DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

Feature	Description
	• `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

your neighborhood, and your school are all helpful.

- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv',nrows=50000)
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 (50000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [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

In [5]:

```
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
project_data.head(1)
```

Out[5]:

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

In [6]:

```
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')
project_data.head(5)
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Gra
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Gra

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Gra

In [7]:

```
X=project_data
X.head(5)
```

Out[7]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Gra
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Gra
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Gra

1.2 preprocessing of `project_subject_categories`

In [8]:

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

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

project_data['clean_categories'] = cat_list
```

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [9]:

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

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

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

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

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

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

1.4 preprocessing of `project_grade_category`

In [10]:

```
catogories = list(project_data['project_grade_category'].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 j in catogories:
    temp = ""
    j=j.replace(' ','_')
    j = j.replace('-','To')
    temp+=j
    cat_list.append(temp)

project_data['project_grade_category'] = cat_list
```

1.5 Text preprocessing

In [11]:

```
# 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 [12]:

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

Out[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra

In [13]:

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

In [14]:

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

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
```

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

In [15]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
```

```
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [16]:

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

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

In [17]:

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

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

In [18]:

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

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

In [19]:

```
# https://gist.github.com/sebleier/554280
```

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [20]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000 [00:
54<00:00, 913.16it/s]
```

In [21]:

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

Out[21]:

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

1.6 Preprocessing of `project_title`

In [22]:

```
# Displaying first two datasets
```

```
X.head(2)
```

Out[22]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra

In [23]:

```
# printing some random project titles.
print(X['project_title'].values[0])
print("="*50)
print(X['project_title'].values[150])
print("="*50)
print(X['project_title'].values[1000])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
```

In [24]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)    #re represents regular expression
    phrase = re.sub(r"can\'t", "can not", phrase)    #sub represents substute

    # 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 [25]:

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

```
We Need To Move It While We Input It!
==================================================
```

In [26]:

```
# \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)
```

```
We Need To Move It While We Input It!
```

In [27]:

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

```
we need to move it while we input it
```

In [28]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [29]:

```
sent = ' '.join(e for e in sent.split() if e not in stopwords)
print(sent)
```

```
need move input
```

In [30]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_project_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(X['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).lower()
```

```
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_project_titles.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000
[00:02<00:00, 22762.25it/s]
```

In [31]:

```
# after preprocesing
preprocessed_project_titles[20000]
```

Out[31]:

```
'need move input'
```

2. Splitting Data

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

In [32]:

```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [33]:

```
X_train=X_train.reset_index()
X_test=X_test.reset_index()
X_cv=X_cv.reset_index()
```

2.1 Preparing data for models

In [34]:

```
X.columns
```

Out[34]:

```
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', 'price', 'quantity',
       'clean_categories', 'clean_subcategories', 'essay'],
      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
```

2.2 Vectorizing Categorical data

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

In [37]:

```
vectorizer = CountVectorizer()
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_cv_state_ohe = vectorizer.transform(X_cv['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_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 51) (22445,)
(11055, 51) (11055,)
(16500, 51) (16500,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', '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']
====================================================================================================
```

In [38]:

```
X_train['teacher_prefix'].fillna(value='Teacher',inplace=True)
X_cv['teacher_prefix'].fillna(value='Teacher',inplace=True)
X_test['teacher_prefix'].fillna(value='Teacher',inplace=True)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

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

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

```
After vectorizations
(22445, 5) (22445,)
(11055, 5) (11055,)
(16500, 5) (16500,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================================
```

In [39]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['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['project_grade_category'].values)
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)
```

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

```
After vectorizations
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['grades_3to5', 'grades_6to8', 'grades_9to12', 'grades_prekto2']
====================================================================================================
```

In [40]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['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['project_grade_category'].values)
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)

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

```
After vectorizations
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['grades_3to5', 'grades_6to8', 'grades_9to12', 'grades_prekto2']
====================================================================================================
```

In [41]:

```
vectorizer = CountVectorizer()
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_category_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_category_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_category_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_category_ohe.shape, y_train.shape)
print(X_cv_category_ohe.shape, y_cv.shape)
print(X_test_category_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 9) (22445,)
(11055, 9) (11055,)
(16500, 9) (16500,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language',
'math_science', 'music_arts', 'specialneeds', 'warmth']
====================================================================================================
```

In [42]:

```
vectorizer = CountVectorizer()
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_subcategory_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_subcategory_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_subcategory_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcategory_ohe.shape, y_train.shape)
print(X_cv_subcategory_ohe.shape, y_cv.shape)
print(X_test_subcategory_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 30) (22445,)
(11055, 30) (11055,)
(16500, 30) (16500,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience',
'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness',
'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'm
athematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socia
lsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
====================================================================================================
```

2.3 Vectorizing Text data

2.3.1 Bag of words

Vectorizing Essay Text

In [43]:

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

print("="*100)


from sklearn.feature_extraction.text import CountVectorizer
vectorizer_essay = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_essay.fit(X_train['essay'].values) # fit has to happen only on train data

featurenames=vectorizer_essay.get_feature_names()
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_essay.transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer_essay.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer_essay.transform(X_test['essay'].values)

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
(22445, 20) (22445,)
(11055, 20) (11055,)
(16500, 20) (16500,)
====================================================================================================

After vectorizations
(22445, 5000) (22445,)
(11055, 5000) (11055,)
(16500, 5000) (16500,)
====================================================================================================
```

Vectorizing Title Text

In [44]:

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

print("="*100)

from sklearn.feature_extraction.text import CountVectorizer
vectorizer_title = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_title.fit(X_train['project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer_title.transform(X_train['project_title'].values)
X_cv_title_bow = vectorizer_title.transform(X_cv['project_title'].values)
X_test_title_bow = vectorizer_title.transform(X_test['project_title'].values)

print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
print("="*100)
```

```
(22445, 20) (22445,)
(11055, 20) (11055,)
(16500, 20) (16500,)
====================================================================================================

After vectorizations
(22445, 2692) (22445,)
(11055, 2692) (11055,)
(16500, 2692) (16500,)
====================================================================================================
```

2.3.2 TFIDF vectorizer

Vectorizing Essay Text

In [45]:

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

print("="*100)


from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essay = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_essay.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
featurenames=vectorizer_essay.get_feature_names()
X_train_essay_tfidf = vectorizer_essay.transform(X_train['essay'].values)
X_cv_essay_tfidf = vectorizer_essay.transform(X_cv['essay'].values)
X_test_essay_tfidf = vectorizer_essay.transform(X_test['essay'].values)

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

```
(22445, 20) (22445,)
(11055, 20) (11055,)
(16500, 20) (16500,)
====================================================================================================

After vectorizations
(22445, 5000) (22445,)
(11055, 5000) (11055,)
```

```
(16500, 5000) (16500,)
==================================================================================================
```

Vectorizing Title Text

In [46]:

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

print("="*100)


from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_title = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_title.fit(X_train['project_title'].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_title.transform(X_train['project_title'].values)
X_cv_title_tfidf = vectorizer_title.transform(X_cv['project_title'].values)
X_test_title_tfidf = vectorizer_title.transform(X_test['project_title'].values)

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

```
(22445, 20) (22445,)
(11055, 20) (11055,)
(16500, 20) (16500,)
==================================================================================================

After vectorizations
(22445, 2692) (22445,)
(11055, 2692) (11055,)
(16500, 2692) (16500,)
==================================================================================================
```

2.3.3 AVG W2V for Essays

AVG W2V for Essays

In [49]:

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

Using Train Data

In [50]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_essays_tr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
```

```
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_essays_tr.append(vector)

print(len(avg_w2v_vectors_for_essays_tr))
print(len(avg_w2v_vectors_for_essays_tr[0]))

avg_w2v_vectors_for_essays_tr=csr_matrix(avg_w2v_vectors_for_essays_tr)
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:14<00:00, 1554.77it/s]
```

```
22445
300
```

Using Test Data

In [51]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_essays_te = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_essays_te.append(vector)

print(len(avg_w2v_vectors_for_essays_te))
print(len(avg_w2v_vectors_for_essays_te[0]))

avg_w2v_vectors_for_essays_te=csr_matrix(avg_w2v_vectors_for_essays_te)
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:10<00:00, 1614.01it/s]
```

```
16500
300
```

Using CV Data

In [52]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_essays_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_essays_cv.append(vector)

print(len(avg_w2v_vectors_for_essays_cv))
print(len(avg_w2v_vectors_for_essays_cv[0]))

avg_w2v_vectors_for_essays_cv=csr_matrix(avg_w2v_vectors_for_essays_cv)
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:06<00:00, 1593.48it/s]
```

```
11055
300
```

AVG W2V for Titles

Using Train Data

In [53]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_titles_tr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_titles_tr.append(vector)

print(len(avg_w2v_vectors_for_titles_tr))
print(len(avg_w2v_vectors_for_titles_tr[0]))

avg_w2v_vectors_for_titles_tr=csr_matrix(avg_w2v_vectors_for_titles_tr)
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:00<00:00, 100550.22it/s]
```

```
22445
300
```

Using Test Data

In [54]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_titles_te = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_titles_te.append(vector)

print(len(avg_w2v_vectors_for_titles_te))
print(len(avg_w2v_vectors_for_titles_te[0]))

avg_w2v_vectors_for_titles_te=csr_matrix(avg_w2v_vectors_for_titles_te)
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 93950.77it/s]
```

```
16500
300
```

Using CV Data

In [55]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
avg_w2v_vectors_for_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_for_titles_cv.append(vector)

print(len(avg_w2v_vectors_for_titles_cv))
print(len(avg_w2v_vectors_for_titles_cv[0]))

avg_w2v_vectors_for_titles_cv=csr_matrix(avg_w2v_vectors_for_titles_cv)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 120935.26it/s]
```

```
11055
300
```

2.3.4 Using Pretrained Models: TFIDF weighted W2V

TFIDF weighted W2V for Essays

Using Train Data

In [56]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['essay'].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.
from scipy.sparse import csr_matrix
tfidf_w2v_vectors_for_essays_tr = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_train['essay'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_essays_tr.append(vector)

print(len(tfidf_w2v_vectors_for_essays_tr))
```

```
print(len(tfidf_w2v_vectors_for_essays_tr))
print(len(tfidf_w2v_vectors_for_essays_tr[0]))

tfidf_w2v_vectors_for_essays_tr=csr_matrix(tfidf_w2v_vectors_for_essays_tr)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 22445/22445 [02:
36<00:00, 143.27it/s]
```

```
22445
300
```

Using Test Data

In [58]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_for_essays_te = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_test['essay'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_essays_te.append(vector)

print(len(tfidf_w2v_vectors_for_essays_te))
print(len(tfidf_w2v_vectors_for_essays_te[0]))

tfidf_w2v_vectors_for_essays_te=csr_matrix(tfidf_w2v_vectors_for_essays_te)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 16500/16500 [01:
54<00:00, 143.73it/s]
```

```
16500
300
```

Using CV Data

In [59]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_for_essays_cv = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_cv['essay'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_essays_cv.append(vector)

print(len(tfidf_w2v_vectors_for_essays_cv))
```

```
print(len(tfidf_w2v_vectors_for_essays_cv[0]))

tfidf_w2v_vectors_for_essays_cv=csr_matrix(tfidf_w2v_vectors_for_essays_cv)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 11055/11055 [01:
17<00:00, 142.77it/s]
```

```
11055
300
```

TFIDF weighted W2V for Titles

Using Train Data

In [60]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['project_title'].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 [61]:

```
# average Word2Vec
# compute average word2vec for each review.
from scipy.sparse import csr_matrix
tfidf_w2v_vectors_for_titles_tr = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_train['project_title'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_titles_tr.append(vector)

print(len(tfidf_w2v_vectors_for_titles_tr))
print(len(tfidf_w2v_vectors_for_titles_tr[0]))

tfidf_w2v_vectors_for_titles_tr=csr_matrix(tfidf_w2v_vectors_for_titles_tr)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 22445/22445
[00:00<00:00, 60612.70it/s]
```

```
22445
300
```

Using Test Data

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_for_titles_te = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_test['project_title'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_titles_te.append(vector)

print(len(tfidf_w2v_vectors_for_titles_te))
print(len(tfidf_w2v_vectors_for_titles_te[0]))

tfidf_w2v_vectors_for_titles_te=csr_matrix(tfidf_w2v_vectors_for_titles_te)
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 61774.04it/s]
```

```
16500
300
```

Using CV Data

In [63]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_for_titles_cv = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_cv['project_title'].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 tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_for_titles_cv.append(vector)

print(len(tfidf_w2v_vectors_for_titles_cv))
print(len(tfidf_w2v_vectors_for_titles_cv[0]))

tfidf_w2v_vectors_for_titles_cv=csr_matrix(tfidf_w2v_vectors_for_titles_cv)
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 70062.66it/s]
```

```
11055
300
```

2.4 Vectorizing Numerical features

In [64]:

```
X_train_price_norm = (X_train['price'].values.reshape(-1,1))
X_cv_price_norm = (X_cv['price'].values.reshape(-1,1))
X_test_price_norm = (X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
```

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

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

In [65]:

```
X_train_teacher_norm = (X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1
))
X_cv_teacher_norm = (X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_test_teacher_norm = (X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_teacher_norm.shape, y_train.shape)
print(X_cv_teacher_norm.shape, y_cv.shape)
print(X_test_teacher_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

In [66]:

```
X_train_quantity_norm = (X_train['quantity'].values.reshape(-1,1))
X_cv_quantity_norm = (X_cv['quantity'].values.reshape(-1,1))
X_test_quantity_norm = (X_test['quantity'].values.reshape(-1,1))

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

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.5 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [67]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow,X_train_title_bow, X_train_state_ohe, X_train_teacher_ohe,
X_train_grade_ohe,X_train_category_ohe,X_train_subcategory_ohe,X_train_price_norm,X_train_teacher_n
orm,X_train_quantity_norm)).tocsr()
X_cr = hstack((X_cv_essay_bow,X_cv_title_bow, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe,X_cv
_category_ohe,X_cv_subcategory_ohe,X_cv_price_norm,X_cv_teacher_norm,X_cv_quantity_norm)).tocsr()
X_te = hstack((X_test_essay_bow, X_test_title_bow,X_test_state_ohe, X_test_teacher_ohe, X_test_grad
e_ohe,X_test_category_ohe,X_test_subcategory_ohe,X_test_quantity_norm,X_test_teacher_norm,X_test_qu
antity_norm)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 7794) (22445,)
(11055, 7794) (11055,)
(16500, 7794) (16500,)
==================================================================================================
```

In [68]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X2_tr = hstack((X_train_essay_tfidf,X_train_title_tfidf, X_train_state_ohe, X_train_teacher_ohe, X_
train_grade_ohe,X_train_category_ohe,X_train_subcategory_ohe,X_train_price_norm,X_train_teacher_nor
m,X_train_quantity_norm)).tocsr()
X2_cr = hstack((X_cv_essay_tfidf,X_cv_title_tfidf, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe
,X_cv_category_ohe,X_cv_subcategory_ohe,X_cv_price_norm,X_cv_teacher_norm,X_cv_quantity_norm)).toc
sr()
X2_te = hstack((X_test_essay_tfidf, X_test_title_tfidf,X_test_state_ohe, X_test_teacher_ohe, X_test
_grade_ohe,X_test_category_ohe,X_test_subcategory_ohe,X_test_quantity_norm,X_test_teacher_norm,X_t
est_quantity_norm)).tocsr()

print("Final Data matrix")
print(X2_tr.shape, y_train.shape)
print(X2_cr.shape, y_cv.shape)
print(X2_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 7794) (22445,)
(11055, 7794) (11055,)
(16500, 7794) (16500,)
==================================================================================================
```

In [69]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X3_tr = hstack((avg_w2v_vectors_for_essays_tr,avg_w2v_vectors_for_titles_tr, X_train_state_ohe,
X_train_teacher_ohe,
X_train_grade_ohe,X_train_category_ohe,X_train_subcategory_ohe,X_train_price_norm,X_train_teacher_n
orm,X_train_quantity_norm)).tocsr()
X3_cr = hstack((avg_w2v_vectors_for_essays_cv,avg_w2v_vectors_for_titles_cv, X_cv_state_ohe, X_cv_t
eacher_ohe,
X_cv_grade_ohe,X_cv_category_ohe,X_cv_subcategory_ohe,X_cv_price_norm,X_cv_teacher_norm,X_cv_quanti
ty_norm)).tocsr()
X3_te = hstack((avg_w2v_vectors_for_essays_te,avg_w2v_vectors_for_titles_te,X_test_state_ohe,
X_test_teacher_ohe,
X_test_grade_ohe,X_test_category_ohe,X_test_subcategory_ohe,X_test_quantity_norm,X_test_teacher_nor
m,X_test_quantity_norm)).tocsr()

print("Final Data matrix")
print(X3_tr.shape, y_train.shape)
print(X3_cr.shape, y_cv.shape)
print(X3_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
==================================================================================================
```

In [70]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X4_tr = hstack((tfidf_w2v_vectors_for_essays_tr,tfidf_w2v_vectors_for_titles_tr, X_train_state_ohe
, X_train_teacher_ohe,
X_train_grade_ohe,X_train_category_ohe,X_train_subcategory_ohe,X_train_price_norm,X_train_teacher_n
```

```
orm,X_train_quantity_norm)).tocsr()
X4_cr = hstack((tfidf_w2v_vectors_for_essays_cv,tfidf_w2v_vectors_for_titles_cv, X_cv_state_ohe,
X_cv_teacher_ohe,
X_cv_grade_ohe,X_cv_category_ohe,X_cv_subcategory_ohe,X_cv_price_norm,X_cv_teacher_norm,X_cv_quanti
ty_norm)).tocsr()
X4_te = hstack((tfidf_w2v_vectors_for_essays_te,tfidf_w2v_vectors_for_titles_te,X_test_state_ohe,
X_test_teacher_ohe,
X_test_grade_ohe,X_test_category_ohe,X_test_subcategory_ohe,X_test_quantity_norm,X_test_teacher_nor
m,X_test_quantity_norm)).tocsr()

print("Final Data matrix")
print(X4_tr.shape, y_train.shape)
print(X4_cr.shape, y_cv.shape)
print(X4_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
====================================================================================================
```

2.6 Decision Tree

2.6.1 Applying Decision Trees on BOW, SET 1

In [98]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt =DecisionTreeClassifier(random_state=0,class_weight="balanced")
parameters = {'max_depth':[1, 5, 10, 50,100,500],'min_samples_split':[5,10,100,500]}
clf = GridSearchCV(dt, parameters, cv=2, scoring='roc_auc')
clf.fit(X_tr,y_train)

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

In [35]:

```
clf.best_params_
```

```
{'max_depth': 10, 'min_samples_split': 3}
```

In [100]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=train_auc, name
= 'train')
trace2 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=cv_auc, name =
'Cross validation')
data = [trace1, trace2]

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

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

The best value of max depth obtained from the plot is 10 and minimum samples split features is 3.

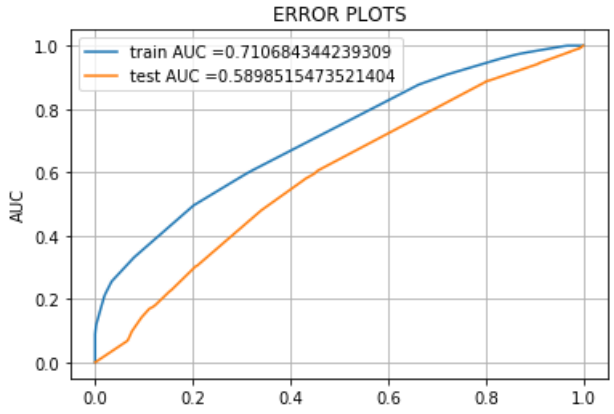
In [71]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

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

In [83]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier

clf = DecisionTreeClassifier(max_depth=10,
min_samples_split=3,random_state=0,class_weight="balanced",splitter='random')
clf.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = clf.predict_proba(X_tr)
preds = y_train_pred[:,1] #code copied from https://stackoverflow.com/questions/25009284/how-to-pl
ot-roc-curve-in-python to remove the error-bad input shape
y_test_pred = clf.predict_proba(X_te)
preds2=y_test_pred[:,1]


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, preds)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, preds2)

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("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

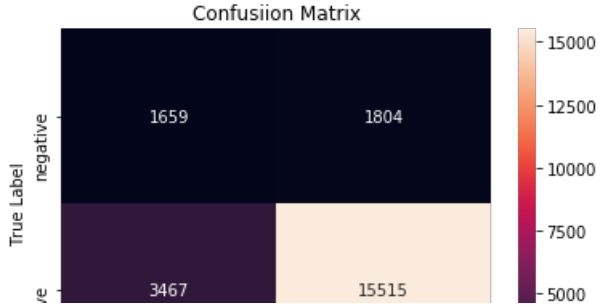


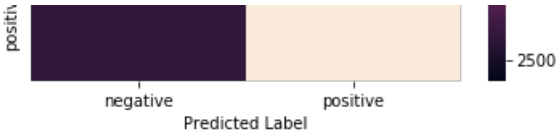
- Train AUC is 0.7106
- Test AUC is 0.5898 represent the prediction level on the test dataset. In other words if a data point is provided the probabilty of classifying it correctly after the training has been done is 58.98 %.

In [74]:

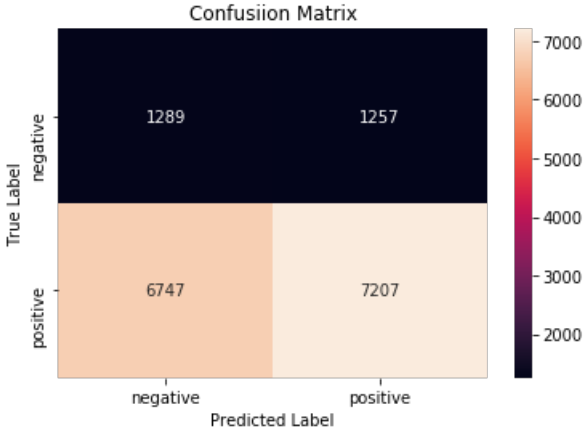
```
print("="*100)
from sklearn.metrics import confusion_matrix
import seaborn as sns
class_label = ["negative", "positive"]

# Reference: https://seaborn.pydata.org/generated/seaborn.heatmap.html
# https://stackoverflow.com/questions/37790429/seaborn-heatmap-using-pandas-dataframe

print("Train confusion matrix")
cm=confusion_matrix(y_train, predict(preds, tr_thresholds, train_fpr, train_fpr))
df= pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()

print("Test confusion matrix")

cm=confusion_matrix(y_test, predict(preds2, tr_thresholds, test_fpr, test_fpr))
df = pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24956170044467443 for threshold 0.359
```






```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499697629601198 for threshold 0.803
```



In [58]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
from scipy.sparse import csr_matrix
FP=[]
X_te=csr_matrix(X_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X_te[i])==1):
        FP.append(X_test['essay'][i])

#converting array to string as word cloud accepts string as a parameter
string=''.join(str(e) for e in FP)
```

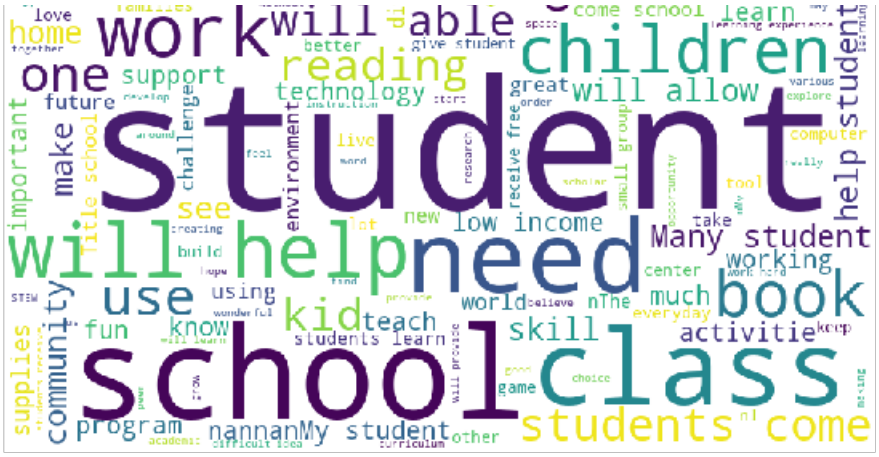
Word Cloud of False Positive features

In [59]:

```
#Reference:https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud
wordcloud=WordCloud(width=800,height=800,background_color='white',min_font_size=10).generate(string
)
plt.figure(figsize=(10,10),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
```

Out[59]:

```
(-0.5, 799.5, 799.5, -0.5)
```



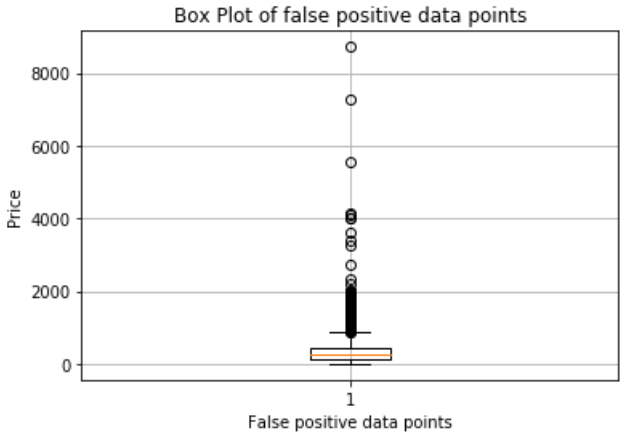
In [60]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
price_FP=[]
X_te=csr_matrix(X_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X_te[i])==1):
        price_FP.append(X_test_price_norm[i])
price_FP=np.asarray(price_FP).reshape(-1)
```

Box Plot of False positive features

In [61]:

```
plt.boxplot([price_FP])
plt.title('Box Plot of false positive data points')
plt.xlabel('False positive data points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



The median value lies around 250. And it does not give clear interpretation of the false data points.

In [62]:

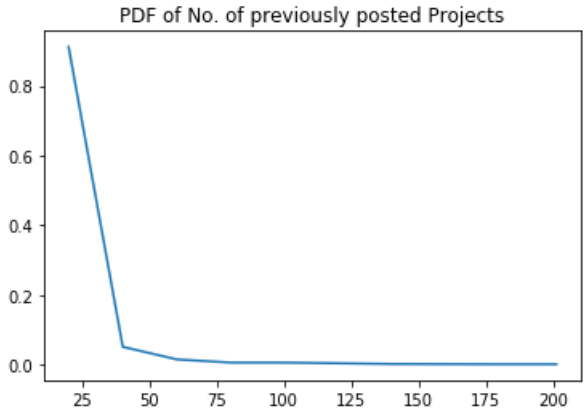
```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
teacher_FP=[]
X_te=csr_matrix(X_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X_te[i])==1):
        teacher_FP.append(X_test_teacher_norm[i])
teacher_FP=np.asarray(teacher_FP).reshape(-1)
```

PDF of False positive features

In [63]:

```
#Combined CDF and PDF with Classes 1 and 2
#Plot CDF and PDF of age with Class=1
counts, bin_edges = np.histogram(teacher_FP, bins=10, normed = True)
pdf = counts/(sum(counts))

plt.plot(bin_edges[1:],pdf,label='PDF')
plt.title("PDF of No. of previously posted Projects")
plt.show()
```

```
C:\Users\dheer\Anaconda3\lib\site-packages\ipykernel_launcher.py:3: VisibleDeprecationWarning:

Passing `normed=True` on non-uniform bins has always been broken, and computes neither the probabi
lity density function nor the probability mass function. The result is only correct if the bins ar
e uniform, when density=True will produce the same result anyway. The argument will be removed in
a future version of numpy.
```



There is a high probability of no. of previously posted projects at lower values. As the value increases the probablity falls sharply (i.e after 40) and remains constant.

2.6.1. Graphviz visualization of Decision Tree on BOW, SET 1

In [66]:

```
# Refernce: https://pythonprogramminglanguage.com/decision-tree-visual-example/
from sklearn.feature_selection import SelectFromModel
dt =DecisionTreeClassifier(random_state=0,max_depth=3,min_samples_split=500)
dt.fit(X_train_essay_bow,y_train)

from sklearn import tree
import collections
import pydotplus

dot_data =
tree.export_graphviz(dt,feature_names=featurenames,out_file=None,filled=True,rounded=True)
graph_data = pydotplus.graph_from_dot_data(dot_data)

colors = ('blue', 'orange')
edges = collections.defaultdict(list)

for edge in graph_data.get_edge_list():
    edges[edge.get_source()].append(int(edge.get_destination()))

for edge in edges:
    edges[edge].sort()
    for i in range(2):
        dest = graph_data.get_node(str(edges[edge][i]))[0]
        dest.set_fillcolor(colors[i])

graph_data.write_png('bow_tree.png')
```

Out[66]:

```
True
```

2.6.2 Applying Decision Trees on TFIDF, SET 2

In [64]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt =DecisionTreeClassifier(random_state=0,class_weight="balanced")
parameters = {'max_depth':[1, 5, 10, 50,100,500],'min_samples_split':[5,10,100,500]}
clf = GridSearchCV(dt, parameters, cv=2, scoring='roc_auc')
clf.fit(X2_tr,y_train)

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

In [65]:

```
clf.best_params_
```

Out[65]:

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

In [111]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=train_auc, name
= 'Train')
trace2 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=cv_auc, name =
'Cross validation')
data = [trace1, trace2]

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

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

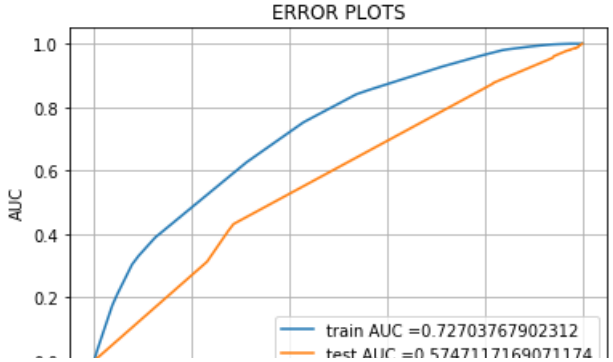
The best value of max depth obtained from the plot is 10 and minimum samples split features is 500.

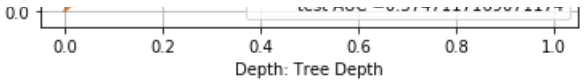
In [69]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

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

In [73]:

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

clf = DecisionTreeClassifier(max_depth=10, min_samples_split=
500,random_state=0,class_weight="balanced")
clf.fit(X2_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = clf.predict_proba(X2_tr)
preds = y_train_pred[:,1] #code copied from https://stackoverflow.com/questions/25009284/how-to-pl
ot-roc-curve-in-python to remove the error-bad input shape
y_test_pred = clf.predict_proba(X2_te)
preds2=y_test_pred[:,1]


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, preds)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, preds2)

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("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



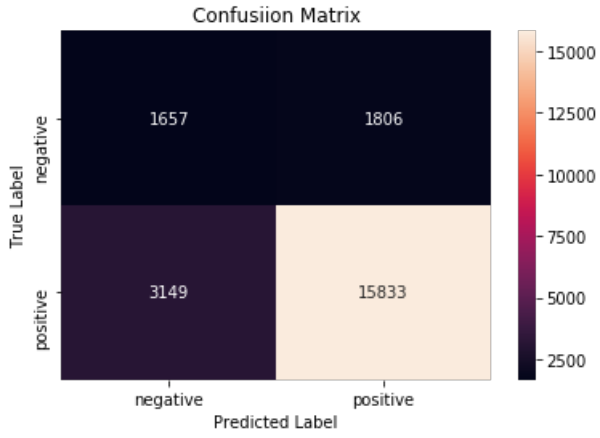


- Train AUC is 0.7270
- Test AUC is 0.5747 represent the prediction level on the test dataset. In other words if a data point is provided the probabilty of classifying it correctly after the training has been done is 57.47 %.

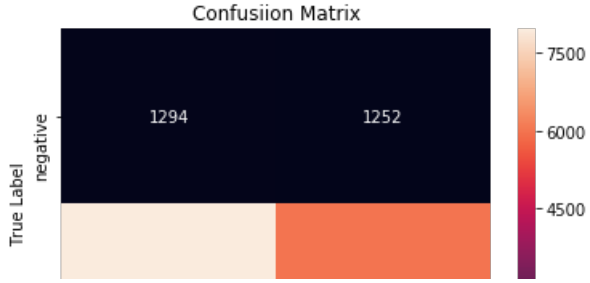
In [71]:

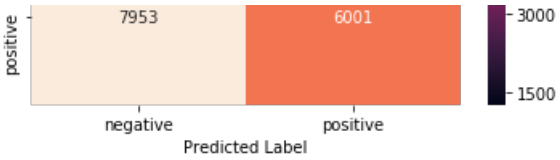
```
print("="*100)
from sklearn.metrics import confusion_matrix
import seaborn as sns
class_label = ["negative", "positive"]

# Reference: https://seaborn.pydata.org/generated/seaborn.heatmap.html
# https://stackoverflow.com/questions/37790429/seaborn-heatmap-using-pandas-dataframe

print("Train confusion matrix")
cm=confusion_matrix(y_train, predict(preds, tr_thresholds, train_fpr, train_fpr))
df= pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()

print("Test confusion matrix")

cm=confusion_matrix(y_test, predict(preds2, tr_thresholds, test_fpr, test_fpr))
df = pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24953718485480225 for threshold 0.832
```




```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24993196666026954 for threshold 0.952
```





In [73]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
from scipy.sparse import csr_matrix
FP=[]
X2_te=csr_matrix(X2_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X2_te[i])==1):
        FP.append(X_test['essay'][i])


#converting array to string as word cloud accepts string as a parameter
string=''.join(str(e) for e in FP)
```

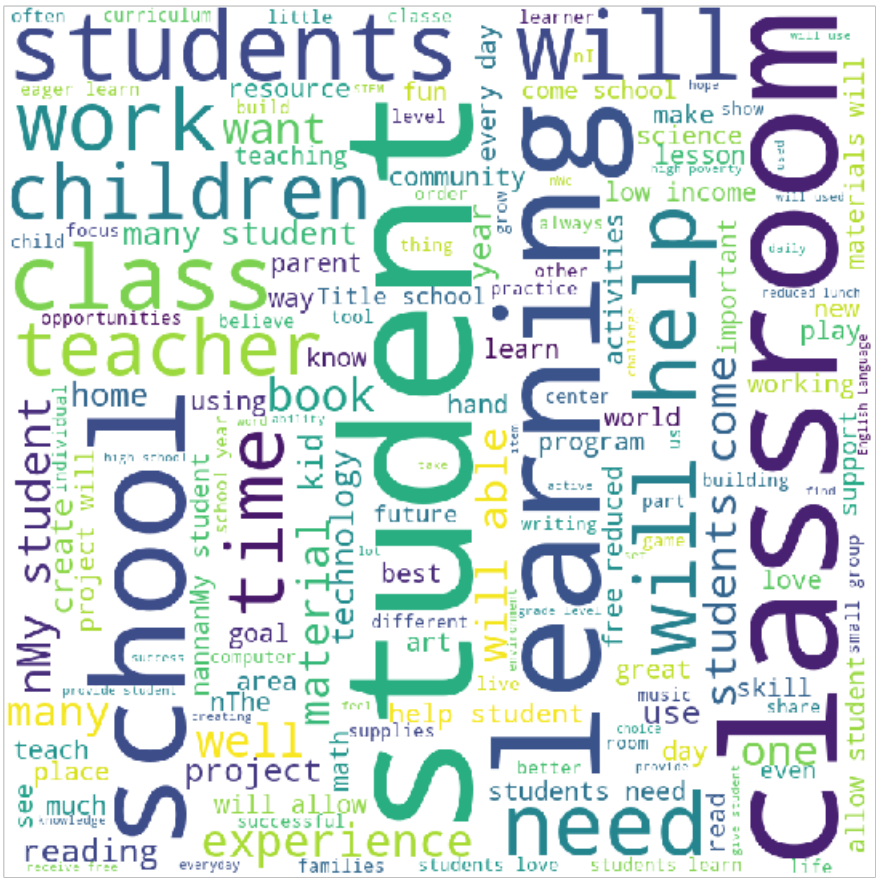
Word cloud of False positive features

In [74]:

```
# Refernce: https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud
wordcloud=WordCloud(width=800,height=800,background_color='white',min_font_size=10).generate(string
)
plt.figure(figsize=(10,10),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
```

Out[74]:

```
(-0.5, 799.5, 799.5, -0.5)
```



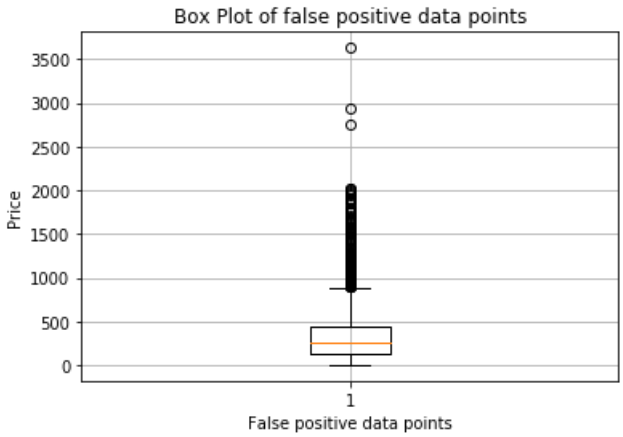
In [76]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
price_FP=[]
X2_te=csr_matrix(X2_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X2_te[i])==1):
        price_FP.append(X_test_price_norm[i])
price_FP=np.asarray(price_FP).reshape(-1)
```

Box Plot of False positive features

In [77]:

```
plt.boxplot([price_FP])
plt.title('Box Plot of false positive data points')
plt.xlabel('False positive data points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



The median value lies around 300. And it does not give clear interpretation of the false data points.

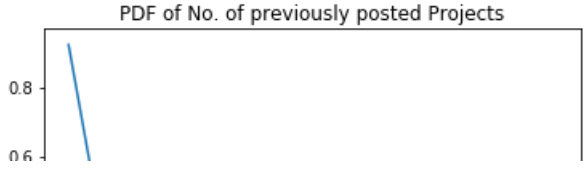
In [78]:

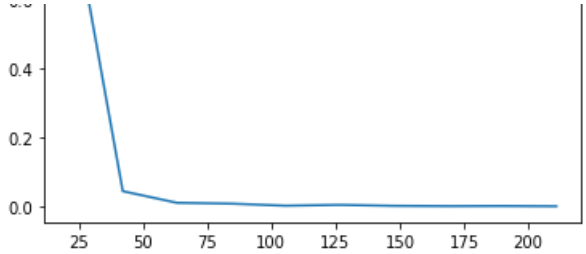
```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
teacher_FP=[]
X2_te=csr_matrix(X2_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X2_te[i])==1):
        teacher_FP.append(X_test_teacher_norm[i])
teacher_FP=np.asarray(teacher_FP).reshape(-1)
```

PDF of False positive features

In [79]:

```
counts, bin_edges = np.histogram(teacher_FP, bins=10, density = True)
pdf = counts/(sum(counts))

plt.plot(bin_edges[1:],pdf,label='PDF')
plt.title("PDF of No. of previously posted Projects")

plt.show()
```





There is a high probability of no. of previously posted projects at lower values. As the value increases the probablity falls sharply (i.e after 40) and remains constant.

2.6.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [80]:

```
# Refernce: https://pythonprogramminglanguage.com/decision-tree-visual-example/
from sklearn.feature_selection import SelectFromModel
dt =DecisionTreeClassifier(random_state=0,max_depth=3,min_samples_split=500)
dt.fit(X_train_essay_tfidf,y_train)

from sklearn import tree
import collections
import pydotplus

dot_data =
tree.export_graphviz(dt,feature_names=featurenames,out_file=None,filled=True,rounded=True)
graph_data = pydotplus.graph_from_dot_data(dot_data)

colors = ('blue', 'orange')
edges = collections.defaultdict(list)

for edge in graph_data.get_edge_list():
    edges[edge.get_source()].append(int(edge.get_destination()))

for edge in edges:
    edges[edge].sort()
    for i in range(2):
        dest = graph_data.get_node(str(edges[edge][i]))[0]
        dest.set_fillcolor(colors[i])

graph_data.write_png('tfidf_tree.png')
```

Out[80]:

```
True
```

2.6.3 Applying Decision Trees on AVG W2V, SET 3

In [76]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt =DecisionTreeClassifier(random_state=0,class_weight="balanced")
parameters = {'max_depth':[1, 5, 10, 50,100,500],'min_samples_split':[5,10,100,500]}
clf = GridSearchCV(dt, parameters, cv=2, scoring='roc_auc')
clf.fit(X3_tr,y_train)

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

In [38]:

```
clf.best_params_
```

```
{'max_depth': 5, 'min_samples_split': 5}
```

In [78]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=train_auc, name
= 'Train')
trace2 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=cv_auc, name =
'Cross validation')
data = [trace1, trace2]

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

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

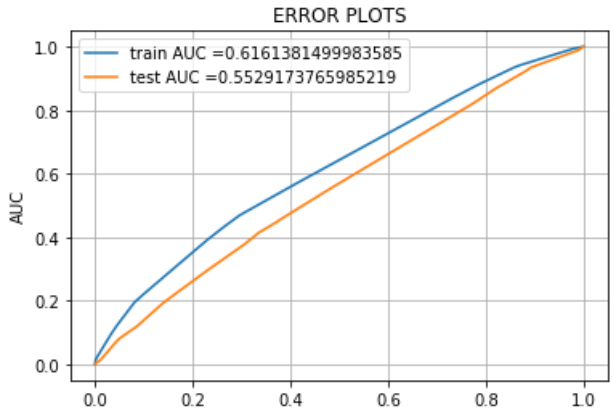
The best value of max depth obtained from the plot is 5 and minimum samples split features is 5.

In [79]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

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

In [82]:

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

clf = DecisionTreeClassifier(max_depth=5, min_samples_split= 5,random_state=0,class_weight="balance
d",splitter='random')
clf.fit(X3_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = clf.predict_proba(X3_tr)
preds = y_train_pred[:,1] #code copied from https://stackoverflow.com/questions/25009284/how-to-pl
ot-roc-curve-in-python to remove the error-bad input shape
y_test_pred = clf.predict_proba(X3_te)
preds2=y_test_pred[:,1]


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, preds)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, preds2)

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("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



- Train AUC is 0.6161
- Test AUC is 0.5529 represent the prediction level on the test dataset. In other words if a data point is provided the probabilty of classifying it correctly after the training has been done is 55.29%.

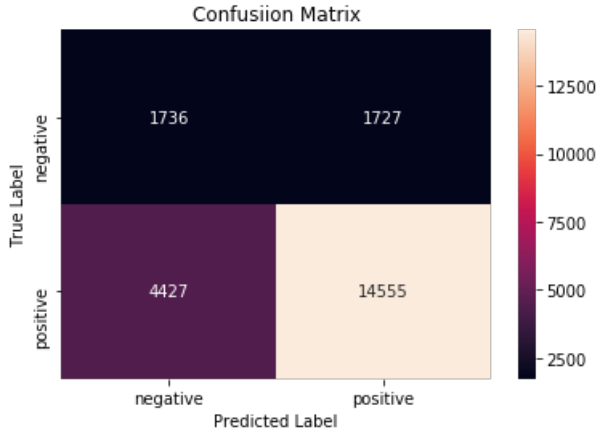
In [92]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
import seaborn as sns
class_label = ["negative", "positive"]

# Reference: https://seaborn.pydata.org/generated/seaborn.heatmap.html
# https://stackoverflow.com/questions/37790429/seaborn-heatmap-using-pandas-dataframe

print("Train confusion matrix")
cm=confusion_matrix(y_train, predict(preds, tr_thresholds, train_fpr, train_fpr))
df= pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()

print("Test confusion matrix")

cm=confusion_matrix(y_test, predict(preds2, tr_thresholds, test_fpr, test_fpr))
```

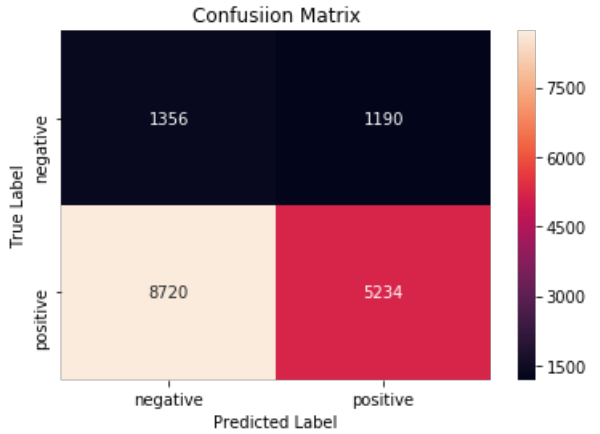
```
df = pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```

==========

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999831142620782 for threshold 0.833
```




```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2489372297564561 for threshold 0.948
```



In [93]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
from scipy.sparse import csr_matrix
FP=[]
X3_te=csr_matrix(X3_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X3_te[i])==1):
        FP.append(X_test['essay'][i])

#converting array to string as word cloud accepts string as a parameter
string=''.join(str(e) for e in FP)
```

Word Cloud of False positive features

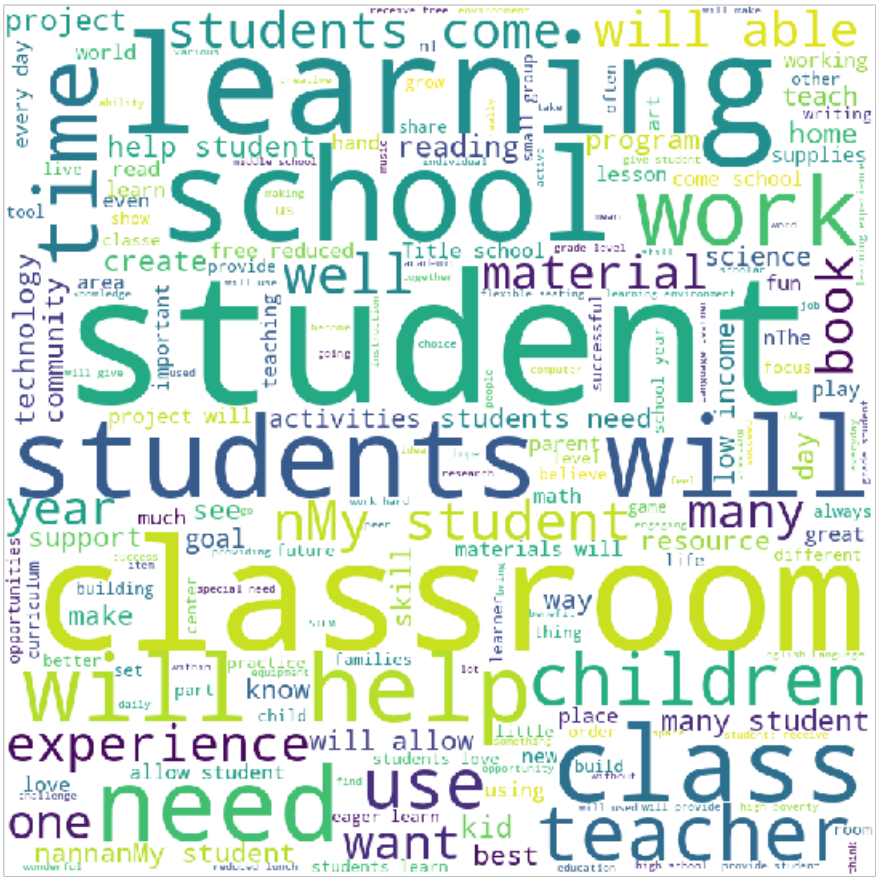
In [94]:

```
# Reference: https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud
wordcloud=WordCloud(width=800,height=800,background_color='white',min_font_size=10).generate(string
)
plt.figure(figsize=(10,10), facecolor=None)
```

```
plt.figure(figsize=(10,10),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
```

Out[94]:

```
(-0.5, 799.5, 799.5, -0.5)
```



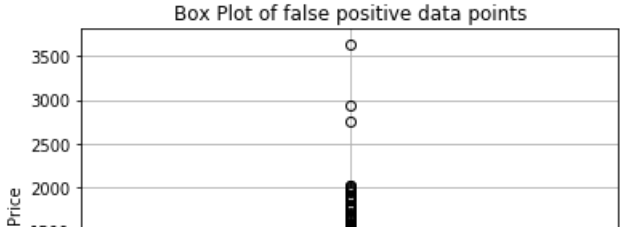
In [95]:

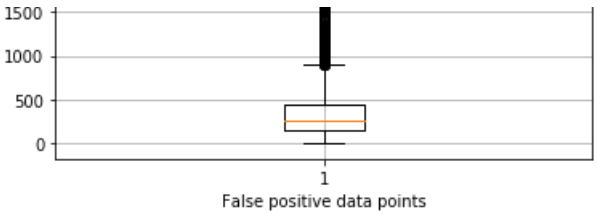
```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives-false-negatives-identified-by-a-conf
price_FP=[]
X3_te=csr_matrix(X3_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X3_te[i])==1):
        price_FP.append(X_test_price_norm[i])
price_FP=np.asarray(price_FP).reshape(-1)
```

Box Plot of False positive features

In [96]:

```
plt.boxplot([price_FP])
plt.title('Box Plot of false positive data points')
plt.xlabel('False positive data points')
plt.ylabel('Price')
plt.grid()
plt.show()
```





The median value lies around 250. And it does not give clear interpretation of the false data points.

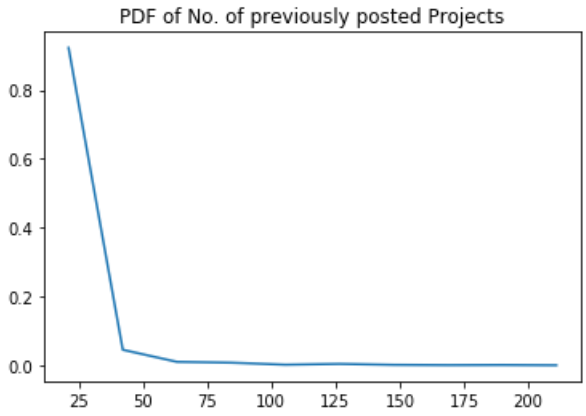
In [97]:

```
#Reference:https://stackoverflow.com/questions/36184432/is-it-possible-to-retrieve-false-positives
-false-negatives-identified-by-a-conf
teacher_FP=[]
X3_te=csr_matrix(X3_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X3_te[i])==1):
        teacher_FP.append(X_test_teacher_norm[i])
teacher_FP=np.asarray(teacher_FP).reshape(-1)
```

PDF of False positive features

In [98]:

```
counts, bin_edges = np.histogram(teacher_FP, bins=10, density = True)
pdf = counts/(sum(counts))

plt.plot(bin_edges[1:],pdf,label='PDF')
plt.title("PDF of No. of previously posted Projects")

plt.show()
```



There is a high probability of no. of previously posted projects at lower values. As the value increases the probablity falls sharply (i.e after 40) and remains constant.

2.6.4 Applying Decision Trees on TFIDF W2V, SET 4

In [56]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt =DecisionTreeClassifier(random_state=0,class_weight="balanced")
parameters = {'max_depth':[1, 5, 10, 50,100,500],'min_samples_split':[5,10,100,500]}
clf = GridSearchCV(dt, parameters, cv=2, scoring='roc_auc')
clf.fit(X4_tr,y_train)

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

```
cv_auc_std= clf.cv_results_['std_test_score']
```

In [57]:

```
clf.best_params_
```

Out[57]:

```
{'max_depth': 5, 'min_samples_split': 500}
```

In [58]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=train_auc, name
= 'Train')
trace2 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=cv_auc, name =
'Cross validation')
data = [trace1, trace2]

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

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

The best value of max depth obtained from the plot is 5 and minimum samples split features is 500.

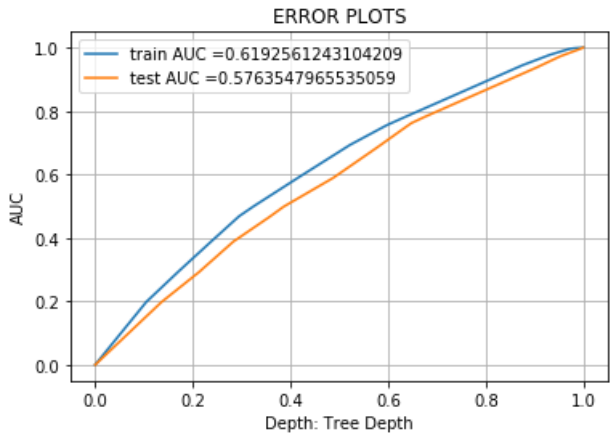
In [102]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
```

```
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [72]:

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

clf = DecisionTreeClassifier(max_depth=5, min_samples_split= 500,random_state=0,class_weight="balan
ced")
clf.fit(X4_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = clf.predict_proba(X4_tr)
preds = y_train_pred[:,1] #code copied from https://stackoverflow.com/questions/25009284/how-to-pl
ot-roc-curve-in-python to remove the error-bad input shape
y_test_pred = clf.predict_proba(X4_te)
preds2=y_test_pred[:,1]


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, preds)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, preds2)

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("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



- Train AUC is 0.6192
- Test AUC is 0.5763 represent the prediction level on the test dataset. In other words if a data point is provided the probabilty of classifying it correctly after the training has been done is 57.63 %.

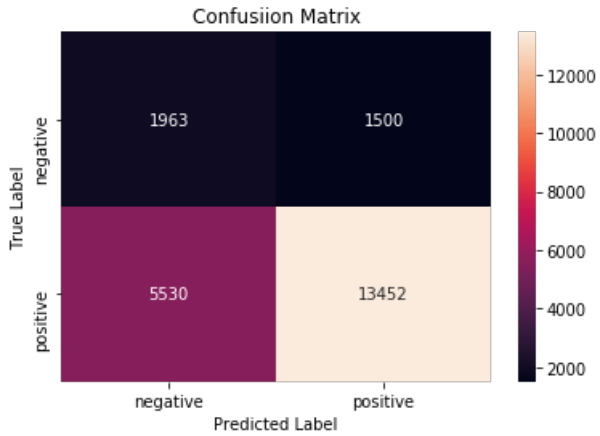
In [104]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
import seaborn as sns
class_label = ["negative", "positive"]

# Reference: https://seaborn.pydata.org/generated/seaborn.heatmap.html
# https://stackoverflow.com/questions/37790429/seaborn-heatmap-using-pandas-dataframe

print("Train confusion matrix")
prediction_y_train=predict(preds, tr_thresholds, train_fpr, train_fpr)
cm=confusion_matrix(y_train, prediction_y_train)
```

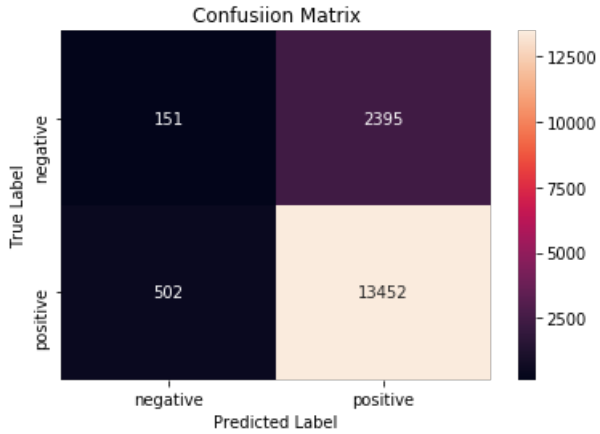
```
df= pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()

print("Test confusion matrix")
prediction_y_test=predict(preds2, tr_thresholds, train_fpr, train_fpr)
cm=confusion_matrix(y_test, prediction_y_test)
df = pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```

==========

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24553113734242166 for threshold 0.807
```




```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24553113734242166 for threshold 0.807
```



In [88]:

```
from scipy.sparse import csr_matrix
FP=[]
X4_te=csr_matrix(X4_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X4_te[i])==1):
        FP.append(X_test['essay'][i])

#converting array to string as word cloud accepts string as a parameter
string=''.join(str(e) for e in FP)
```

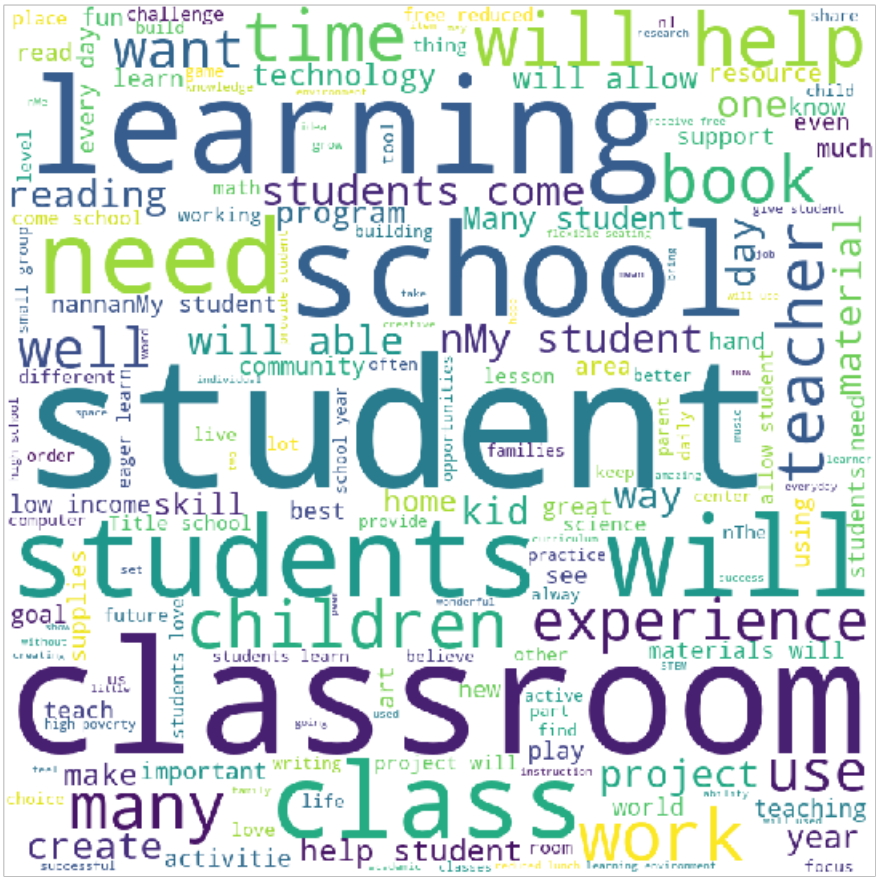
Word Cloud of False positive features

In [89]:

```
# Reference: https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud
wordcloud=WordCloud(width=800,height=800,background_color='white',min_font_size=10).generate(string
)
plt.figure(figsize=(10,10),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
```

Out[89]:

```
(-0.5, 799.5, 799.5, -0.5)
```



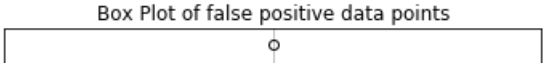
In [90]:

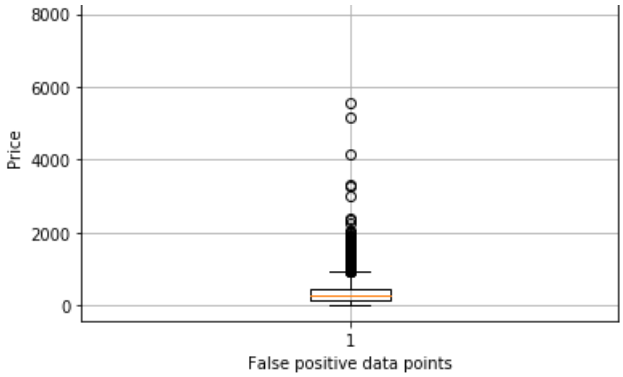
```
price_FP=[]
X4_te=csr_matrix(X4_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X4_te[i])==1):
        price_FP.append(X_test_price_norm[i])
price_FP=np.asarray(price_FP).reshape(-1)
```

Box Plot of False positive features

In [92]:

```
plt.boxplot([price_FP])
plt.title('Box Plot of false positive data points')
plt.xlabel('False positive data points')
plt.ylabel('Price')
plt.grid()
plt.show()
```





The median value lies around 200. And it does not give clear interpretation of the false data points.

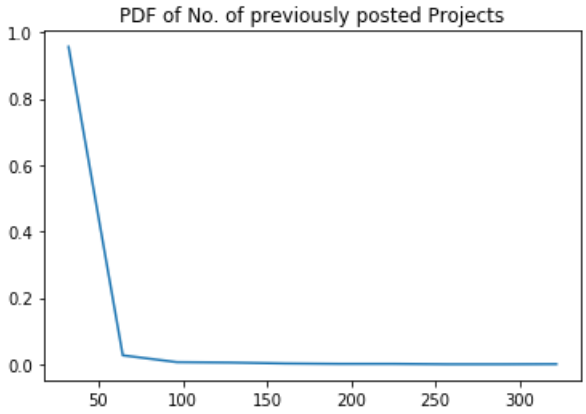
In [93]:

```
teacher_FP=[]
X4_te=csr_matrix(X4_te)
for i in range(16500):
    if(y_test[i]==0 and clf.predict(X4_te[i])==1):
        teacher_FP.append(X_test_teacher_norm[i])
teacher_FP=np.asarray(teacher_FP).reshape(-1)
```

PDF of False positive features

In [94]:

```
counts, bin_edges = np.histogram(teacher_FP, bins=10, density = True)
pdf = counts/(sum(counts))

plt.plot(bin_edges[1:],pdf,label='PDF')
plt.title("PDF of No. of previously posted Projects")

plt.show()
```



There is a high probability of no. of previously posted projects at lower values. As the value increases the probablity falls sharply (i.e after 60) and remains constant.

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

In [77]:

```
#Reference:https://scikit-
learn.org/stable/modules/generated/sklearn.feature_selection.SelectFromModel.html
from sklearn.feature_selection import SelectFromModel
dt =DecisionTreeClassifier(random_state=0,max_depth=10,min_samples_split=500)
dt.fit(X2_tr,y_train)
top5k=SelectFromModel(estimator=dt,max_features=5000,threshold=-np.inf,prefit=True)
X2_tr_new =top5k.transform(X2_tr)
print(X2_tr_new.shape)
```

```
X2_cr_new =top5k.transform(X2_tr)
print(X2_cr_new.shape)
X2_te_new =top5k.transform(X2_te)
print(X2_te_new.shape)
```

```
(22445, 5000)
(22445, 5000)
(16500, 5000)
```

In [83]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier

dt =DecisionTreeClassifier(random_state=0,class_weight="balanced")
parameters = {'max_depth':[1, 5, 10, 50,100,500],'min_samples_split':[5,10,100,500]}
clf = GridSearchCV(dt, parameters, cv=2, scoring='roc_auc')
clf.fit(X2_tr_new,y_train)

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

In [40]:

```
clf.best_params_
```

```
{'max_depth': 10, 'min_samples_split': 50}
```

In [85]:

```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=train_auc, name
= 'Train')
trace2 = go.Scatter3d(x=parameters['max_depth'],y=parameters['min_samples_split'],z=cv_auc, name =
'Cross validation')
data = [trace1, trace2]

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

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

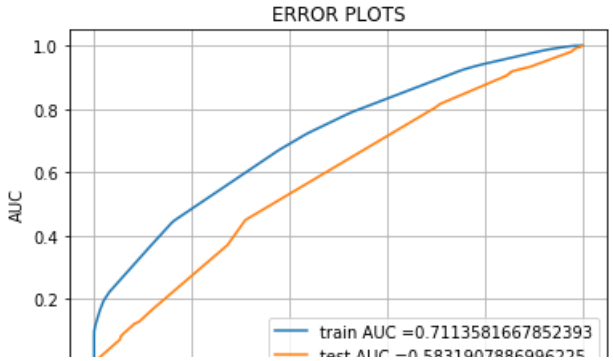
The best value of max depth obtained from the plot is 10 and minimum samples split features is 50.

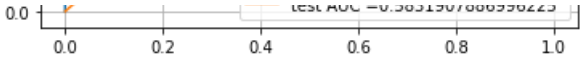
In [86]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

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

In [79]:

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

clf = DecisionTreeClassifier(max_depth=10, min_samples_split=
50,random_state=0,class_weight="balanced",splitter='random')
clf.fit(X2_tr_new, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = clf.predict_proba(X2_tr_new)
preds = y_train_pred[:,1] #code copied from https://stackoverflow.com/questions/25009284/how-to-pl
ot-roc-curve-in-python to remove the error-bad input shape
y_test_pred = clf.predict_proba(X2_te_new)
preds2=y_test_pred[:,1]


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, preds)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, preds2)

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("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



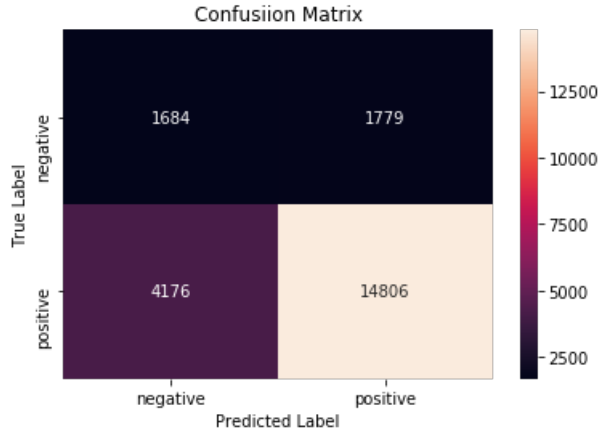


- Train AUC is 0.7113.
- Test AUC is 0.5831 represent the prediction level on the test dataset. In other words if a data point is provided the probabilty of classifying it correctly after the training has been done is 58.31 %.

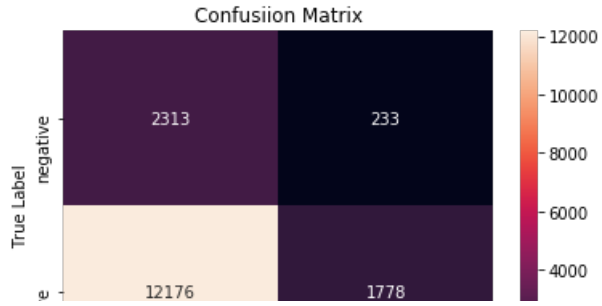
In [80]:

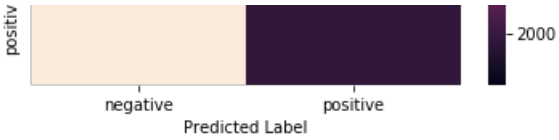
```
print("="*100)
from sklearn.metrics import confusion_matrix
import seaborn as sns
class_label = ["negative", "positive"]

# Reference: https://seaborn.pydata.org/generated/seaborn.heatmap.html
# https://stackoverflow.com/questions/37790429/seaborn-heatmap-using-pandas-dataframe

print("Train confusion matrix")
cm=confusion_matrix(y_train, predict(preds, tr_thresholds, train_fpr, train_fpr))
df= pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()

print("Test confusion matrix")

cm=confusion_matrix(y_test, predict(preds2, tr_thresholds, test_fpr, test_fpr))
df = pd.DataFrame(cm, index = class_label, columns = class_label)
sns.heatmap(df, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24981185952500295 for threshold 0.426
```




```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2147516335715066 for threshold 0.745
```





3. Conclusion

In [41]:

```
# Please compare all your models using Prettytable library
# Reference: http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer",  "Max depth Hyper Parameter","Min features split Hyper Parameter","A
UC"]
x.add_row(["BOW", 10 ,3,0.5898])
x.add_row(["TFIDF",  10,500,0.5747])
x.add_row(["AVG W2V", 5,5,0.5529])
x.add_row(["TFIDF W2V",  5,500,0.5763])
x.add_row(["Best 5k Features", 10,50,0.5831 ])
print(x)
```

```
+------------------+---------------------------+-----------------------------------+--------+
|    Vectorizer    | Max depth Hyper Parameter | Min features split Hyper Parameter |  AUC   |
+------------------+---------------------------+-----------------------------------+--------+
|       BOW        |             10            |                 3                 | 0.5898 |
|      TFIDF       |             10            |                500                | 0.5747 |
|     AVG W2V      |             5             |                 5                 | 0.5529 |
|    TFIDF W2V     |             5             |                500                | 0.5763 |
| Best 5k Features |             10            |                 50                | 0.5831 |
+------------------+---------------------------+-----------------------------------+--------+
```

- In Decision Tree the best value of Hyperparameter 'max_depth' lies between 5 to 10 and 'min_samples_split' lies between 3 -500 according to the observations made with BOW,TFIDF,AVG W2V,TFIDF W2V and best 5k feaqtures.
- Decision Tree with BOW,TFIDF,AVG W2V,TFIDF W2V have almost the same AUC and give almost same results .
- Decision Tree with best 5k features gives AUC of 0.5831 which is comparatively same as compared to other models.
- Thus from the observations made, Decision Tree is not a suitable classifying model for predicting the project is approved or not in this case as it gives prediction rate between 50-60%.