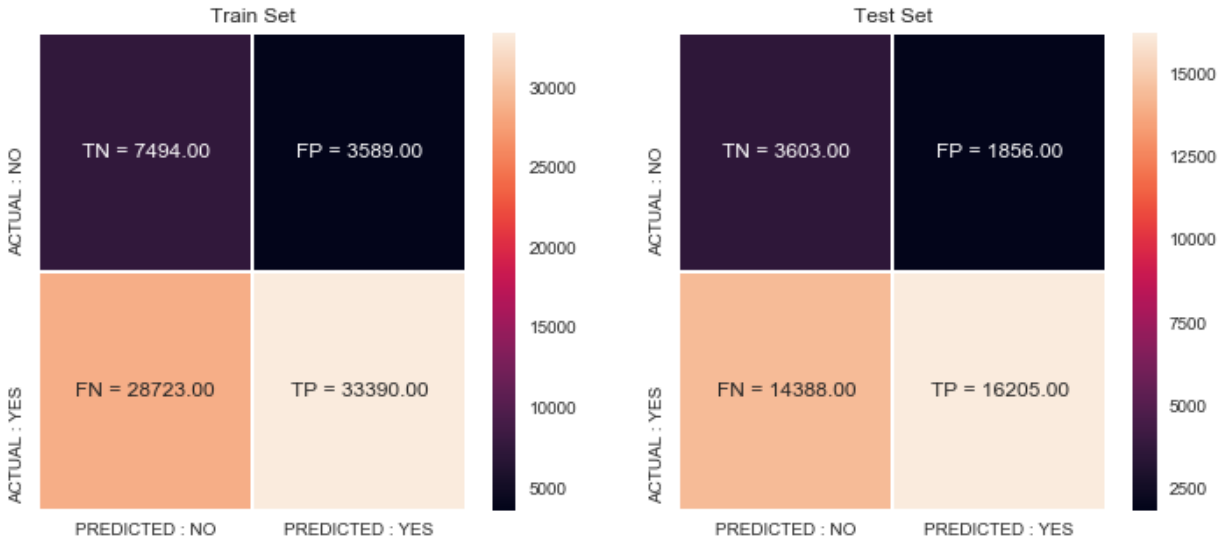
In [101]:
```
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold",
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [102]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htm
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(max_depth = max_depth_best_param, min_samples_
classifier.fit(X_train, y_train)

y_train_pred = batch_predict(classifier,X_train)
y_test_pred = batch_predict(classifier,X_test)

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

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

Confusion Matrix For Train & Test Data

In [103]:
```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
print("For the Train Data")
con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, trai
print("For the Test Data")
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fp

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

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED

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

plt.show()
```

```
For the Train Data
the maximum value of tpr*(1-fpr) 0.3634881598116023 for threshold 0.855
For the Test Data
the maximum value of tpr*(1-fpr) 0.34960540350877234 for threshold 0.855
```



False Positive Word Cloud

Using Bag of words of essay for Word Cloud

In [104]:
```
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(preprocessed_essays_train)
test_text_bow = vectorizer.transform(preprocessed_essays_test)
print("Shape of matrix after BOW encodig ",test_text_bow.shape)
# cv_text_bow = vectorizer.transform(preprocessed_essays_cv)
# print("Shape of matrix after BOW encodig ",cv_text_bow.shape)
BOW_feat_essay= vectorizer.get_feature_names() #for decision tree
```

```
Shape of matrix after BOW encodig  (36052, 14156)
```

In [105]:
```
test_text_bow
```

Out[105]:
```
<36052x14156 sparse matrix of type '<class 'numpy.int64'>'
        with 3622126 stored elements in Compressed Sparse Row format>
```

In [106]:
```
print(test_text_bow)
```

```
  (0, 282)      2
  (0, 353)      1
  (0, 674)      1
  (0, 1509)     1
  (0, 1932)     2
  (0, 1934)     1
  (0, 2090)     1
  (0, 2256)     1
  (0, 2354)     1
  (0, 2500)     1
  (0, 2582)     1
  (0, 2682)     4
  (0, 3163)     1
  (0, 3166)     2
  (0, 3609)     1
  (0, 3808)     1
  (0, 3828)     1
  (0, 4145)     1
  (0, 4276)     1
  (0, 4368)     2
  (0, 4452)     1
  (0, 4455)     1
  (0, 4516)     1
  (0, 4769)     1
  (0, 4851)     1
  :     :
  (36051, 10921)        1
  (36051, 11074)        1
  (36051, 11666)        1
  (36051, 11685)        1
  (36051, 11797)        1
  (36051, 11809)        1
  (36051, 11995)        1
  (36051, 12030)        2
  (36051, 12080)        1
  (36051, 12210)        7
  (36051, 12491)        2
  (36051, 12492)        1
  (36051, 12566)        1
  (36051, 12706)        1
  (36051, 12952)        1
  (36051, 12953)        2
  (36051, 13466)        1
  (36051, 13471)        1
  (36051, 13472)        1
  (36051, 13517)        1
  (36051, 13520)        1
  (36051, 13786)        1
  (36051, 13842)        1
  (36051, 13887)        1
  (36051, 14006)        1
```

In [107]:
```
y_predicted=predict(y_test_pred, te_thresholds, test_fpr, test_tpr)
y_test=list(y_test[::])
y_predicted=list(y_predicted[::])
for x,y in zip(y_test,y_predicted):
    print(x,y)
```

```
1 1
1 0
1 1
1 0
1 1
1 0
1 1
1 1
1 0
1 0
1 1
1 1
1 0
1 1
1 0
1 1
0 0
1 0
0 0
```

In [108]:
```
bow_test = test_text_bow.todense()
print(bow_test.shape)
len(BOW_feat_essay)
```

```
(36052, 14156)
```

Out[108]:
```
14156
```

In [109]:
```
fp_index = []
fp_count = 0

for i in range(len(y_test_pred)):
    if y_test[i] == 0 and y_predicted[i]==1:
        fp_index.append(i)
        fp_count = fp_count + 1
    else :
        pass
print(fp_count)
print(fp_index[0:10])
```

```
1856
[25, 26, 93, 95, 100, 142, 150, 159, 177, 196]
```

In [110]:
```
df1 = pd.DataFrame(test_text_bow.todense())
df1_final = df1.iloc[fp_index,:]
print(df1_final.shape)
```

```
(1856, 14156)
```

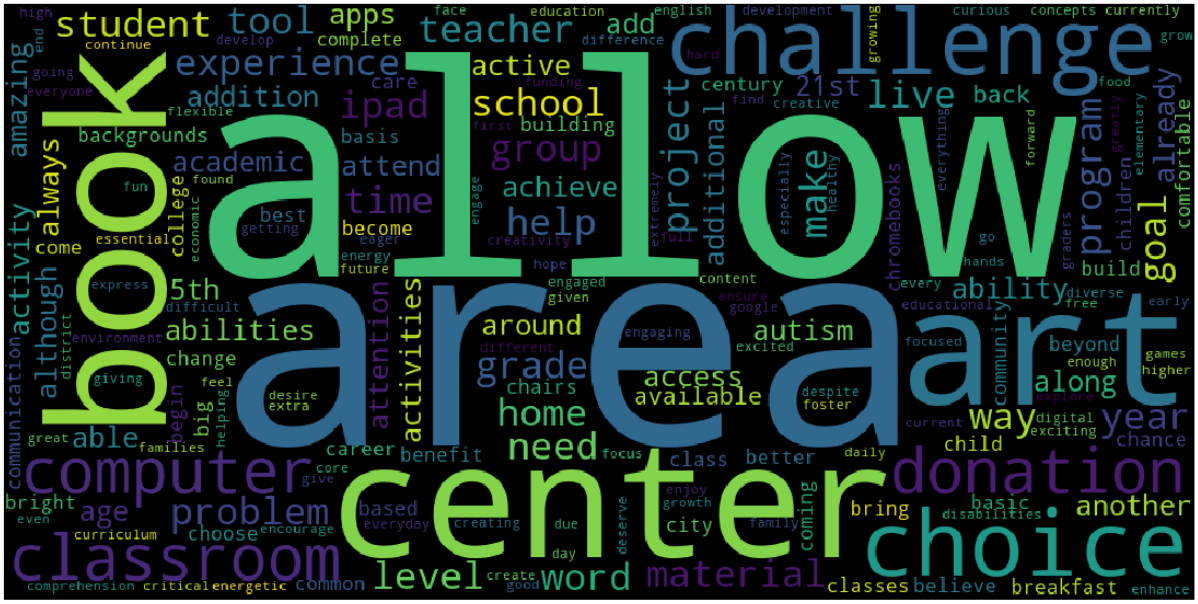
In [111]:
```
best_indices = []

for j in tqdm(range(df1_final.shape[1])):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
print(len(best_indices))
print(best_indices[0:10])
```

```
100%|██████████████████████████████████████████████████████████████████████████████
| 14156/14156 [00:05<00:00, 2459.20it/s]

475
[4, 92, 180, 249, 250, 252, 281, 298, 353, 388]
```

In [112]:
```
fp_words = []

for a in best_indices :
    fp_words.append(str(BOW_feat_essay[a]))
print(fp_words[0:10])
```

```
['100', '21st', '5th', 'abilities', 'ability', 'able', 'academic', 'access', 'a
chieve', 'active']
```

In [113]:
```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```



Box & PDF plot for False Positives

In [114]:
```
df = pd.DataFrame(list(price_for_test))
print(df.head(2))
```

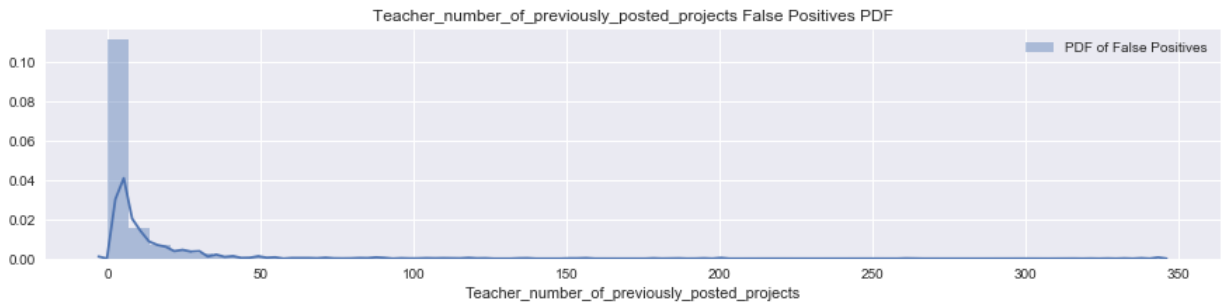
```
        0
0   14.85
1  117.72
```

In [115]:
```
plt.figure(figsize=(15,3))
df1 = df.iloc[fp_index, : ]
sns.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positives")
plt.xlabel("Price")
plt.show()
```

In [116]:
```
df = pd.DataFrame(list(number_of_previously_posted_projects_dtrees))
df1 = df.iloc[fp_index, : ]
```

In [117]:
```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```

```
C:\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning:

The 'normed' kwarg is deprecated, and has been replaced by the 'density' kwarg.
```



Set2 TFIDF W2V

In [118]:
```
from scipy.sparse import hstack
X_train = hstack((train_categories_one_hot , sub_categories_one_hot_train, school
                  teacher_prefix_categories_one_hot_train,tfidf_w2v_vectors_train
                  prev_projects_train, price_train,title_word_count_train,
                  essay_word_count_train, positive_intensity_train, negative_inte
                  neutral_intensity_train)).tocsr()
print(X_train.shape, y_train.shape)
print(type(X_train))
```

```
(73196, 706) (73196,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [119]:
```
X_test = hstack((test_categories_one_hot ,sub_categories_one_hot_test,school_stat
                 teacher_prefix_categories_one_hot_test,tfidf_w2v_vectors_test, t
                  prev_projects_test, price_test,title_word_count_test,
                  essay_word_count_test, title_word_count_test, negative_intensit
                  neutral_intensity_test)).tocsr()
print(X_test.shape)
print(type(X_test))
```

```
(36052, 706)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [120]:
```
# X_cv = hstack((cv_categories_one_hot ,sub_categories_one_hot_cv,school_state_ca
#                  teacher_prefix_categories_one_hot_cv,tfidf_w2v_vectors_cv, tfi
#                  prev_projects_cv, price_cv, title_word_count_cv,
#                   essay_word_count_cv ,positive_intensity_cv, negative_intensit
#                   neutral_intensity_cv)).tocsr()
# print(X_cv.shape, y_cv.shape)
# print(type(X_cv))
```

In [121]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
DT = DecisionTreeClassifier()

parameters = {'max_depth': [1, 3, 10, 30], 'min_samples_split': [5, 10, 100, 500]}

classifier_5 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',verbose=10,n_
classifier_5.fit(X_train, y_train)
```

```
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
eprecationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: D
```

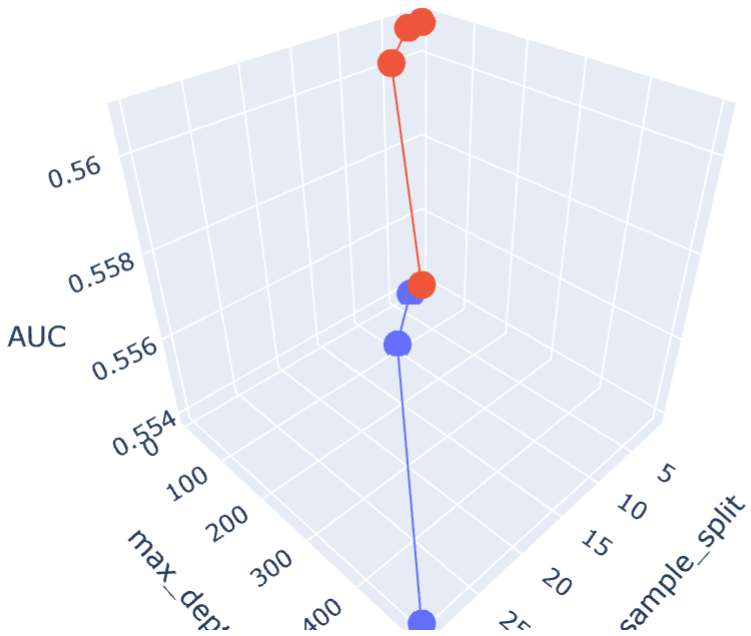
In [122]:
```
max_depth_best_param=classifier_5.best_params_['max_depth']
min_samples_split_best_param=classifier_5.best_params_['min_samples_split']
print(classifier_5.best_params_)
```

```
{'max_depth': 10, 'min_samples_split': 500}
```

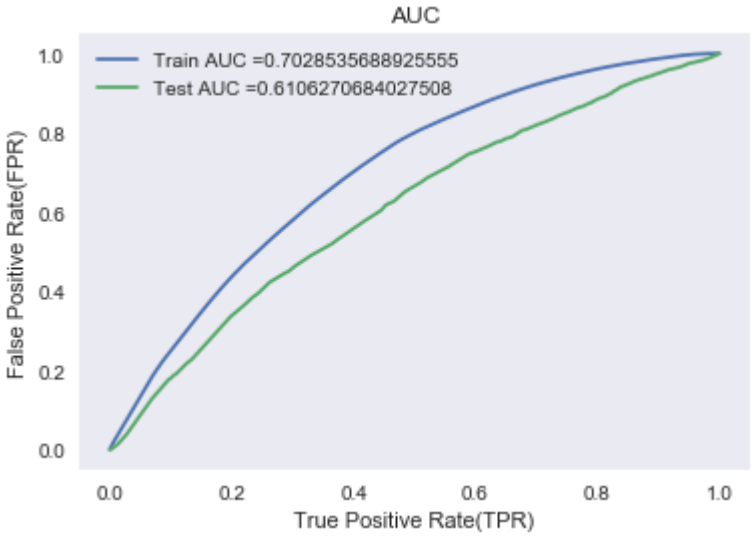
In [123]:
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [124]:
```
x1 =  [1, 3, 10, 30]#min_sample_split
y1 = [5, 10, 100, 500]#max_depth
z1 = classifier_5.cv_results_['mean_test_score']

x2 = [1, 3, 10, 30] #min_sample_split
y2 = [5, 10, 100, 500] #max_depth
z2 = classifier_5.cv_results_['mean_train_score']
```

In [125]:
```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'Cross Validation')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Train')
data = [trace1, trace2]

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

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



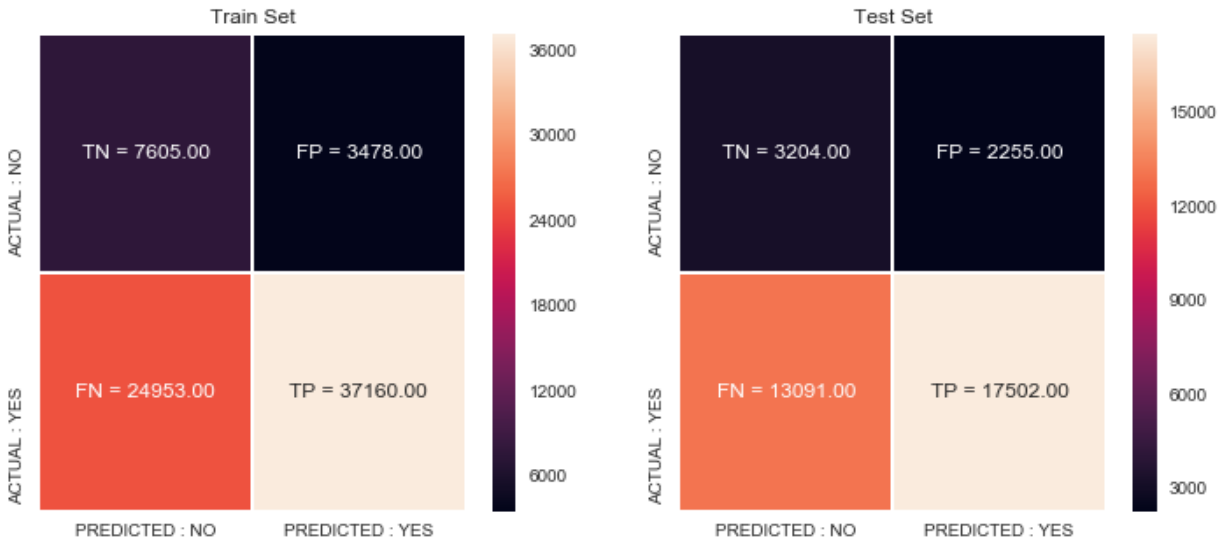
In [126]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htm
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(max_depth = max_depth_best_param, min_samples_
classifier.fit(X_train, y_train)

y_train_pred = batch_predict(classifier,X_train)
y_test_pred = batch_predict(classifier,X_test)

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

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



Confusion Matrix For Train & Test Data

In [127]:
```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
print("For the Train Data")
con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, trai
print("For the Test Data")
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fp

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

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED

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

plt.show()
```

```
For the Train Data
the maximum value of tpr*(1-fpr) 0.4211632999792407 for threshold 0.883
For the Test Data
the maximum value of tpr*(1-fpr) 0.33784456234209853 for threshold 0.883
```



False Positive Word Cloud

In [128]:
```
y_predicted=predict(y_test_pred, te_thresholds, test_fpr, test_tpr)
y_test=list(y_test[::])
y_predicted=list(y_predicted[::])
for x,y in zip(y_test,y_predicted):
    print(x,y)
```

```
the maximum value of tpr*(1-fpr) 0.33784456234209853 for threshold 0.883
1 1
1 0
1 1
1 1
1 0
0 0
1 0
1 0
1 1
1 1
1 0
1 0
1 0
1 1
1 1
1 0
1 1
1 1
```

In [129]:
```
bow_test = test_text_bow.todense()
print(bow_test.shape)
len(BOW_feat_essay)
```

```
(36052, 14156)
```

Out[129]:
```
14156
```

In [130]:
```
fp_index = []
fp_count = 0

for i in range(len(y_test_pred)):
    if y_test[i] == 0 and y_predicted[i]==1:
        fp_index.append(i)
        fp_count = fp_count + 1
    else :
        pass
print(fp_count)
print(fp_index[0:10])
```

```
2255
[25, 26, 78, 132, 142, 150, 159, 177, 207, 216]
```

In [131]:
```
df1 = pd.DataFrame(test_text_bow.todense())
df1_final = df1.iloc[fp_index,:]
print(df1_final.shape)
```

```
(2255, 14156)
```

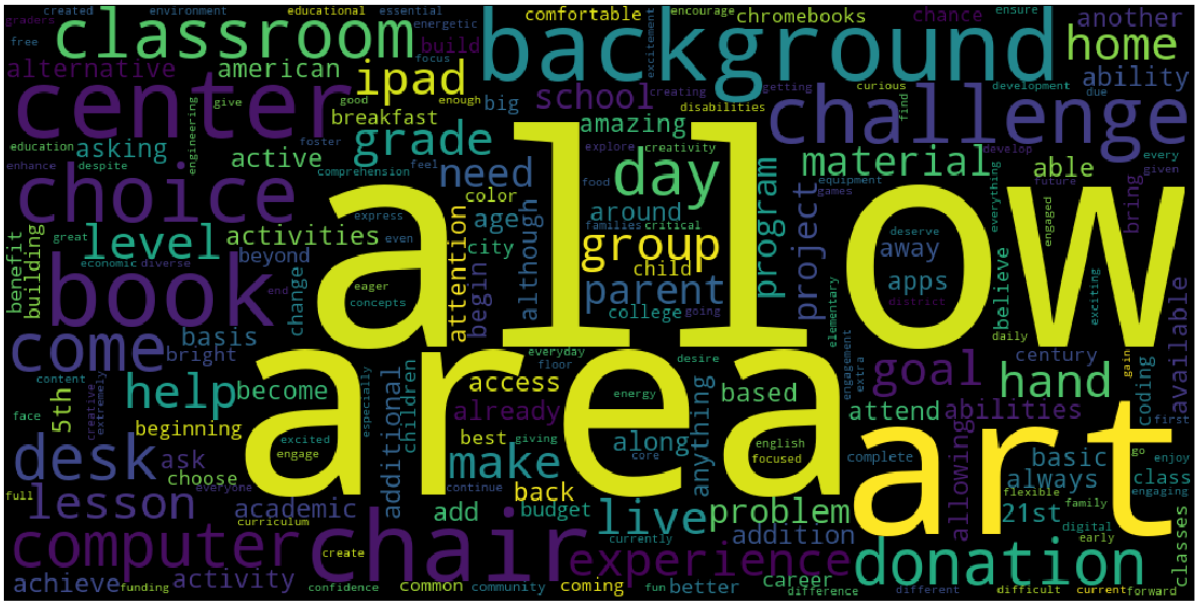
In [132]:
```
best_indices = []

for j in range(12059):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
print(len(best_indices))
print(best_indices[0:10])
```

```
438
[4, 92, 180, 249, 250, 252, 281, 298, 353, 388]
```

In [133]:
```
fp_words = []

for a in best_indices :
    fp_words.append(str(BOW_feat_essay[a]))
print(fp_words[0:10])
```

```
['100', '21st', '5th', 'abilities', 'ability', 'able', 'academic', 'access', 'achieve', 'active']
```

In [134]:
```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```



Box & PDF plot for False Positives

In [135]:
```
df = pd.DataFrame(list(price_for_test))
print(df.head(2))
```

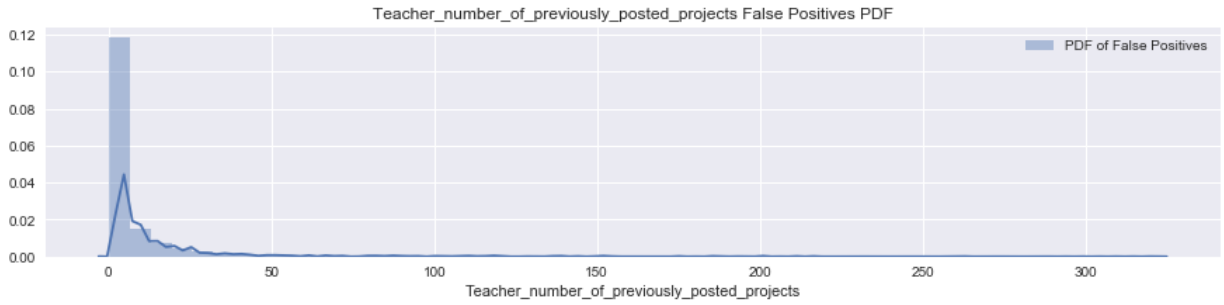
```
        0
0   14.85
1  117.72
```

In [136]:
```
plt.figure(figsize=(15,3))
df1 = df.iloc[fp_index, : ]
sns.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positives")
plt.xlabel("Price")
plt.show()
```

In [137]:
```
df = pd.DataFrame(list(number_of_previously_posted_projects_dtrees))
df1 = df.iloc[fp_index, : ]
```

In [138]:
```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```

```
C:\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning:

The 'normed' kwarg is deprecated, and has been replaced by the 'density' kwarg.
```



Task 2

In [139]:
```
from scipy.sparse import hstack
X_train = hstack((train_categories_one_hot , sub_categories_one_hot_train, school
                  teacher_prefix_categories_one_hot_train,text_tfidf_train,title_
                  prev_projects_train, price_train,title_word_count_train,
                  essay_word_count_train, positive_intensity_train, negative_inte
                  neutral_intensity_train)).tocsr()
print(X_train.shape, y_train.shape)
print(type(X_train))
```

```
(73196, 7652) (73196,)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [140]:
```
X_test = hstack((test_categories_one_hot ,sub_categories_one_hot_test,school_stat
                 teacher_prefix_categories_one_hot_test,text_tfidf_test, title_tf
                  prev_projects_test, price_test,title_word_count_test,
                  essay_word_count_test, title_word_count_test, negative_intensit
                  neutral_intensity_test)).tocsr()
print(X_test.shape)
print(type(X_test))
```

```
(36052, 7652)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [141]:
```
## #https://stackoverflow.com/questions/47111434/randomforestregressor-and-featur

# from sklearn.ensemble import RandomForestClassifier
# from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV
def selectKImportance(model, X, k):
    return X[:,model.feature_importances_.argsort()[::-1][:k]]
```

In [142]:
```
dt_tfidf_imp_feature_testModel = DecisionTreeClassifier(class_weight='balanced')
dt_tfidf_imp_feature_testModel.fit(X_train, y_train)
```

Out[142]:
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=None, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
```

In [143]:
```
nonZeroFeatures=0
for i in range (len(dt_tfidf_imp_feature_testModel.feature_importances_)):
    if(dt_tfidf_imp_feature_testModel.feature_importances_[i]>0):
        nonZeroFeatures=nonZeroFeatures+1
```

In [144]:
```
x_train_impFeatureDataset1=selectKImportance(dt_tfidf_imp_feature_testModel,X_tra
x_test_impFeatureDataset1=selectKImportance(dt_tfidf_imp_feature_testModel,X_test
```

In [145]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
DT = DecisionTreeClassifier()

parameters = {'max_depth': [1, 3, 10, 30], 'min_samples_split': [5, 10, 100, 500]

classifier_5 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',verbose=10,n_
classifier_5.fit(x_train_impFeatureDataset1, y_train)
```

```
Fitting 3 folds for each of 16 candidates, totalling 48 fits

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

C:\Anaconda3\lib\site-packages\sklearn\externals\joblib\numpy_pickle.py:93: Dep
recationWarning:

tostring() is deprecated. Use tobytes() instead.

[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:    3.0s
[Parallel(n_jobs=-1)]: Done   9 tasks      | elapsed:    6.8s
[Parallel(n_jobs=-1)]: Done  16 tasks      | elapsed:    9.6s
[Parallel(n_jobs=-1)]: Done  25 tasks      | elapsed:   20.9s
[Parallel(n_jobs=-1)]: Done  38 out of  48 | elapsed:  1.1min remaining:   16.6
s
[Parallel(n_jobs=-1)]: Done  43 out of  48 | elapsed:  1.1min remaining:    7.9
s
[Parallel(n_jobs=-1)]: Done  48 out of  48 | elapsed:  1.5min remaining:    0.0
s
[Parallel(n_jobs=-1)]: Done  48 out of  48 | elapsed:  1.5min finished
```

Out[145]:
```
GridSearchCV(cv=3, error_score='raise',
       estimator=DecisionTreeClassifier(class_weight=None, criterion='gini',
max_depth=None,
```

```
                max_features=None, max_leaf_nodes=None,
                min_impurity_decrease=0.0, min_impurity_split=None,
                min_samples_leaf=1, min_samples_split=2,
                min_weight_fraction_leaf=0.0, presort=False, random_state=None,
                splitter='best'),
       fit_params=None, iid=True, n_jobs=-1,
       param_grid={'max_depth': [1, 3, 10, 30], 'min_samples_split': [5, 10,
100, 500]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='roc_auc', verbose=10)
```

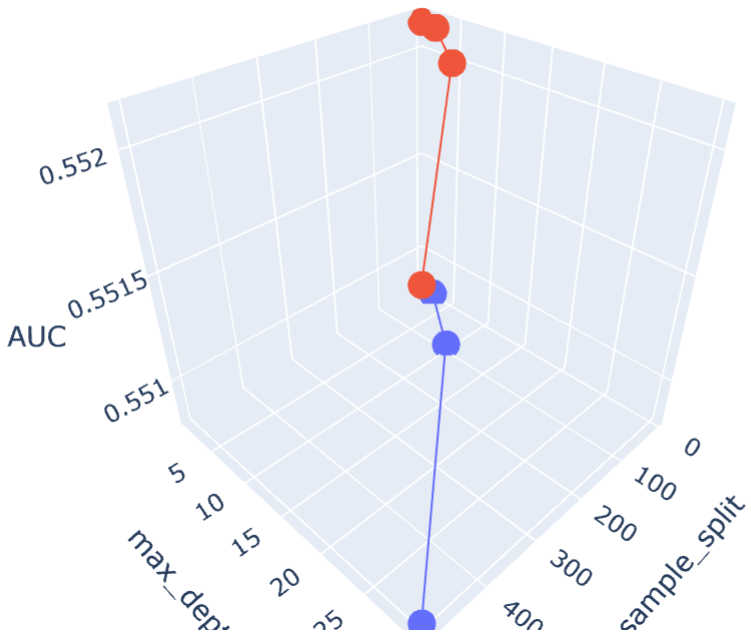
In [146]:
```
max_depth_best_param=classifier_5.best_params_['max_depth']
min_samples_split_best_param=classifier_5.best_params_['min_samples_split']
print(classifier_5.best_params_)
```

```
{'max_depth': 10, 'min_samples_split': 500}
```

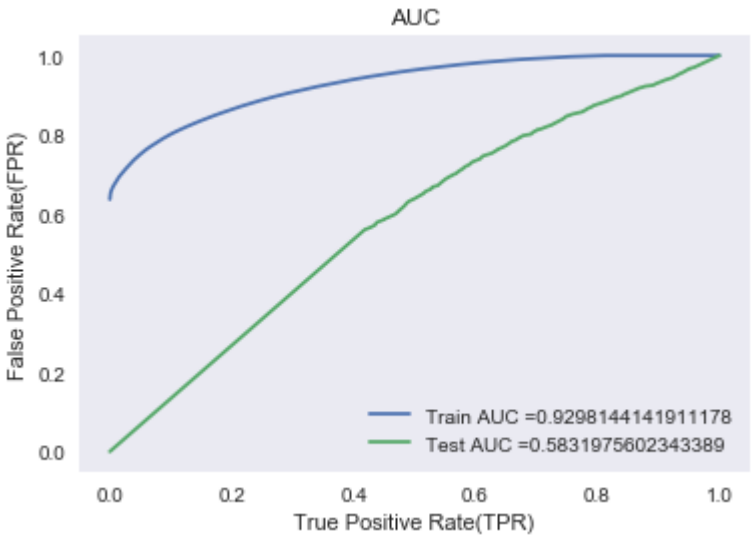
In [147]:
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [148]:
```
x1 = [5, 10, 100, 500] #min_sample_split
y1 =[1, 3, 10, 30] #max_depth
z1 = classifier_5.cv_results_['mean_test_score']

x2 = [5, 10, 100, 500] #min_sample_split
y2 = [1, 3, 10, 30] #max_depth
z2 = classifier_5.cv_results_['mean_train_score']
```

In [149]:
```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name = 'Cross Validation')
trace2 = go.Scatter3d(x=x2,y=y2,z=z2, name = 'Train')
data = [trace1, trace2]

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

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



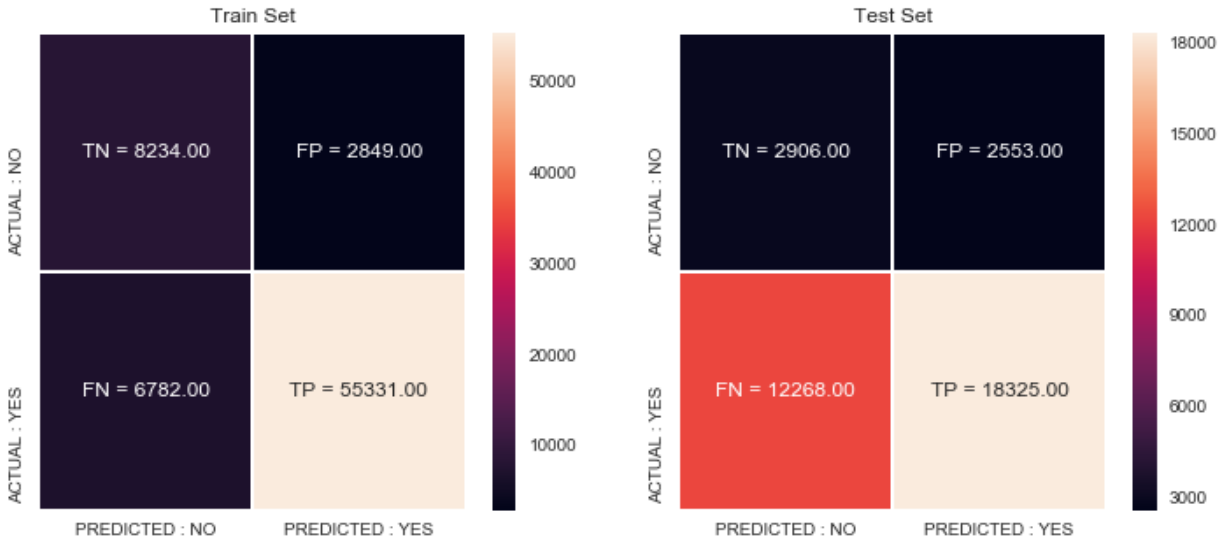
In [150]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htm
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

classifier = DecisionTreeClassifier(min_samples_split = min_samples_split_best_pa
classifier.fit(x_train_impFeatureDataset1, y_train)

y_train_pred = batch_predict(classifier,x_train_impFeatureDataset1)
y_test_pred = batch_predict(classifier,x_test_impFeatureDataset1)

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

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



Confusion Matrix For Train & Test Data

In [151]:
```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
print("For the Train Data")
con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, trai
print("For the Test Data")
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fp

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

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED

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

plt.show()
```

```
For the Train Data
the maximum value of tpr*(1-fpr) 0.7214974194470031 for threshold 0.702
For the Test Data
the maximum value of tpr*(1-fpr) 0.32595387646401114 for threshold 0.936
```



In [152]:
```
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(preprocessed_essays_train)
test_text_bow = vectorizer.transform(preprocessed_essays_test)
print("Shape of matrix after BOW encodig ",test_text_bow.shape)
# cv_text_bow = vectorizer.transform(preprocessed_essays_cv)
# print("Shape of matrix after BOW encodig ",cv_text_bow.shape)
BOW_feat_essay= vectorizer.get_feature_names() #for decision tree
```

```
Shape of matrix after BOW encodig  (36052, 14156)
```

In [153]:
```
y_predicted=predict(y_test_pred, te_thresholds, test_fpr, test_tpr)
y_test=list(y_test[::])
y_predicted=list(y_predicted[::])
```

```
the maximum value of tpr*(1-fpr) 0.32595387646401114 for threshold 0.936
```

In [154]:
```
bow_test = test_text_bow.todense()
print(bow_test.shape)
len(BOW_feat_essay)
```

```
(36052, 14156)
```

Out[154]:
```
14156
```

In [155]:
```
fp_index = []
fp_count = 0

for i in range(len(y_test_pred)):
    if y_test[i] == 0 and y_predicted[i]==1:
        fp_index.append(i)
        fp_count = fp_count + 1
    else :
        pass
print(fp_count)
print(fp_index[0:10])
```

```
2553
[5, 26, 47, 78, 93, 95, 159, 161, 177, 183]
```

In [156]:
```
df1 = pd.DataFrame(test_text_bow.todense())
df1_final = df1.iloc[fp_index,:]
print(df1_final.shape)
```

```
(2553, 14156)
```

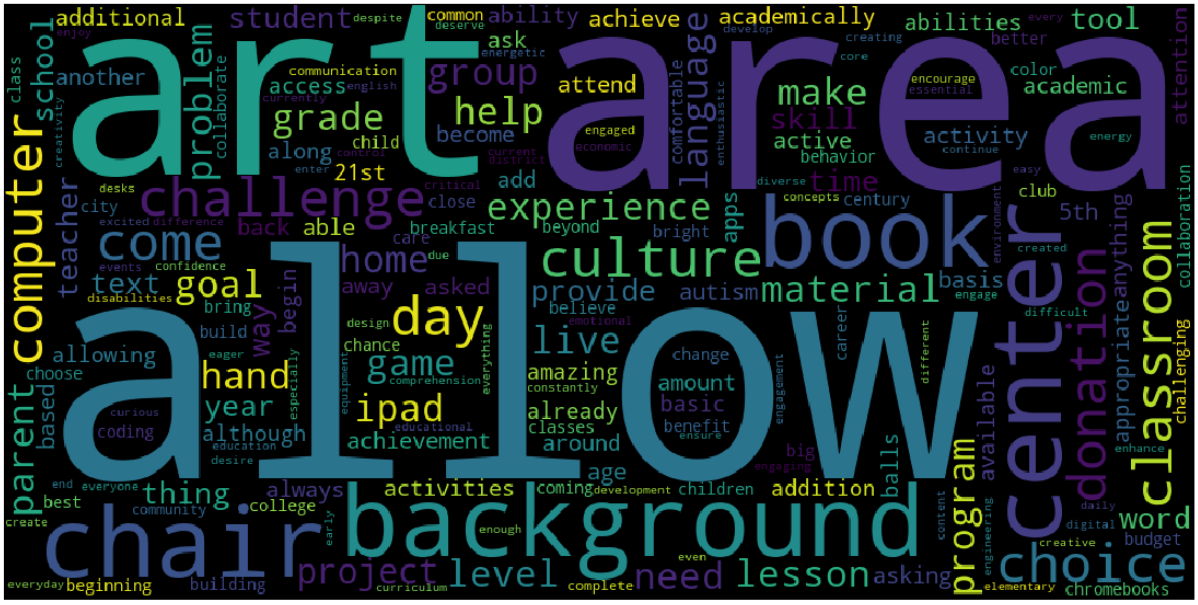
In [157]:
```
best_indices = []

for j in tqdm(range(df1_final.shape[1])):
    s = df1_final[j].sum()
    if s >= 100 :
        best_indices.append(j)
    else :
        continue
print(len(best_indices))
print(best_indices[0:10])
```

```
100%|██████████████████████████████████████████████████████████████████████████████
| 14156/14156 [00:05<00:00, 2517.97it/s]

592
[4, 92, 180, 249, 250, 252, 281, 282, 298, 353]
```

In [158]:
```
fp_words = []

for a in best_indices :
    fp_words.append(str(BOW_feat_essay[a]))
print(fp_words[0:10])
```

```
['100', '21st', '5th', 'abilities', 'ability', 'able', 'academic', 'academicall
y', 'access', 'achieve']
```

In [159]:
```
from wordcloud import WordCloud
from wordcloud import STOPWORDS
#convert list to string and generate
words_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(words_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.show()
```



Box & PDF plot for False Positives

In [160]:
```
df = pd.DataFrame(list(price_for_test))
print(df.head(2))
```

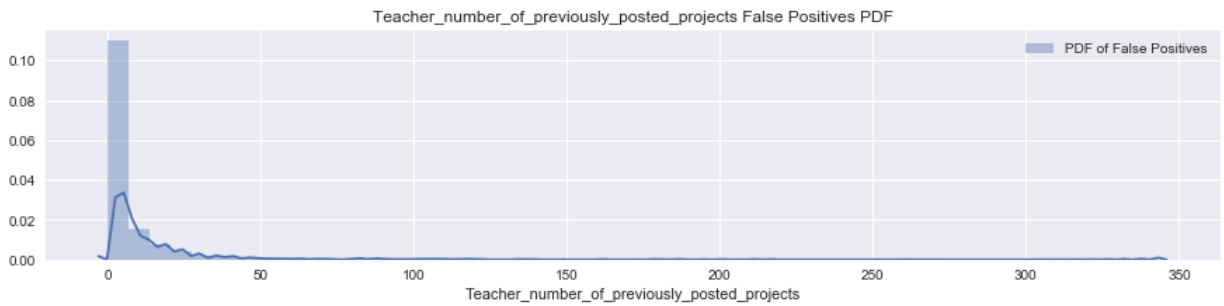
```
        0
0   14.85
1  117.72
```

In [161]:
```
plt.figure(figsize=(15,3))
df1 = df.iloc[fp_index, : ]
sns.boxplot(df1.values)
plt.title("Rejected Projects that Predicted as Positive")
plt.ylabel("Box plot for False Positives")
plt.xlabel("Price")
plt.show()
```

In [162]:
```
df = pd.DataFrame(list(number_of_previously_posted_projects_dtrees))
df1 = df.iloc[fp_index, : ]
```

In [163]:
```
plt.figure(figsize=(15,3))
sns.distplot(df1.values, label="PDF of False Positives")
plt.title('Teacher_number_of_previously_posted_projects False Positives PDF')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.legend()
plt.show()
```

```
C:\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning:

The 'normed' kwarg is deprecated, and has been replaced by the 'density' kwarg.
```



Conclusion

In [165]:
```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
TB = PrettyTable()
TB.field_names = ["Model", "Hyperparameter", "Train_AUC", "Test_Auc"]
TB.title = "Decision Tree"
TB.add_row(["TFIDF", "Depth:10 | Samp_Split:500", 0.6610,0.63480])
TB.add_row(["TFIDF-W2V", "Depth:10 | Samp_Split:500", 0.7028, 0.6106])
TB.add_row(["TFIDF-IMP-FEATURES", "Depth:10 | Samp_Split:500", 0.9298, 0.5831])
print(TB)
```

```
+-----------------------------------------------------------------------+
|                            Decision Tree                              |
+--------------------+---------------------------+-----------+----------+
|       Model        |       Hyperparameter      | Train_AUC | Test_Auc |
+--------------------+---------------------------+-----------+----------+
|       TFIDF        | Depth:10 | Samp_Split:500 |   0.661   |  0.6348  |
|     TFIDF-W2V      | Depth:10 | Samp_Split:500 |   0.7028  |  0.6106  |
| TFIDF-IMP-FEATURES | Depth:10 | Samp_Split:500 |   0.9298  |  0.5831  |
+--------------------+---------------------------+-----------+----------+
```

In [ ]: