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	Desc
`project_id`	A unique identifier for the proposed project. **Example:** `p0`
`project_title`	Title of the project. **Exa** • `Art Will Make You H` • `First Grad`
`project_grade_category`	Grade level of students for which the project is targeted. One of the fo enumerated v • `Grades P` • `Grade` • `Grade` • `Grades`

Feature	Desc
`project_subject_categories`	One or more (comma-separated) subject categories for the project fr following enumerated list of v • `Applied Lea` • `Care & H` • `Health & S` • `History & C` • `Literacy & Lan` • `Math & Sc` • `Music & The` • `Special` • `W` **Exar** • `Music & The` • `Literacy & Language, Math & Sc`
`school_state`	State where school is located (Two-letter U.S. post: (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_c **Exampl**
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the p **Exar** • `Lit` • `Literature & Writing, Social Sci`
`project_resource_summary`	An explanation of the resources needed for the project. **Exa** • `My students need hands on literacy materials to ma sensory needs!<`
`project_essay_1`	First application
`project_essay_2`	Second application
`project_essay_3`	Third application
`project_essay_4`	Fourth application
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-( 12:43:5`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Ex:** `bdf8baa8fedef6bfeec7ae4ff1c`
`teacher_prefix`	Teacher's title. One of the following enumerated v • • • • • • `Tea`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same te **Examp**

* 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`

Feature	Description
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

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

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

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

Notes on the Essay Data

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

- **project_essay_1:** "Introduce us to your classroom"
- **project_essay_2:** "Tell us more about your students"
- **project_essay_3:** "Describe how your students will use the materials you're requesting"
- **project_essay_3:** "Close by sharing why your project will make a difference"

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

- **project_essay_1:** "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- **project_essay_2:** "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

Out[4]:

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

1.2 preprocessing of `project_subject_categories`

In [5]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

# 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", '
        if 'The' in j.split(): # this will split each of the catogory based on space "Math
            j=j.replace('The','') # if we have the words "The" we are going to replace it w
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math
        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 [6]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

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

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

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

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

1.3 Text preprocessing

In [7]:

```
# 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 [8]:

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

Out[8]:

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

In [9]:

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

In [10]:

```python
# 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)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second
or third languages. We are a melting pot of refugees, immigrants, and native
-born Americans bringing the gift of language to our school. \r\n\r\n We hav
e over 24 languages represented in our English Learner program with 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 a
nd experiences to us that open our eyes to new cultures, beliefs, and respec
t.\"The limits of your language are the limits of your world.\"-Ludwig Wittg
enstein  Our English learner's have a strong support system at home that beg
s for more resources.  Many times our parents are learning to read and speak
English along side of their children.  Sometimes this creates barriers for p
arents to be able to help their child learn phonetics, letter recognition, a
nd other reading skills.\r\n\r\nBy providing these dvd's and players, studen
ts are able to continue their mastery of the English language even if no one
at home is able to assist.  All families with students within the Level 1 pr
oficiency status, will be a offered to be a part of this program.  These edu
cational videos will be specially chosen by the English Learner Teacher and
will be sent home regularly to watch.  The videos are to help the child deve
lop early reading skills.\r\n\r\nParents that do not have access to a dvd pl
ayer will have the opportunity to check out a dvd player to use for the yea
r.  The plan is to use these videos and educational dvd's for the years to c
ome for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year a
ll love learning, at least most of the time. At our school, 97.3% of the stu
dents receive free or reduced price lunch. Of the 560 students, 97.3% are mi
nority students. \r\nThe school has a vibrant community that loves to get to
gether and celebrate. Around Halloween there is a whole school parade to sho
w off the beautiful 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 e
nd of the year the school hosts a carnival to celebrate the hard work put in
during the school year, with a dunk tank being the most popular activity.My
students will use these five brightly colored Hokki stools in place of regul
ar, stationary, 4-legged chairs. As I will only have a total of ten in the c
lassroom and not enough for each student to have an individual one, they wil
l 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 th
em in place of chairs at my small group tables during math and reading time
s. The rest of the day they will be used by the students who need the highes
t 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. Whe
n the students are sitting in group with me on the Hokki Stools, they are al
ways 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 taken. Ther
e are always students who head over to the kidney table to get one of the st
ools 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 comprom
ise that allow my students to do desk work and move at the same time. These
stools will help students to meet their 60 minutes a day of movement by allo
wing them to activate their core muscles for balance while they sit. For man
y of my students, these chairs will take away the barrier that exists in sch
ools for a child who can't sit still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment wit
h 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 cl
ass is made up of 28 wonderfully unique boys and girls of mixed races in Ark
ansas.\r\nThey attend a Title I school, which means there is a high enough p
ercentage of free and reduced-price lunch to qualify. Our school is an \"ope
n classroom\" concept, which is very unique as there are no walls separating
the classrooms. These 9 and 10 year-old students are very eager learners; th
ey are like sponges, absorbing all the information and experiences and keep
on wanting more.With these resources such as the comfy red throw pillows and
the whimsical nautical hanging 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 nauti
cal environment. Creating a classroom environment is very important in the s
uccess 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 pictures of each child with them, hav
e them developed, and then hung in our classroom ready for their first day o
f 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\nYou
r generous donations will help me to help make our classroom a fun, invitin
g, learning environment from day one.\r\n\r\nIt costs lost of money out of m
y own pocket on resources to get our classroom ready. Please consider helpin
g with this project to make our new school year a very successful one. Thank
you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations. \r\n\r\nThe materials we have are the ones I seek out for my stu
dents. I teach in a Title I school where most of the students receive free o
r reduced price lunch.  Despite their disabilities and limitations, my stude
nts love coming to school and come eager to learn and explore.Have you ever
felt like you had ants in your pants and you needed to groove and move as yo
u were in a meeting? This is how my kids feel all the time. The want to be a
ble to move as they learn or so they say.Wobble chairs are the answer and I
love then because they develop their core, which enhances gross motor and in
Turn fine motor skills. \r\nThey also want to learn through games, my kids d
on't want to sit and do worksheets. They want to learn to count by jumping a
nd playing. Physical engagement is the key to our success. The number toss a
nd color and shape mats can make that happen. My students will forget they a
re doing work and just have the fun a 6 year old deserves.nannan
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher
demonstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school
has 803 students which is makeup is 97.6% African-American, making up the la
rgest segment of the student body. A typical school in Dallas is made up of
23.2% African-American students. Most of the students are on free or reduced
lunch. We aren't receiving doctors, lawyers, or engineers children from rich
backgrounds or neighborhoods. As an educator I am inspiring minds of young c
hildren and we focus not only on academics but one smart, effective, efficie
nt, and disciplined students with good character.In our classroom we can uti
lize the Bluetooth for swift transitions during class. I use a speaker which
```

```
doesn't amplify the sound enough to receive the message. Due to the volume o
f my speaker my students can't hear videos or books clearly and it isn't mak
ing the lessons as meaningful. But with the bluetooth speaker my students wi
ll be able to hear and I can stop, pause and replay it at any time.\r\nThe c
art will allow me to have more room for storage of things that are needed fo
r the day and has an extra part to it I can use.  The table top chart has al
l of the letter, words and pictures for students to learn about different le
tters and it is more accessible.nannan
==================================================
```

In [11]:

```
# 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 [12]:

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

```
My kindergarten students have varied disabilities ranging from speech and la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations. \r\n\r\nThe materials we have are the ones I seek out for my stu
dents. I teach in a Title I school where most of the students receive free o
r reduced price lunch.  Despite their disabilities and limitations, my stude
nts love coming to school and come eager to learn and explore.Have you ever
felt like you had ants in your pants and you needed to groove and move as yo
u were in a meeting? This is how my kids feel all the time. The want to be a
ble to move as they learn or so they say.Wobble chairs are the answer and I
love then because they develop their core, which enhances gross motor and in
Turn fine motor skills. \r\nThey also want to learn through games, my kids d
o 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 mats can make that happen. My students will forget they
are doing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [13]:

```
# \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 la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations.     The materials we have are the ones I seek out for my student
s. I teach in a Title I school where most of the students receive free or re
duced price 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 groove and move as you wer
e in a meeting? This is how my kids feel all the time. The want to be able t
o move as they learn or so they say.Wobble chairs are the answer and I love
then because they develop their core, which enhances gross motor and in Turn
fine motor skills.   They also want to learn through games, my kids do not w
ant to sit and do worksheets. They want to learn to count by jumping and pla
ying. Physical engagement is the key to our success. The number toss and col
or and shape mats can make that happen. My students will forget they are doi
ng work and just have the fun a 6 year old deserves.nannan
```

In [14]:

```
#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 la
nguage delays cognitive delays gross fine motor delays to autism They are ea
ger beavers and always strive to work their hardest working past their limit
ations 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 eager to learn and explore Have you ever felt like you had a
nts in your pants and you needed to groove and move as you were in a meeting
This is how my kids feel all the time The want to be able to move as they le
arn or so they say Wobble chairs are the answer and I love then because they
develop their core which enhances gross motor and in Turn fine motor skills
They also want to learn through games my kids do not want to sit and do work
sheets They want to learn to count by jumping and playing Physical engagemen
t is the key to our success The number toss and color and shape mats can mak
e that happen My students will forget they are doing work and just have the
fun a 6 year old deserves nannan
```

In [15]:

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

In [16]:

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

```
100%|██████████| 109248/109248 [01:10<00:00, 1542.37it/s]
```

In [17]:

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

Out[17]:

```
'my kindergarten students varied disabilities ranging speech language delays
cognitive delays gross fine motor delays autism they eager beavers always st
rive work hardest working past limitations the materials ones i seek student
s i teach title i school students receive free reduced price lunch despite d
isabilities limitations students love coming school come eager learn explore
have ever felt like ants pants needed groove move meeting this kids feel tim
e the want able move learn say wobble chairs answer i love develop core enha
nces gross motor turn fine motor skills they also want learn games kids not
want sit worksheets they want learn count jumping playing physical engagemen
t key success the number toss color shape mats make happen my students forge
t work fun 6 year old deserves nannan'
```

1.4 Preprocessing of `project_title`

In [18]:

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

```
100%|██████████| 109248/109248 [00:03<00:00, 34806.81it/s]
```

1.5 Preparing data for models

In [19]:

```
project_data.columns
```

Out[19]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_titl
e',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       '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
```

1.5.1 Vectorizing Categorical data

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

In [20]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, bina
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Music_Arts', 'Literacy_Language', 'AppliedLearning', 'Care_Hunger', 'Speci
alNeeds', 'Warmth', 'History_Civics', 'Math_Science', 'Health_Sports']
Shape of matrix after one hot encodig  (109248, 9)
```

In [21]:

```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False,
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].value
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'Health_Wellness', 'Civics_Government', 'Literature_Writing',
'SpecialNeeds', 'VisualArts', 'NutritionEducation', 'Warmth', 'College_Caree
rPrep', 'EarlyDevelopment', 'History_Geography', 'Health_LifeScience', 'Lite
racy', 'EnvironmentalScience', 'FinancialLiteracy', 'Music', 'PerformingArt
s', 'AppliedSciences', 'Gym_Fitness', 'CharacterEducation', 'SocialScience
s', 'Extracurricular', 'ESL', 'ParentInvolvement', 'Care_Hunger', 'ForeignLa
nguages', 'Other', 'CommunityService', 'TeamSports', 'Mathematics']
Shape of matrix after one hot encodig  (109248, 30)
```

In [22]:

```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [0]:

```
# We are considering only the words which appeared in at least 10 documents(rows or project
vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16623)
```

In [0]:

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

1.5.2.2 TFIDF vectorizer

In [0]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16623)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [0]:

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

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

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

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

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

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

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

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


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickl

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


'''
```

Out[26]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4
```

```
084039\ndef (https://stackoverflow.com/a/38230349/4084039\ndef) loadGloveMod
el(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFil
e,\'r\', encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n
 splitLine = line.split()\n        word = splitLine[0]\n        embedding =
 np.array([float(val) for val in splitLine[1:]])\n        model[word] = embe
dding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmo
del = loadGloveModel(\'glove.42B.300d.txt\')\n\n# ==========================
==\nOutput:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDon
e. 1917495  words loaded!\n\n# ============================\n\nwords = []\nf
or i in preproced_texts:\n    words.extend(i.split(\' \'))\n\nfor i in prepr
oced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the
 coupus", len(words))\nwords = set(words)\nprint("the unique words in the co
upus", len(words))\n\ninter_words = set(model.keys()).intersection(words)\np
rint("The number of words that are present in both glove vectors and our cou
pus",       len(inter_words),"(",np.round(len(inter_words)/len(words)*100,
3),"%)")\n\nwords_courpus = {}\nwords_glove = set(model.keys())\nfor i in wo
rds:\n    if i in words_glove:\n        words_courpus[i] = model[i]\nprint
("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pi
ckle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-
load-variables-in-python/\n\nimport (http://www.jessicayung.com/how-to-use-p
ickle-to-save-and-load-variables-in-python/\n\nimport) pickle\nwith open(\'g
love_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [23]:

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

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████
█| 109248/109248 [00:27<00:00, 3953.36it/s]

109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [0]:

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

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|████████████████████████████████████
█| 109248/109248 [03:22<00:00, 539.44it/s]

109248
300
```

In [0]:

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

1.5.3 Vectorizing Numerical features

In [23]:

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

In [24]:

```
project_data['clean_essay']=preprocessed_essays
project_data['clean_title']=preprocessed_titles
```

In [25]:

```
project_data.columns
```

Out[25]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_titl
e',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'quantit
y',
       'clean_essay', 'clean_title'],
      dtype='object')
```

In [26]:

```
project_data.drop(['Unnamed: 0', 'project_submitted_datetime','project_essay_1','project_es
```

Out[26]:

	teacher_id	teacher_prefix	school_state	project_grade_category	teacher_nur
0	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	Grades PreK-2	
1	897464ce9ddc600bced1151f324dd63a	Mr.	FL	Grades 6-8	
2	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	Grades 6-8	

In [ ]:

In [ ]:

1.5.4 Merging all the above features

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

In [ ]:

```

```

In [27]:

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

In [28]:

```
# please write all the code with proper documentation, and proper titles for each subsectio
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

Computing Sentiment Scores

In [28]:

```
X=project_data['clean_essay'].values
```

In [29]:

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

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

sid = SentimentIntensityAnalyzer()

for_sentiment = X
'''a person is a person no matter how small dr seuss i teach the smallest students with the
for learning my students learn in many different ways using all of our senses and multiple
of techniques to help all my students succeed students in my class come from a variety of d
for wonderful sharing of experiences and cultures including native americans our school is
learners which can be seen through collaborative student project based learning in and out
in my class love to work with hands on materials and have many different opportunities to p
mastered having the social skills to work cooperatively with friends is a crucial aspect of
montana is the perfect place to learn about agriculture and nutrition my students love to r
in the early childhood classroom i have had several kids ask me can we try cooking with rea
and create common core cooking lessons where we learn important math and writing concepts w
food for snack time my students will have a grounded appreciation for the work that went in
of where the ingredients came from as well as how it is healthy for their bodies this proje
nutrition and agricultural cooking recipes by having us peel our own apples to make homemad
and mix up healthy plants from our classroom garden in the spring we will also create our c
shared with families students will gain math and literature skills as well as a life long e
nannan'''
NEG=[]
NEU=[]
POS=[]
COMP=[]
s={}
h=[]
for i in for_sentiment:

    ss = sid.polarity_scores(i)

    for k in ss:
        s={k:ss[k]}

        h.append(s)

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

In [30]:

```
g=pd.DataFrame(h)
print(g.head(5))
```

```
   compound    neg    neu    pos
0    0.9694    NaN    NaN    NaN
1       NaN    NaN  0.844    NaN
2       NaN    NaN    NaN  0.144
3       NaN  0.012    NaN    NaN
4    0.9856    NaN    NaN    NaN
```

In [31]:

```
compound=list(g['compound'].dropna())
#print(compound)
pos=list(g['pos'].dropna())
#print(pos)
neu=list(g['neu'].dropna())
#print(neu)
neg=list(g['neg'].dropna())
#print(neg)
```

In [32]:

```
q={'pos':pos,'neg':neg,'compound':compound,'neu':neu}
```

In [33]:

```
q=pd.DataFrame(q)
print(q.head(10))
```

```
   compound    neg    neu    pos
0    0.9694  0.012  0.844  0.144
1    0.9856  0.048  0.669  0.283
2    0.9816  0.122  0.659  0.219
3    0.9656  0.106  0.649  0.246
4    0.8524  0.066  0.791  0.143
5    0.9776  0.111  0.647  0.242
6    0.9743  0.079  0.680  0.241
7    0.9891  0.011  0.768  0.222
8    0.9975  0.009  0.630  0.361
9    0.9893  0.105  0.559  0.336
```

In [34]:

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

In [31]:

```
project_data.columns
```

Out[31]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_titl
e',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'quantity', 'pric
e',
       'clean_essay', 'clean_title'],
      dtype='object')
```

Assignment 8: DT

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

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

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

    - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Graphviz**

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

4. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
      Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
      Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points

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

5. **[Task-2]**

    - Select 5k best features from features of Set 2 using `feature_importances_` (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

6. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link (http://zetcode.com/python/prettytable/)

2. Decision Tree

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

In [31]:

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

In [32]:

```
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)
```

In [33]:

```
print("="*100)

print("train=>",X_train.shape, y_train.shape)

print("test=>",X_test.shape, y_test.shape)

print("="*100)
```

```
============================================================================
========================
train=> (73196, 22) (73196,)
test=> (36052, 22) (36052,)
============================================================================
========================
```

2.2 Make Data Model Ready: encoding numerical, categorical features

numerical

In [34]:

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

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

from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

normalizer.fit(X_train['price'].values.reshape(-1,1)) # use code from sample

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

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

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)

print(X_test_price_norm.shape, y_test.shape)

print("="*100)
```

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

In [35]:

```
'''encode numerical feature teacher_number_of_previously_posted_projects'''

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

X_train_posted_norm= normalizer.transform(X_train['teacher_number_of_previously_posted_proj

X_test_posted_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_proje

print("After vectorizations")
print(X_train_posted_norm.shape, y_train.shape)

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

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

In [37]:

```
'''encode numerical feature compound from sentimental'''
```

Out[37]:

```
'encode numerical feature compound from sentimental'
```

In [42]:

```
'''encode numerical feature pos from sentimental'''

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

X_train_pos_norm= normalizer.transform(X_train['pos'].values.reshape(-1,1))

X_test_pos_norm = normalizer.transform(X_test['pos'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_pos_norm.shape, y_train.shape)

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

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

In [43]:

```
'''encode numerical feature neg from sentimental'''

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

X_train_neg_norm= normalizer.transform(X_train['neg'].values.reshape(-1,1))

X_test_neg_norm = normalizer.transform(X_test['neg'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_neg_norm.shape, y_train.shape)

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

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

In [44]:

```
'''encode numerical feature neu from sentimental'''

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

X_train_neu_norm= normalizer.transform(X_train['neu'].values.reshape(-1,1))

X_test_neu_norm = normalizer.transform(X_test['neu'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_neu_norm.shape, y_train.shape)

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

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

In [45]:

```
'''encode numerical feature quantity from sentimental'''

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

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

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

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)

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

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

In [46]:

```
#How to calculate number of words in a string in DataFrame: https://stackoverflow.com/a/374
'''count no of words in titles'''
title_word_count_train = X_train['clean_title'].str.split().apply(len)
title_word_count_train = title_word_count_train.values



title_word_count_test = X_test['clean_title'].str.split().apply(len)
title_word_count_test =title_word_count_test.values
```

In [47]:

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

X_train_title_norm= normalizer.transform(title_word_count_train.reshape(-1,1))

X_test_title_norm = normalizer.transform(title_word_count_test.reshape(-1,1))

print("After vectorizations")
print(X_train_title_norm.shape, y_train.shape)

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

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

In [48]:

```
#How to calculate number of words in a string in DataFrame: https://stackoverflow.com/a/374
'''count no of words in essays'''
essay_word_count_train = X_train['clean_essay'].str.split().apply(len)
essay_word_count_train = essay_word_count_train.values



essay_word_count_test = X_test['clean_essay'].str.split().apply(len)
essay_word_count_test =essay_word_count_test.values
```

In [49]:

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

X_train_essay_norm= normalizer.transform(essay_word_count_train.reshape(-1,1))

X_test_essay_norm = normalizer.transform(essay_word_count_test.reshape(-1,1))

print("After vectorizations")
print(X_train_essay_norm.shape, y_train.shape)

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

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
============================================================================
========================
<class 'numpy.ndarray'>
```

categorical features

In [38]:

```
'''encoding project grade'''
from collections import Counter
my_counter = Counter()
for word in project_data['project_grade_category'].values:
    my_counter.update(word.split(","))

grade_dict = dict(my_counter)
grade_dict = dict(sorted(grade_dict.items(), key=lambda kv: kv[1]))
vectorizer_1 = CountVectorizer(vocabulary=list(grade_dict.keys()), lowercase=False, binary=
vectorizer_1.fit(X_train['project_grade_category'].values) # fit has to happen only on trai



# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_1.transform(X_train['project_grade_category'].values.astype(
#https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-valueerror-np
X_test_grade_ohe = vectorizer_1.transform(X_test['project_grade_category'].values.astype('U

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)

print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer_1.get_feature_names())
print("="*100)
```

```
After vectorizations
(73196, 4) (73196,)
(36052, 4) (36052,)
['Grades 3-5', 'Grades PreK-2', 'Grades 6-8', 'Grades 9-12']
============================================================================
========================
```

In [39]:

```
'''teacher_prefix
'''

for i in project_data['teacher_prefix'].values:

    if i=='nan':
        i='nan'

```

In [40]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(" ")# to handle nan

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

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

vectorizer = CountVectorizer(vocabulary=list(prefix.keys()), lowercase=False, binary=True)
prefix_one_hot = vectorizer.fit_transform(project_data['teacher_prefix'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",prefix_one_hot.shape)
```

```
['Dr.', 'Teacher', 'Ms.', 'Mr.', 'Mrs.']
Shape of matrix after one hot encodig  (109248, 5)
```

In [41]:

```
X_train['teacher_prefix'] = X_train['teacher_prefix'].fillna("")
X_test['teacher_prefix'] = X_test['teacher_prefix'].fillna("")
```

In [42]:

```
'''encode categorical feature teacher_prefix'''
'''encode categorical feature teacher_prefix'''
vectorizer_2 = CountVectorizer(vocabulary=list(prefix.keys()), lowercase=False, binary=True
vectorizer_2.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_2.transform(X_train['teacher_prefix'].values.astype('U'))
#https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-valueerror-np
X_test_teacher_ohe = vectorizer_2.transform(X_test['teacher_prefix'].values.astype('U'))

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)

print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer_2.get_feature_names()[1])
print("="*100)
```

```
After vectorizations
(73196, 5) (73196,)
(36052, 5) (36052,)
Teacher
============================================================================
========================
```

In [43]:

```
'''encode categorical feature school_state'''


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

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

vectorizer_3 = CountVectorizer(vocabulary=list(state_dict.keys()), lowercase=False, binary=
vectorizer_3.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_3.transform(X_train['school_state'].values)

X_test_state_ohe = vectorizer_3.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)

print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer_3.get_feature_names()[2])
print("="*100)
```

```
After vectorizations
(73196, 51) (73196,)
(36052, 51) (36052,)
IL
============================================================================
========================
```

In [44]:

```
'''clean categories'''
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_4 = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, bi
vectorizer_4.fit(X_train['clean_categories'].values)
#print(vectorizer.get_feature_names())
 # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_cate_ohe = vectorizer_4.transform(X_train['clean_categories'].values)

X_test_clean_cate_ohe = vectorizer_4.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_clean_cate_ohe.shape, y_train.shape)

print(X_test_clean_cate_ohe.shape, y_test.shape)
print(vectorizer_4.get_feature_names())
print("="*100)
```

```
After vectorizations
(73196, 9) (73196,)
(36052, 9) (36052,)
['Music_Arts', 'Literacy_Language', 'AppliedLearning', 'Care_Hunger', 'Speci
alNeeds', 'Warmth', 'History_Civics', 'Math_Science', 'Health_Sports']
============================================================================
========================
```

In [45]:

```
'''clean sub categories'''
vectorizer_5 = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False
vectorizer_5.fit(X_train['clean_subcategories'].values)
# we use the fitted CountVectorizer to convert the text to vector



X_train_subclean_cate_ohe = vectorizer_5.transform(X_train['clean_subcategories'].values)

X_test_subclean_cate_ohe = vectorizer_5.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subclean_cate_ohe.shape, y_train.shape)

print(X_test_subclean_cate_ohe.shape, y_test.shape)
print(vectorizer_5.get_feature_names())
print("="*100)
```

```
After vectorizations
(73196, 30) (73196,)
(36052, 30) (36052,)
['Economics', 'Health_Wellness', 'Civics_Government', 'Literature_Writing',
'SpecialNeeds', 'VisualArts', 'NutritionEducation', 'Warmth', 'College_Caree
rPrep', 'EarlyDevelopment', 'History_Geography', 'Health_LifeScience', 'Lite
racy', 'EnvironmentalScience', 'FinancialLiteracy', 'Music', 'PerformingArt
s', 'AppliedSciences', 'Gym_Fitness', 'CharacterEducation', 'SocialScience
s', 'Extracurricular', 'ESL', 'ParentInvolvement', 'Care_Hunger', 'ForeignLa
nguages', 'Other', 'CommunityService', 'TeamSports', 'Mathematics']
============================================================================
========================
```

In [ ]:

In [ ]:

2.3 Make Data Model Ready: encoding eassay, and project_title

bow

In [45]:

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

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

'''encoding essays in bow'''
#code is taken from this notebook

vectorizer_6 = CountVectorizer(min_df=10)
vectorizer_6.fit(X_train['clean_essay'].values)# fit is for train

X_train_essay_bow = vectorizer_6.transform(X_train['clean_essay'].values)# for train

X_test_essay_bow = vectorizer_6.transform(X_test['clean_essay'].values)#for test

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)

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

```
After vectorizations
(73196, 14271) (73196,)
(36052, 14271) (36052,)
============================================================================
========================
```

In [46]:

```
'''encode titles bow'''
vectorizer_7 = CountVectorizer(min_df=10)
vectorizer_7.fit(X_train['clean_title'].values)# fit for train

# transform for all
X_train_titles_bow = vectorizer_7.transform(X_train['clean_title'].values)

X_test_titles_bow = vectorizer_7.transform(X_test['clean_title'].values)

print("After vectorizations")
print(X_train_titles_bow.shape, y_train.shape)

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

```
After vectorizations
(73196, 2652) (73196,)
(36052, 2652) (36052,)
============================================================================
========================
```

tfidf

In [46]:

```
# Please write all the code with proper documentation
'''tfidf_titles'''
vectorizer_8 = TfidfVectorizer(min_df=10)
vectorizer_8.fit(X_train['clean_title'].values)# fit for train

# transform for all
X_train_titles_tfidf= vectorizer_8.transform(X_train['clean_title'].values)

X_test_titles_tfidf = vectorizer_8.transform(X_test['clean_title'].values)

print("After vectorizations")
print(X_train_titles_tfidf.shape, y_train.shape)

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

```
After vectorizations
(73196, 2633) (73196,)
(36052, 2633) (36052,)
============================================================================
========================
```

In [47]:

```
'''tfidf_essay'''
vectorizer_9 = TfidfVectorizer(min_df=10)
vectorizer_9.fit(X_train['clean_essay'].values)# fit for train

# transform for all
X_train_essay_tfidf= vectorizer_9.transform(X_train['clean_essay'].values)

X_test_essay_tfidf = vectorizer_9.transform(X_test['clean_essay'].values)

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)

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

```
After vectorizations
(73196, 14312) (73196,)
(36052, 14312) (36052,)
============================================================================
========================
```

average word to vector

In [49]:

```
'''average word to vector train essay '''
avg_w2v_vectors_trainessay = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_train['clean_essay']): # 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_trainessay.append(vector)

print(len(avg_w2v_vectors_trainessay))
print(len(avg_w2v_vectors_trainessay[0]))
```

```
100%|██████████| 73196/73196 [00:24<00:00, 2973.71it/s]

73196
300
```

In [50]:

```
'''average word to vector train title'''
avg_w2v_vectors_traintitle = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_train['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_traintitle.append(vector)

print(len(avg_w2v_vectors_traintitle))
print(len(avg_w2v_vectors_traintitle[0]))
```

```
100%|██████████| 73196/73196 [00:01<00:00, 46491.15it/s]

73196
300
```

In [51]:

```
'''average word to vector test essay'''
avg_w2v_vectors_testessay = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm(X_test['clean_essay']): # 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_testessay.append(vector)

print(len(avg_w2v_vectors_testessay))
print(len(avg_w2v_vectors_testessay[0]))
```

```
100%|██████████| 36052/36052 [00:12<00:00, 2929.14it/s]

36052
300
```

In [52]:

```
'''average word to vector test titles'''
avg_w2v_vectors_testtitle = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm(X_test['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_testtitle.append(vector)

print(len(avg_w2v_vectors_testtitle))
print(len(avg_w2v_vectors_testtitle[0]))
```

```
100%|██████████| 36052/36052 [00:00<00:00, 38702.73it/s]

36052
300
```

tfidf word to vector

In [53]:

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

In [54]:

```
# compute average word2vec for each review.
'''train titles'''
tfidf_w2v_vectors_title_tr = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_train['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            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_title_tr.append(vector)

print(len(tfidf_w2v_vectors_title_tr))
print(len(tfidf_w2v_vectors_title_tr[0]))
```

```
100%|██████████| 73196/73196 [00:03<00:00, 21693.74it/s]

73196
300
```

In [55]:

```
'''test titles'''
tfidf_w2v_vectors_title_te = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_test['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            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_title_te.append(vector)
```

```
100%|██████████| 36052/36052 [00:01<00:00, 24000.92it/s]
```

In [56]:

```
'''essay'''
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_essay'])
# 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
'''train essay'''
# compute average word2vec for each review.
tfidf_w2v_vectors_essay_tr = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_train['clean_essay']): # 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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            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_essay_tr.append(vector)

print(len(tfidf_w2v_vectors_essay_tr))
print(len(tfidf_w2v_vectors_essay_tr[0]))
```

```
100%|██████████| 73196/73196 [02:24<00:00, 508.16it/s]

73196
300
```

In [58]:

```
# average Word2Vec
'''test essay'''
# compute average word2vec for each review.
tfidf_w2v_vectors_essay_te = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm(X_test['clean_essay']): # 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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            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_essay_te.append(vector)

print(len(tfidf_w2v_vectors_essay_te))
print(len(tfidf_w2v_vectors_essay_te[0]))
```

```
100%|██████████| 36052/36052 [01:10<00:00, 512.55it/s]

36052
300
```

In [ ]:

```

```

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

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

In [59]:

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

2.4.1 Applying Decision Trees on BOW, SET 1

In [60]:

```
# Please write all the code with proper documentation
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
#merge all features
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tfidf, X_train_state_ohe, X_train_teacher_ohe, X_train_grade_c

X_te = hstack((X_test_essay_tfidf, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe,

print("Final Data matrix")
print("train matrix=>",X_tr.shape, y_train.shape)

print("test matrix=>",X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
train matrix=> (73196, 17024) (73196,)
test matrix=> (36052, 17024) (36052,)
============================================================================
========================
```

In [52]:

```

from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV

from sklearn.tree import DecisionTreeClassifier
```

In [ ]:

```

```

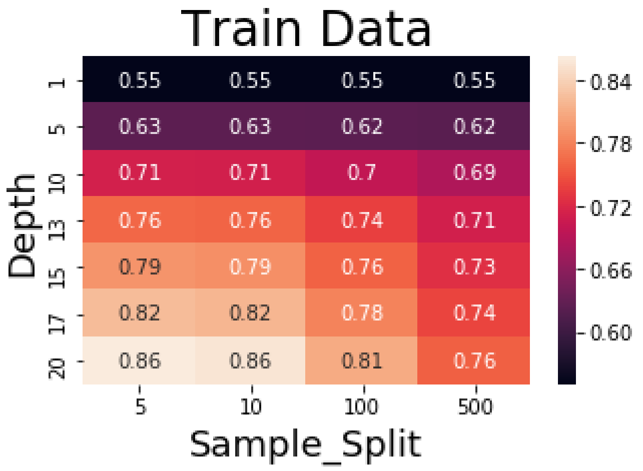
In [50]:

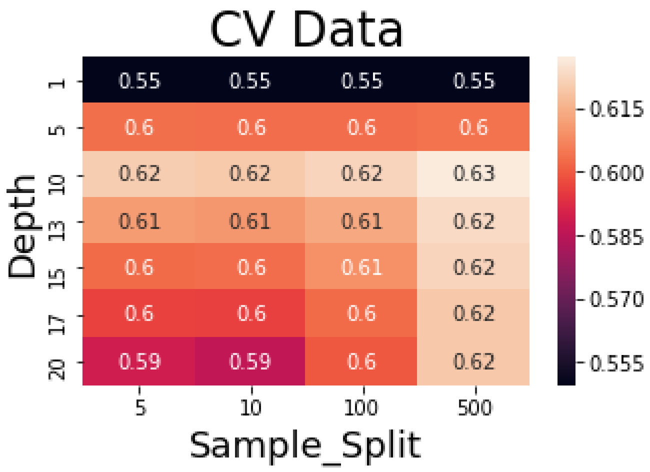
```
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
def gd(X_tr,X_te):

    depth = [1, 5,10,13,15,17,20]
    sample_split = [5, 10, 100, 500]

    tuned_parameters = {'max_depth': depth,'min_samples_split':sample_split}

    dc= DecisionTreeClassifier(class_weight='balanced')

    clf_1 = GridSearchCV(dc, tuned_parameters, cv=3, scoring='roc_auc',verbose=1,n_jobs = -
    clf_1.fit(X_tr, y_train)

    train_auc= clf_1.cv_results_['mean_train_score']

    cv_auc = clf_1.cv_results_['mean_test_score']





    # test AUC
    print("L1+++++++++++++++")
    print(clf_1.score(X_te, y_test))
    print(clf_1.best_estimator_)# to know best parameters
    depth_opt, split_opt = clf_1.best_params_.get('max_depth'), clf_1.best_params_.get('mir
    print(depth_opt)
    print(split_opt)
 #how to draw heatmap
 #https://seaborn.pydata.org/generated/seaborn.heatmap.html
    #https://github.com/omkar1610/Amazon-Fine-Food-Reviews/blob/master/08%20Amazon%20Fine%2

    df_heatmap = pd. DataFrame(train_auc. reshape(7, 4), index=depth, columns=sample_split
    fig = plt. figure(figsize=(5, 3))
    heatmap = sns. heatmap(df_heatmap, annot=True)
    plt. ylabel('Depth' , size=18)
    plt. xlabel('Sample_Split' , size=18)
    plt. title("Train Data", size=24)
    plt. show()

    df_heatmap = pd. DataFrame(cv_auc. reshape(7, 4), index=depth, columns=sample_split )
    fig = plt. figure(figsize=(5, 3))
    heatmap = sns. heatmap(df_heatmap, annot=True)
    plt. ylabel('Depth' , size=18)
    plt. xlabel('Sample_Split' , size=18)
    plt. title("CV Data", size=24)
    plt. show()
```

In [63]:

```
gd(X_tr,X_te)
```

```
Fitting 3 folds for each of 28 candidates, totalling 84 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:  2.1min
[Parallel(n_jobs=-1)]: Done  84 out of  84 | elapsed:  7.7min finished

L1+++++++++++++++
0.6234644800046839
DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=10, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
10
500
```





- AUC BOW=0.6234644800046839
- max_depth=10
- min_sample_split=500

In [64]:

```
#test phase
# TEST PHASE FOR L1
dc=DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=10, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
dc.fit(X_tr,y_train)
pred = dc.predict(X_te)
acc = accuracy_score(y_test, pred, normalize=True)*float(100)

print('\n****Test accuracy  is %f%%' % (acc))
```

```

****Test accuracy  is 69.202818%
```

In [65]:

```
#other measuring parameters
from sklearn.metrics import classification_report
print("classification_report")
print(classification_report(y_test, pred))
```

```
classification_report
              precision    recall  f1-score   support

           0       0.23      0.44      0.30      5459
           1       0.88      0.74      0.80     30593

   micro avg       0.69      0.69      0.69     36052
   macro avg       0.55      0.59      0.55     36052
weighted avg       0.78      0.69      0.73     36052

```

In [66]:

```
pred_proba_te=dc.predict_proba(X_te)
pred_proba_te   = pred_proba_te[:, 1]

pred_proba_tr=dc.predict_proba(X_tr)
pred_proba_tr   = pred_proba_tr[:, 1]
```

In [67]:

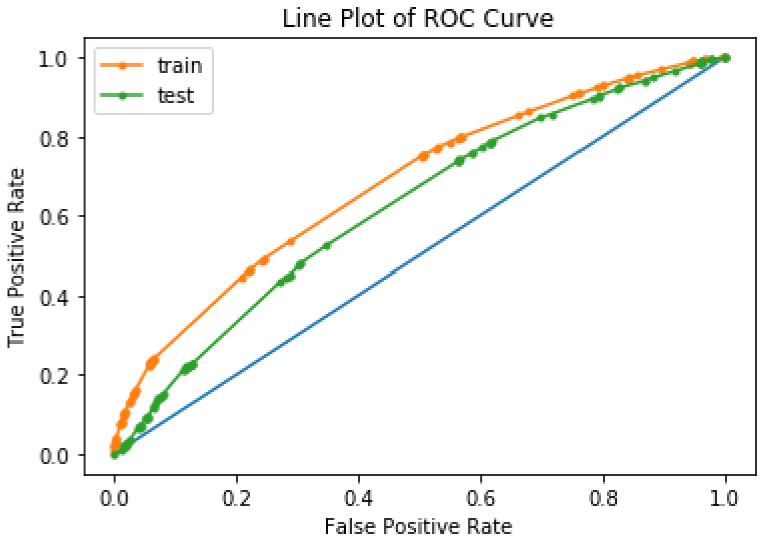
```
fpr, tpr, thresholds = roc_curve(y_test,pred_proba_te )
a=fpr
b=tpr
c=thresholds
```

In [68]:

```
fpr, tpr, thresholds = roc_curve(y_train,pred_proba_tr )
```

In [69]:

```
#PLOT OF ROC
    # plot no skill
plt.plot([0, 1], [0, 1])
    # plot the roc curve for the model
plt.plot(fpr, tpr, marker='.',label="train")
plt.plot(a,b, marker='.',label='test')
    #plt.plot(k,pred_cv)
plt.title("Line Plot of ROC Curve")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend()
plt.show()
```



In [70]:

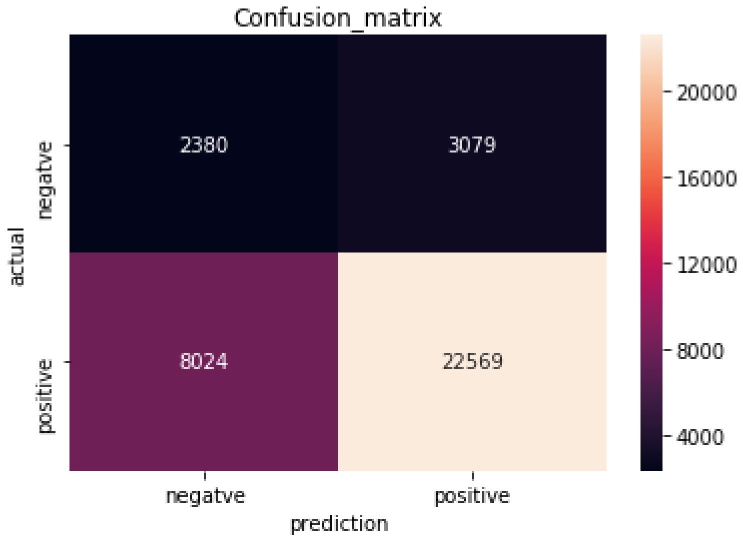
```
#confusion matrices
#https://pandas-ml.readthedocs.io/en/latest/conf_mat.html
con_matrix=confusion_matrix(y_test, pred)
class_label=['negatve','positive']
df=pd.DataFrame(con_matrix,index=class_label,columns=class_label)
df
```

Out[70]:

	negatve	positive
negatve	2380	3079
positive	8024	22569

In [71]:

```
# how can i plot confusion matrix //https://stackoverflow.com/questions/35572000/how-can-i-
sns.heatmap(df,annot=True,fmt='d')
plt.title('Confusion_matrix')
plt.xlabel("prediction")
plt.ylabel("actual")
plt.show()
```



- TN=2380
- FP=3079
- FN=8024
- TP=22569

In [72]:

```
pred
```

Out[72]:

```
array([1, 1, 0, ..., 1, 1, 0])
```

In [ ]:

In [73]:

```
# creating dataframe for y_test
y_Test=pd.DataFrame(y_test)
```

In [74]:

```
y_Test.head()
```

Out[74]:

```
        project_is_approved
106400                    1
 42717                    1
 55693                    0
 78466                    1
 36382                    1
```

In [83]:

```

```

In [84]:

```
# add pred values in that dataframe
y_Test["pred"]=pred
```

In [85]:

```

y_Test.head()
```

Out[85]:

```
        project_is_approved  pred
106400                    1     1
 42717                    1     1
 55693                    0     0
 78466                    1     1
 36382                    1     1
```

In [100]:

```
# selecting rows which are actually false
g=y_Test[y_Test['project_is_approved']==0]
```

In [102]:

```
# now select rows which are correctly pred from all actual false
h=g[g['pred']==1]

```

In [110]:

```
h.head()
```

Out[110]:

	project_is_approved	pred
84111	0	1
74779	0	1
27622	0	1
45146	0	1
56477	0	1

In [106]:

```
# getting index of all fp points
k=h.index
```

In [108]:

```
index_fp=list(k)
```

In [151]:

```
len(index_fp)
```

Out[151]:

```
3079
```

In [113]:

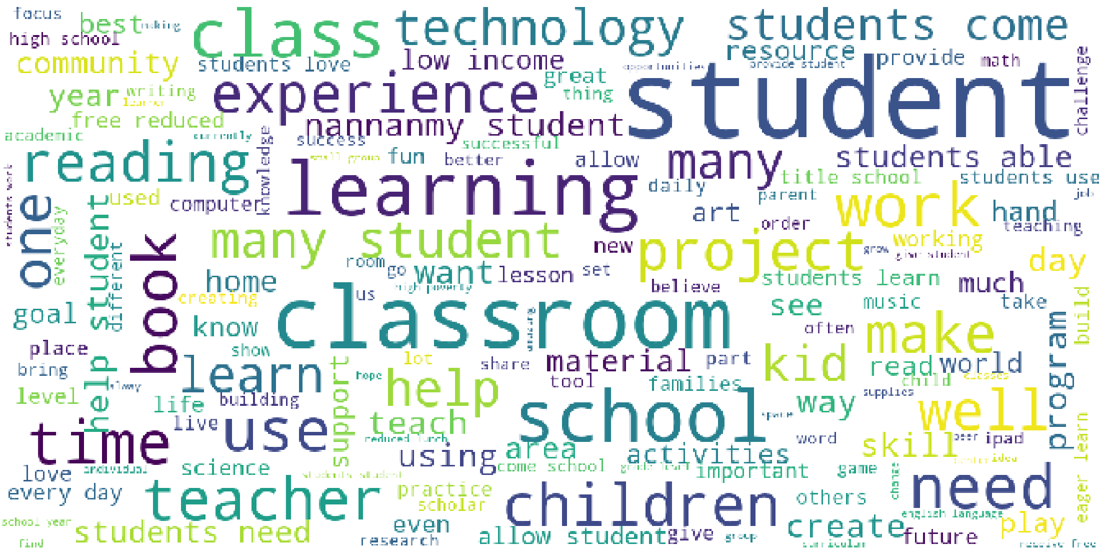
```

t=""

for i in index_fp:
    '''concat all the features'''

    t=t+X.loc[i,"clean_essay"]
    #print( vectorizer_7.get_feature_names()[i])
```

In [114]:

```
# how to plot word cloud
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
#https://stackoverflow.com/questions/342687/algorithm-to-implement-a-word-cloud-like-wordle
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
stopwords = set(STOPWORDS)

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()
```

In [115]:

```
show_wordcloud(t)
```



In [143]:

```
X.columns
```

Out[143]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_titl
e',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'quantity', 'pric
e',
       'clean_essay', 'clean_title'],
      dtype='object')
```

In [237]:

```
price=[]
clas=[]
prev=[]
for i in index_fp:
    clas.append(y_Test.loc[i,'pred'])
    '''concat all the features'''
    price.append(X.loc[i,"price"])
    prev.append(X.loc[i,"teacher_number_of_previously_posted_projects"])
```

In [238]:

```
cd=pd.DataFrame(columns=['price','prev','clas'])
```

In [241]:

```
cd['price']=price
cd['prev']=prev
cd['clas']=clas
```

In [242]:

```
cd.head()
```

Out[242]:

	price	prev	clas
0	185.40	0	1
1	129.99	14	1
2	377.61	2	1
3	208.00	0	1
4	975.78	5	1

In [219]:

```
y_test.head()
```

Out[219]:

```
106400    1
42717     1
55693     0
78466     1
36382     1
Name: project_is_approved, dtype: int64
```

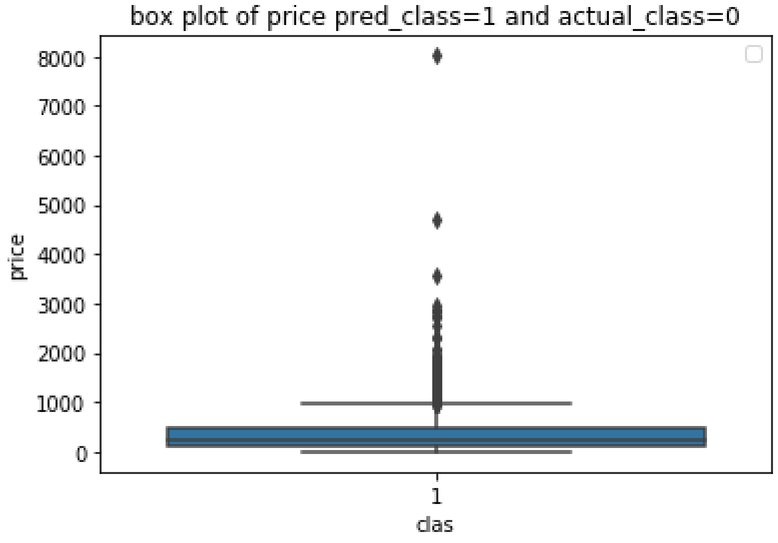
In [209]:

```
approved_price_proj = cd['price']
```

In [259]:

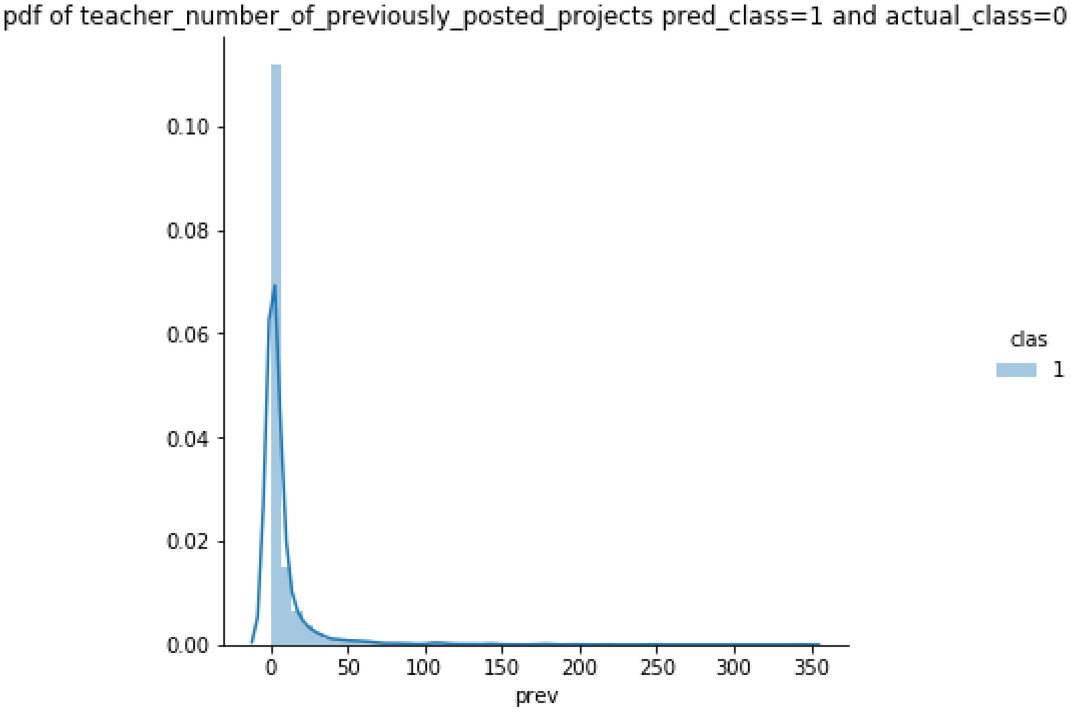
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
import seaborn as sns

sns.boxplot(x='clas',y='price', data=cd)


plt.title("box plot of price pred_class=1 and actual_class=0")
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



In [260]:

```
#pdf
sns.FacetGrid(cd, hue="clas", size=5) \
   .map(sns.distplot, "prev") \
   .add_legend();
plt.title("pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_clas
plt.show();
```



2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [124]:

```
#collecting names of all features
L1=list(vectorizer_1.get_feature_names())
L2=list(vectorizer_2.get_feature_names())
L3=list(vectorizer_3.get_feature_names())
L4=list(vectorizer_4.get_feature_names())
L5=list(vectorizer_5.get_feature_names())
L6=list(vectorizer_6.get_feature_names())
L7=list(vectorizer_7.get_feature_names())
```

In [140]:

```
K=list(vectorizer_7.get_feature_names())
```

In [125]:

```
A=L1+L2+L3+L4+L5+L6+L7
```

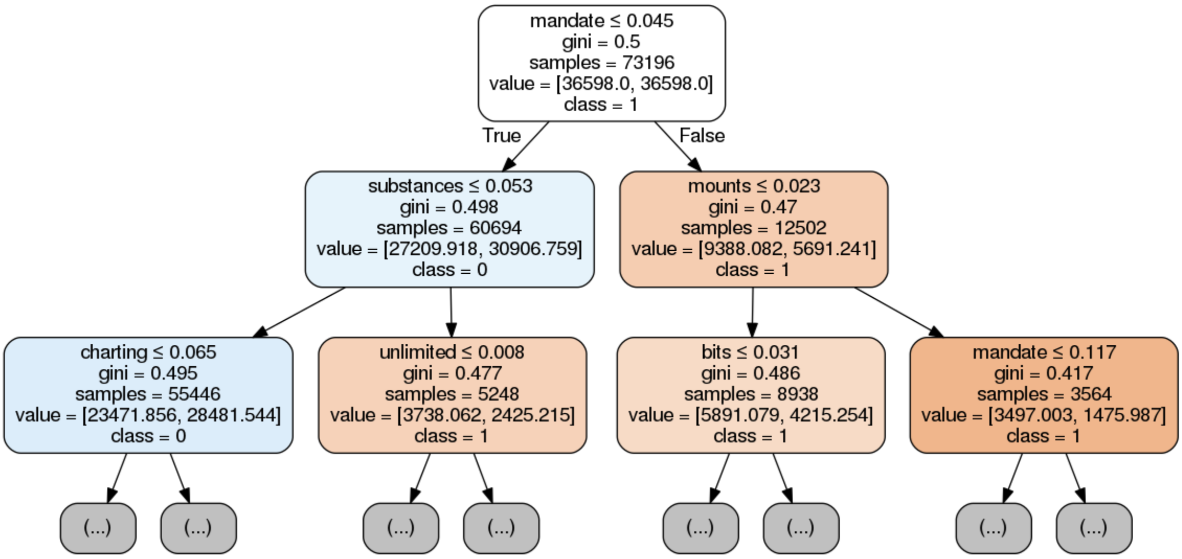
In [126]:

```
A.append("price")

A.append("prev_proposed_projects")
```

In [142]:

```
# what is graphiviz and how to plot it
# https://github.com/scikit-learn/scikit-learn/issues/9952
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
import graphviz
from sklearn import tree
from sklearn import tree
import pydotplus
from IPython.display import Image
from IPython.display import SVG
from graphviz import Source
from IPython.display import display

target = ['1','0']
# Create DOT data
data = tree.export_graphviz(dc,out_file=None,class_names=target,filled=True,rounded=True,sp

# Draw graph
graph = pydotplus.graph_from_dot_data(data)
#graph = Source(data)

# Show graph
Image(graph.create_png())
#display(SVG(graph.pipe(format='svg'))))
```

Out[142]:



In [ ]:

```

```

In [0]:

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

2.4.2 Applying Decision Trees on TFIDF, SET 2

In [48]:

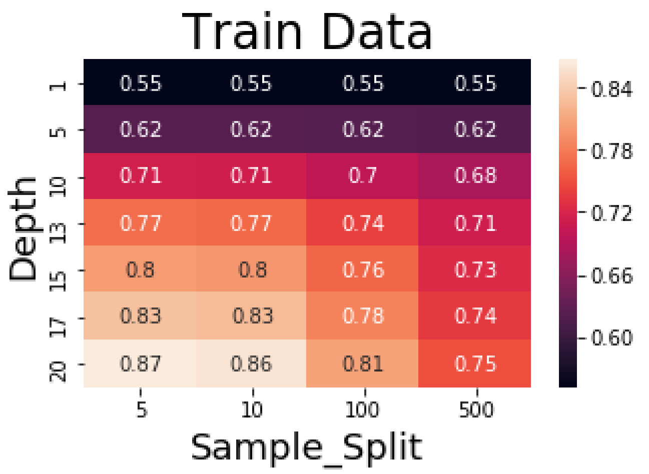
```
# Please write all the code with proper documentation
#merging
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tfidf, X_train_state_ohe, X_train_teacher_ohe, X_train_grade_c
#X_cr = hstack((X_cv_essay_tfidf, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, X_cv_pr
X_te = hstack((X_test_essay_tfidf, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe,

print("Final Data matrix")
print("train matrix=>",X_tr.shape, y_train.shape)

print("test matrix=>",X_te.shape, y_test.shape)
print("="*100)
```

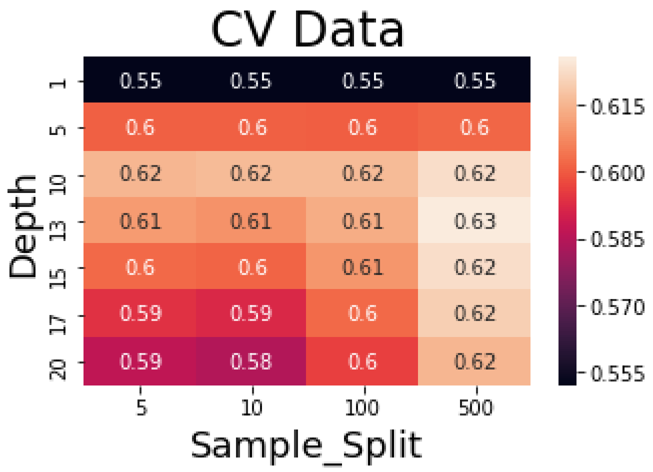
```
Final Data matrix
train matrix=> (73196, 17046) (73196,)
test matrix=> (36052, 17046) (36052,)
============================================================================
========================
```

In [53]:

```
gd(X_tr,X_te)
```

```
Fitting 3 folds for each of 28 candidates, totalling 84 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:  2.2min
[Parallel(n_jobs=-1)]: Done  84 out of  84 | elapsed:  7.7min finished

L1+++++++++++++++
0.6318168510915642
DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=13, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
13
500
```





- AUC tfidf=0.6318168510915642
- max_depth=13
- min_sample_split=500

In [54]:

```
#test phase
# TEST PHASE FOR L1
dc=DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=10, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
dc.fit(X_tr,y_train)
pred = dc.predict(X_te)
acc = accuracy_score(y_test, pred, normalize=True)*float(100)

print('\n****Test accuracy  is %f%%' % (acc))
```

```
****Test accuracy  is 51.425718%
```

In [55]:

```
#other measuring parameters
from sklearn.metrics import classification_report
print("classification_report")
print(classification_report(y_test, pred))
```

```
classification_report
              precision    recall  f1-score   support

           0       0.19      0.69      0.30      5459
           1       0.90      0.48      0.63     30593

   micro avg       0.51      0.51      0.51     36052
   macro avg       0.54      0.58      0.46     36052
weighted avg       0.79      0.51      0.58     36052
```

In [56]:

```
pred_proba_te=dc.predict_proba(X_te)
pred_proba_te  = pred_proba_te[:, 1]

pred_proba_tr=dc.predict_proba(X_tr)
pred_proba_tr  = pred_proba_tr[:, 1]
```

In [57]:

```
#AUC SCORE
auc_score_test_tfidf = roc_auc_score(y_test,pred_proba_te)
print(auc_score_test_tfidf)
```

```
0.6289915684886065
```

In [58]:

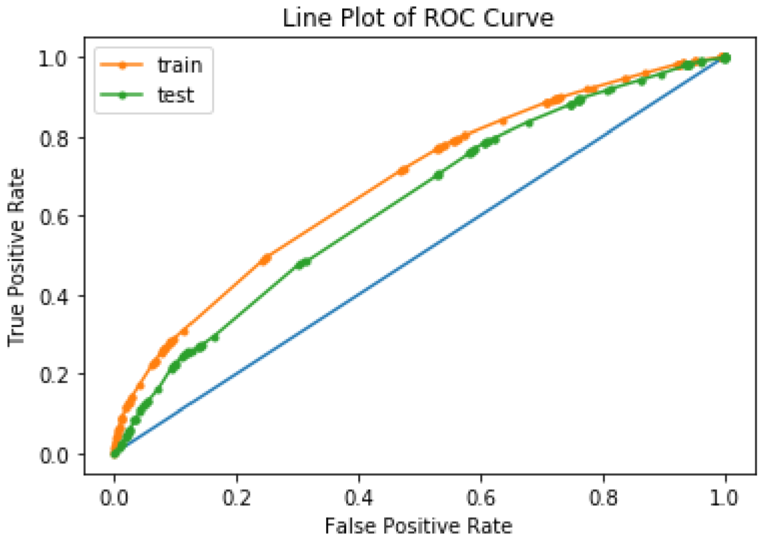
```
fpr, tpr, thresholds = roc_curve(y_test,pred_proba_te )
a=fpr
b=tpr
c=thresholds
```

In [59]:

```
fpr, tpr, thresholds = roc_curve(y_train,pred_proba_tr )
```

In [60]:

```
#PLOT OF ROC
    # plot no skill
plt.plot([0, 1], [0, 1])
    # plot the roc curve for the model
plt.plot(fpr, tpr, marker='.',label="train")
plt.plot(a,b, marker='.',label='test')
    #plt.plot(k,pred_cv)
plt.title("Line Plot of ROC Curve")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend()
plt.show()
```



In [61]:

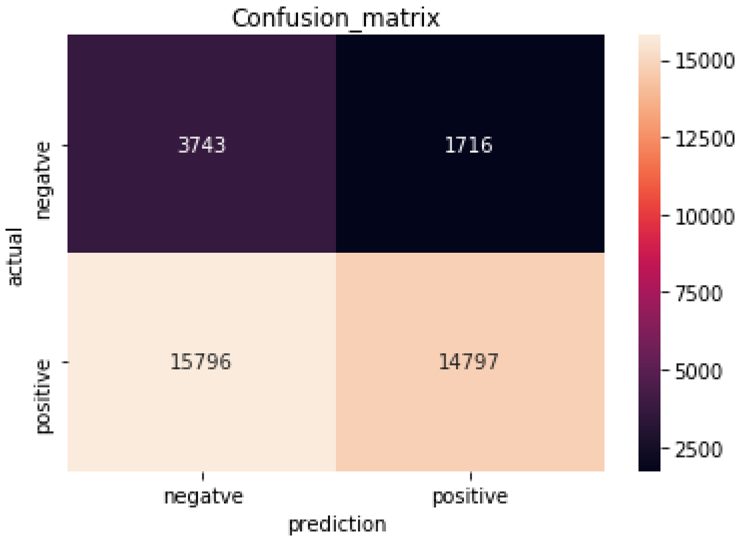
```
#confusion matrices
#https://pandas-ml.readthedocs.io/en/latest/conf_mat.html
con_matrix=confusion_matrix(y_test, pred)
class_label=['negatve','positive']
df=pd.DataFrame(con_matrix,index=class_label,columns=class_label)
df
```

Out[61]:

	negatve	positive
negatve	3743	1716
positive	15796	14797

In [62]:

```
# how can i plot confusion matrix //https://stackoverflow.com/questions/35572000/how-can-i-
sns.heatmap(df,annot=True,fmt='d')
plt.title('Confusion_matrix')
plt.xlabel("prediction")
plt.ylabel("actual")
plt.show()
```



- TN=3743
- FP=1716
- FN=15796
- TP=14797

In [63]:

```
# creating dataframe for y_test
y_Test=pd.DataFrame(y_test)
```

In [64]:

```
# add pred values in that dataframe
y_Test["pred"]=pred
```

In [65]:

```
# selecting rows which are actually false
g=y_Test[y_Test['project_is_approved']==0]
```

In [66]:

```
# now select rows which are correctly pred from all actual false
h=g[g['pred']==1]
```

In [67]:

```
k=h.index
```

In [68]:

```
len(k)
```

Out[68]:

```
1716
```

In [69]:

```
index_fp=list(k)
```

In [70]:

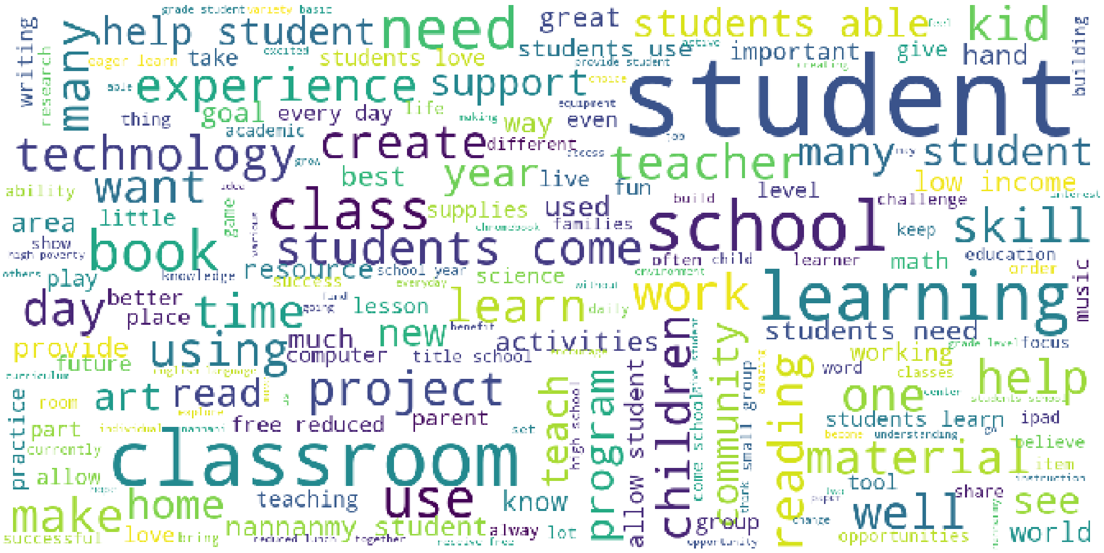
```
t=""

for i in index_fp:
    '''concat all the features'''

    t=t+X.loc[i,"clean_essay"]
```

In [71]:

```
# how to plot word cloud
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
#https://stackoverflow.com/questions/342687/algorithm-to-implement-a-word-cloud-like-wordle
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
stopwords = set(STOPWORDS)

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()
```

In [72]:

```
show_wordcloud(t)
```



In [73]:

```
price=[]
clas=[]
prev=[]
for i in index_fp:
    clas.append(y_Test.loc[i,'pred'])

    price.append(X.loc[i,"price"])
    prev.append(X.loc[i,"teacher_number_of_previously_posted_projects"])
```

In [74]:

```
cd=pd.DataFrame(columns=['price','prev','clas'])
```

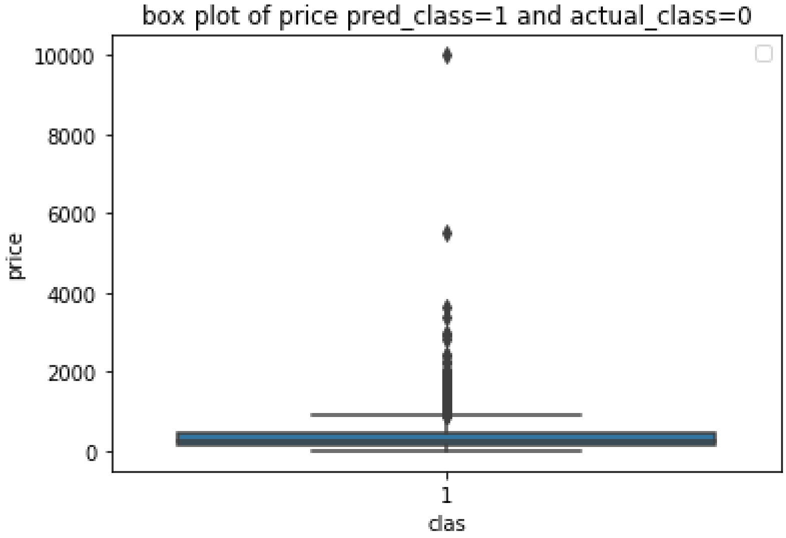
In [75]:

```
cd['price']=price
cd['prev']=prev
cd['clas']=clas
```

In [76]:

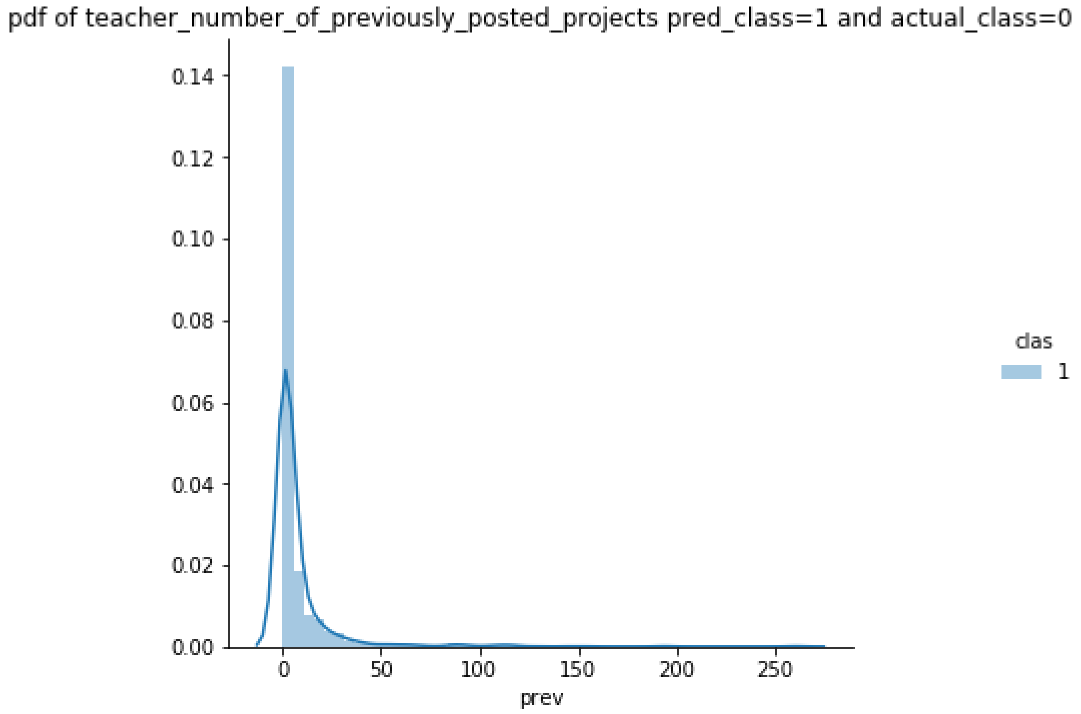
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
import seaborn as sns

sns.boxplot(x='clas',y='price', data=cd)


plt.title("box plot of price pred_class=1 and actual_class=0")
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



In [77]:

```
#pdf
sns.FacetGrid(cd, hue="clas", size=5) \
   .map(sns.distplot, "prev") \
   .add_legend();
plt.title("pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_clas
plt.show();
```


pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_class=0

2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [78]:

```
# Please write all the code with proper documentation
#collecting names of all features
L1=list(vectorizer_1.get_feature_names())
L2=list(vectorizer_2.get_feature_names())
L3=list(vectorizer_3.get_feature_names())
L4=list(vectorizer_4.get_feature_names())
L5=list(vectorizer_5.get_feature_names())
L6=list(vectorizer_8.get_feature_names())
L7=list(vectorizer_9.get_feature_names())
```

In [79]:

```
A=L1+L2+L3+L4+L5+L6+L7
```

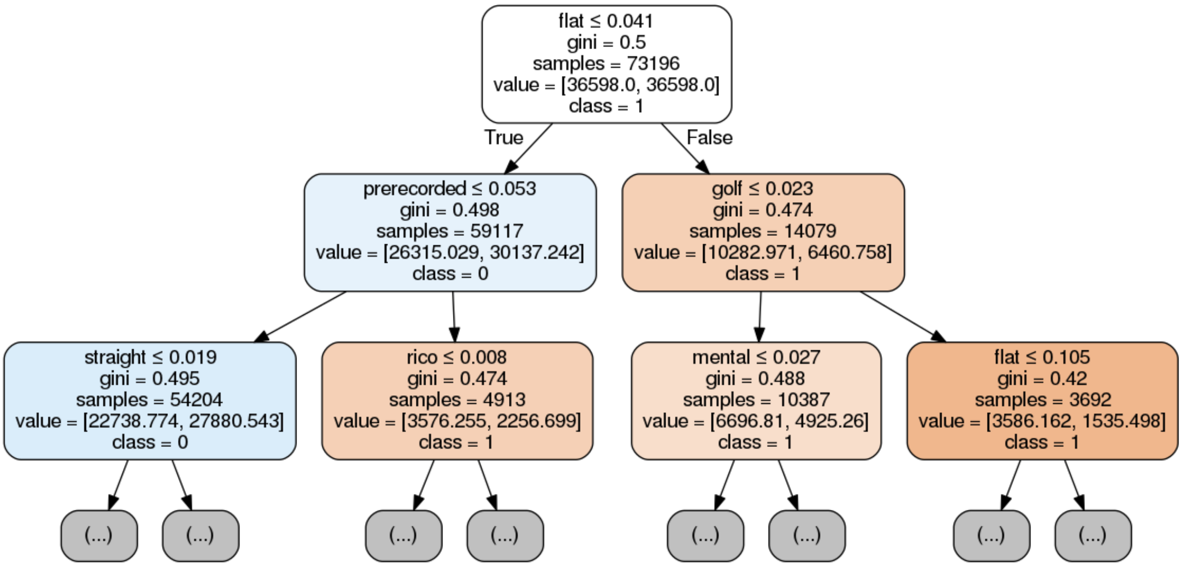
In [80]:

```
A.append("price")

A.append("prev_proposed_projects")
```

In [81]:

```
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
import graphviz
from sklearn import tree
from sklearn import tree
import pydotplus
from IPython.display import Image
from IPython.display import SVG
from graphviz import Source
from IPython.display import display

target = ['1','0']
# Create DOT data
data = tree.export_graphviz(dc,out_file=None,class_names=target,filled=True,rounded=True,sp

# Draw graph
graph = pydotplus.graph_from_dot_data(data)
#graph = Source(data)

# Show graph
Image(graph.create_png())
#display(SVG(graph.pipe(format='svg'))))
```

Out[81]:



2.4.3 Applying Decision Trees on AVG W2V, SET 3

In [294]:

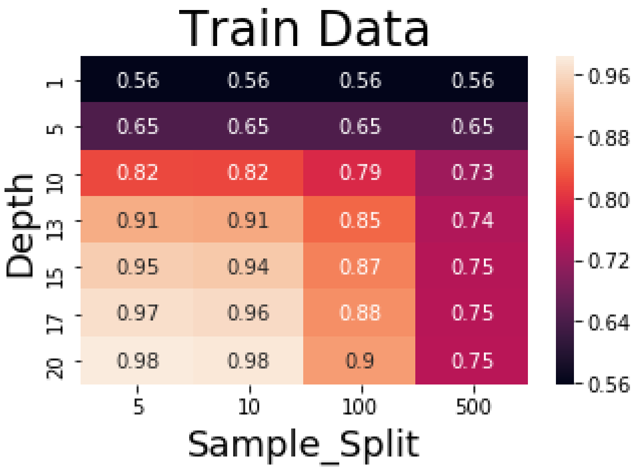
```
# Please write all the code with proper documentation

#merging
from scipy.sparse import hstack
X_tr = hstack((avg_w2v_vectors_traintitle, X_train_state_ohe, X_train_teacher_ohe, X_train_
#X_cr = hstack((avg_w2v_vectors_cvtitle, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, 
X_te = hstack((avg_w2v_vectors_testtitle, X_test_state_ohe, X_test_teacher_ohe, X_test_grad

print("Final Data matrix")
print("train matrix=>",X_tr.shape, y_train.shape)

print("test matrix=>",X_te.shape, y_test.shape)
print("="*100)
```

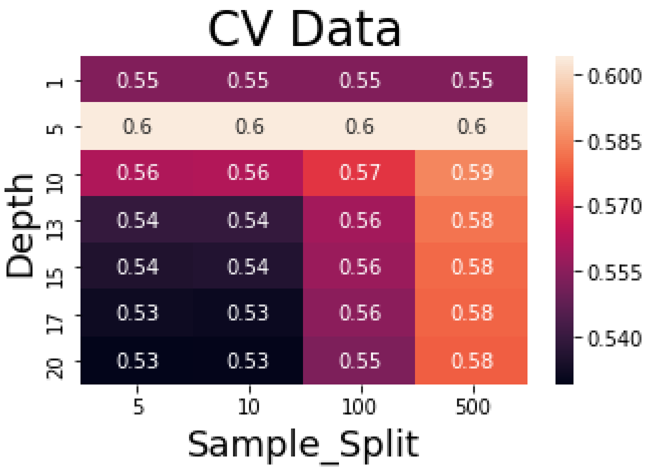
```
Final Data matrix
train matrix=> (73196, 701) (73196,)
test matrix=> (36052, 701) (36052,)
============================================================================
========================
```

In [295]:

```
gd(X_tr,X_te)
```

```
Fitting 3 folds for each of 28 candidates, totalling 84 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed: 12.8min
[Parallel(n_jobs=-1)]: Done  84 out of  84 | elapsed: 40.3min finished

L1+++++++++++++++
0.6093645957883238
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=
5,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=5,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
5
5
```





- AUC avg word=0.6093645957883238
- max_depth=5
- min_sample_split=5

In [296]:

```
#test phase
# TEST PHASE FOR L1
dc=DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=5,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
dc.fit(X_tr,y_train)
pred = dc.predict(X_te)
acc = accuracy_score(y_test, pred, normalize=True)*float(100)

print('\n****Test accuracy  is %f%%' % (acc))
```

```
****Test accuracy  is 66.684234%
```

In [297]:

```
#other measuring parameters
from sklearn.metrics import classification_report
print("classification_report")
print(classification_report(y_test, pred))
```

```
classification_report
              precision    recall  f1-score   support

           0       0.22      0.46      0.29      5459
           1       0.88      0.70      0.78     30593

   micro avg       0.67      0.67      0.67     36052
   macro avg       0.55      0.58      0.54     36052
weighted avg       0.78      0.67      0.71     36052
```

In [298]:

```
pred_proba_te=dc.predict_proba(X_te)
pred_proba_te  = pred_proba_te[:, 1]

pred_proba_tr=dc.predict_proba(X_tr)
pred_proba_tr  = pred_proba_tr[:, 1]
```

In [299]:

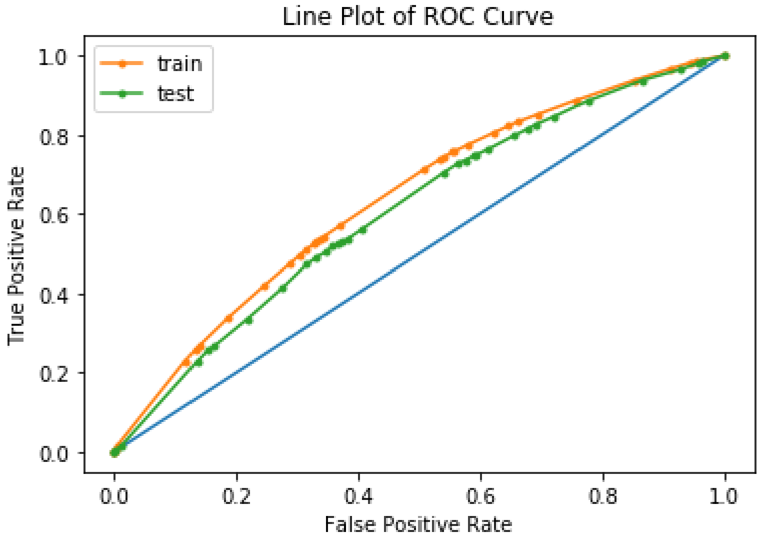
```
fpr, tpr, thresholds = roc_curve(y_test,pred_proba_te )
a=fpr
b=tpr
c=thresholds
```

In [300]:

```
fpr, tpr, thresholds = roc_curve(y_train,pred_proba_tr )
```

In [301]:

```
#PLOT OF ROC
    # plot no skill
plt.plot([0, 1], [0, 1])
    # plot the roc curve for the model
plt.plot(fpr, tpr, marker='.',label="train")
plt.plot(a,b, marker='.',label='test')
    #plt.plot(k,pred_cv)
plt.title("Line Plot of ROC Curve")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend()
plt.show()
```



In [302]:

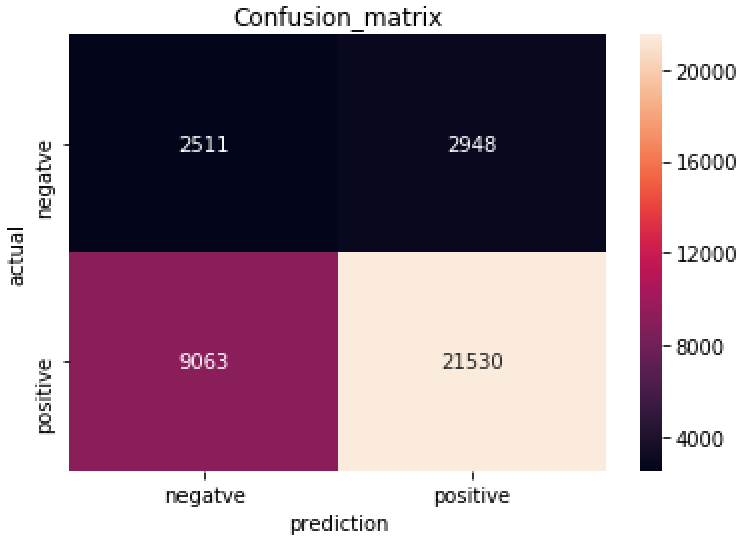
```
#confusion matrices
#https://pandas-ml.readthedocs.io/en/latest/conf_mat.html
con_matrix=confusion_matrix(y_test, pred)
class_label=['negatve','positive']
df=pd.DataFrame(con_matrix,index=class_label,columns=class_label)
df
```

Out[302]:

	negatve	positive
negatve	2511	2948
positive	9063	21530

In [303]:

```
# how can i plot confusion matrix //https://stackoverflow.com/questions/35572000/how-can-i-
sns.heatmap(df,annot=True,fmt='d')
plt.title('Confusion_matrix')
plt.xlabel("prediction")
plt.ylabel("actual")
plt.show()
```



- TN=2511
- FP=2948
- FN=9063
- TP=21530

In [308]:

```
# creating dataframe for y_test
y_Test=pd.DataFrame(y_test)
```

In [309]:

```
# add pred values in that dataframe
y_Test["pred"]=pred
```

In [310]:

```
# selecting rows which are actually false
g=y_Test[y_Test['project_is_approved']==0]
```

In [312]:

```
g.head()
```

Out[312]:

	project_is_approved	pred
55693	0	0
84111	0	1
82335	0	0
74779	0	1
27622	0	0

In [313]:

```
 #now select rows which are correctly pred from all actual false
h=g[g['pred']==1]
```

In [314]:

```
k=h.index
```

In [315]:

```
index_fp=list(k)
```

In [316]:

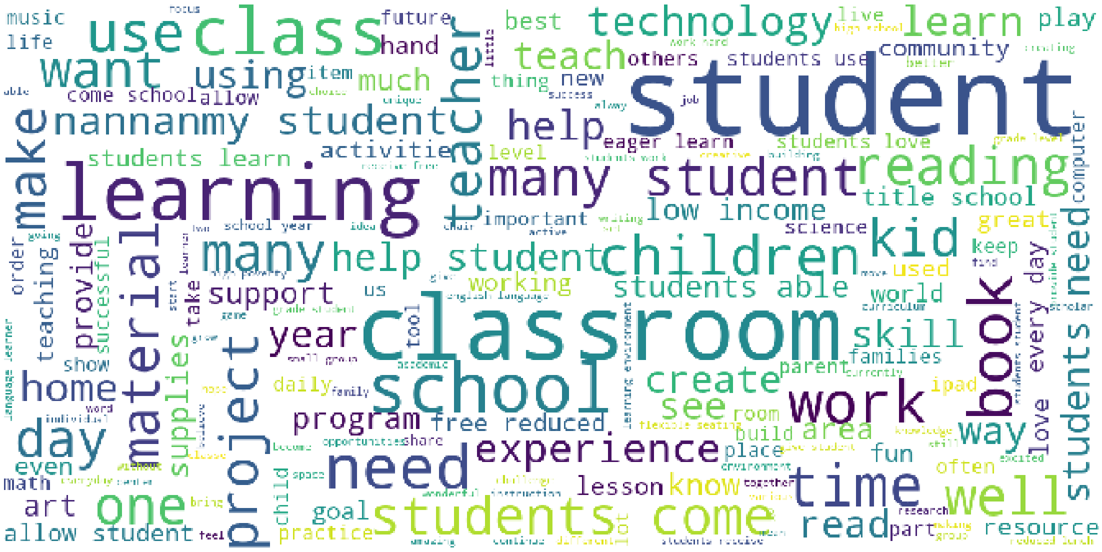
```
t=""

for i in index_fp:
    '''concat all the features'''

    t=t+X.loc[i,"clean_essay"]
```

In [317]:

```
# how to plot word cloud
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
#https://stackoverflow.com/questions/342687/algorithm-to-implement-a-word-cloud-like-wordle
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
stopwords = set(STOPWORDS)

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()
```

In [318]:

```
show_wordcloud(t)
```



In [319]:

```
price=[]
clas=[]
prev=[]
for i in index_fp:
    clas.append(y_Test.loc[i,'pred'])

    price.append(X.loc[i,"price"])
    prev.append(X.loc[i,"teacher_number_of_previously_posted_projects"])
```

In [320]:

```
cd=pd.DataFrame(columns=['price','prev','clas'])
```

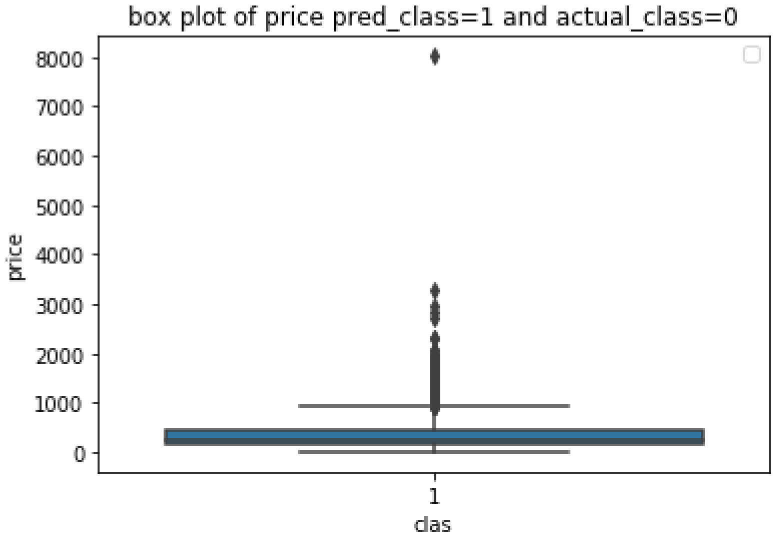
In [321]:

```
cd['price']=price
cd['prev']=prev
cd['clas']=clas
```

In [322]:

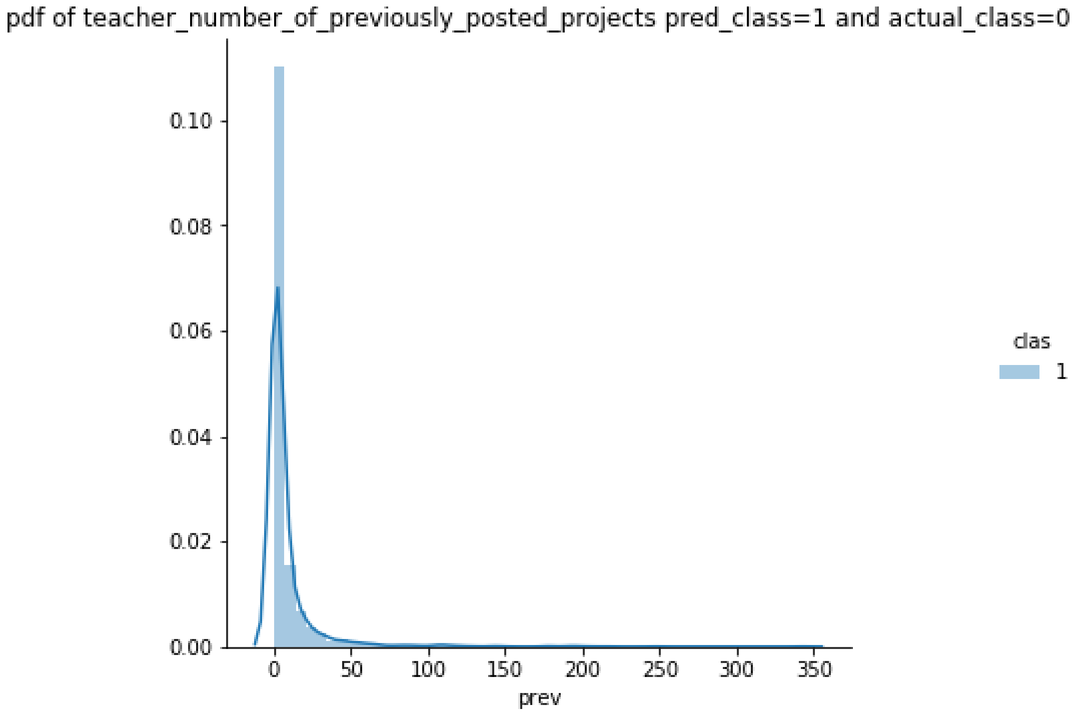
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
import seaborn as sns

sns.boxplot(x='clas',y='price', data=cd)


plt.title("box plot of price pred_class=1 and actual_class=0")
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



In [323]:

```
#pdf
sns.FacetGrid(cd, hue="clas", size=5) \
   .map(sns.distplot, "prev") \
   .add_legend();
plt.title("pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_clas
plt.show();
```


pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_class=0

2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

In [324]:

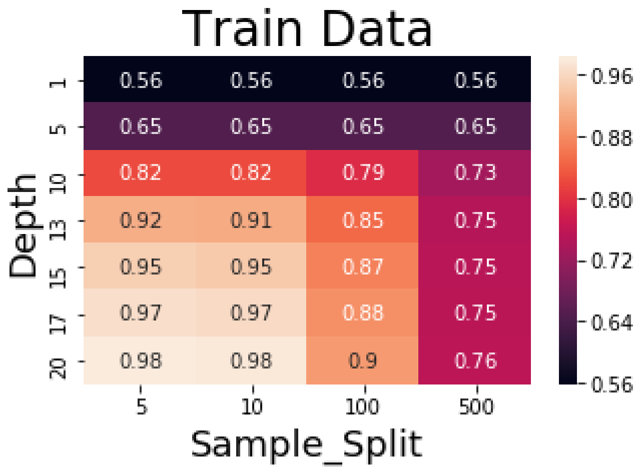
```
# Please write all the code with proper documentation
#merging
from scipy.sparse import hstack
X_tr = hstack((tfidf_w2v_vectors_title_tr, X_train_state_ohe, X_train_teacher_ohe, X_train_
#X_cr = hstack((tfidf_w2v_vectors_title_cv, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_oh
X_te = hstack((tfidf_w2v_vectors_title_te, X_test_state_ohe, X_test_teacher_ohe, X_test_gra

print("Final Data matrix")
print("train matrix=>",X_tr.shape, y_train.shape)

print("test matrix=>",X_te.shape, y_test.shape)
print("="*100)
```

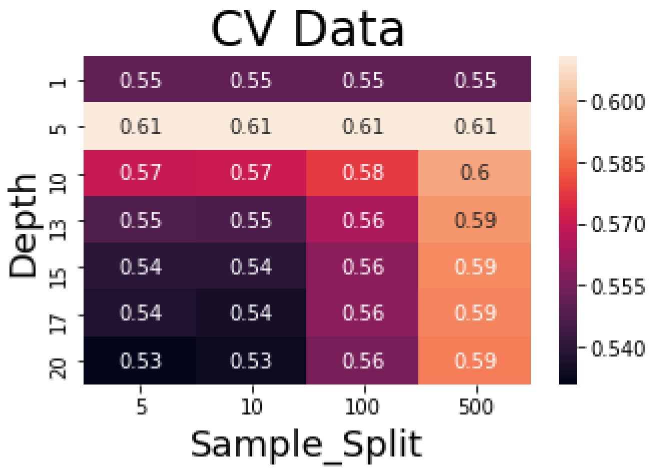
```
Final Data matrix
train matrix=> (73196, 701) (73196,)
test matrix=> (36052, 701) (36052,)
============================================================================
========================
```

In [325]:

```
gd(X_tr,X_te)
```

```
Fitting 3 folds for each of 28 candidates, totalling 84 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed: 13.1min
[Parallel(n_jobs=-1)]: Done  84 out of  84 | elapsed: 41.2min finished

L1+++++++++++++++
0.6210380634696877
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=
5,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
5
500
```





- AUC TFIDF word=0.6210380634696877
- max_depth=5
- min_sample_split=500

In [326]:

```
#test phase
# TEST PHASE FOR L1
dc=DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
dc.fit(X_tr,y_train)
pred = dc.predict(X_te)
acc = accuracy_score(y_test, pred, normalize=True)*float(100)

print('\n****Test accuracy  is %f%%' % (acc))
```

```
****Test accuracy  is 62.104738%
```

In [327]:

```
#other measuring parameters
from sklearn.metrics import classification_report
print("classification_report")
print(classification_report(y_test, pred))
```

```
classification_report
              precision    recall  f1-score   support

           0       0.21      0.53      0.30      5459
           1       0.88      0.64      0.74     30593

   micro avg       0.62      0.62      0.62     36052
   macro avg       0.55      0.58      0.52     36052
weighted avg       0.78      0.62      0.67     36052
```

In [329]:

```
pred_proba_te=dc.predict_proba(X_te)
pred_proba_te  = pred_proba_te[:, 1]

pred_proba_tr=dc.predict_proba(X_tr)
pred_proba_tr  = pred_proba_tr[:, 1]
```

In [330]:

```
#AUC SCORE
auc_score_test_tfidf = roc_auc_score(y_test,pred_proba_te)
print(auc_score_test_tfidf)
```

```
0.6210380634696877
```

In [331]:

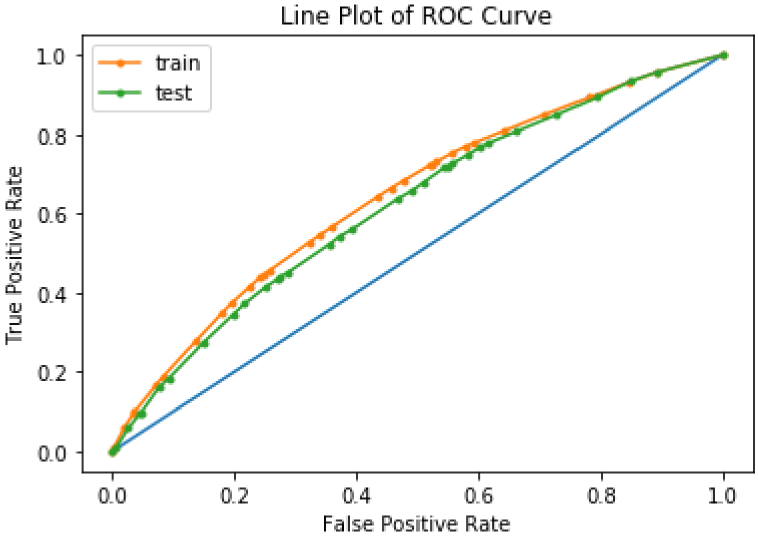
```
fpr, tpr, thresholds = roc_curve(y_test,pred_proba_te )
a=fpr
b=tpr
c=thresholds
```

In [332]:

```
fpr, tpr, thresholds = roc_curve(y_train,pred_proba_tr )
```

In [333]:

```
#PLOT OF ROC
    # plot no skill
plt.plot([0, 1], [0, 1])
    # plot the roc curve for the model
plt.plot(fpr, tpr, marker='.',label="train")
plt.plot(a,b, marker='.',label='test')
    #plt.plot(k,pred_cv)
plt.title("Line Plot of ROC Curve")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend()
plt.show()
```



In [334]:

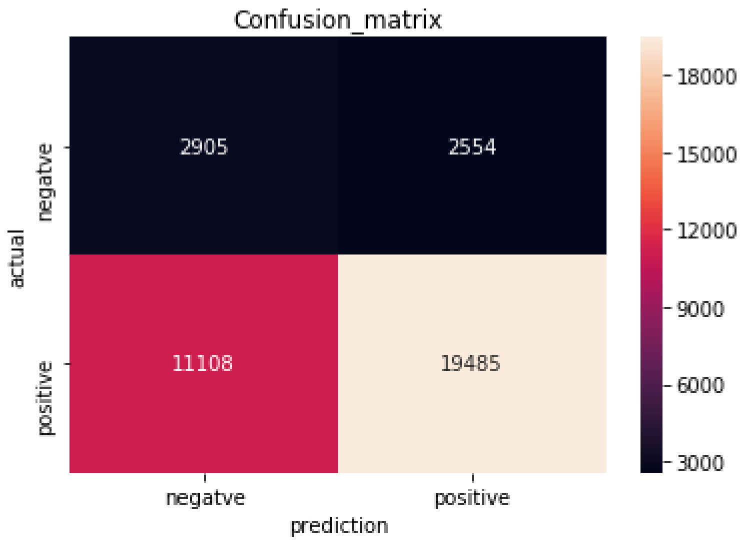
```
#confusion matrices
#https://pandas-ml.readthedocs.io/en/latest/conf_mat.html
con_matrix=confusion_matrix(y_test, pred)
class_label=['negatve','positive']
df=pd.DataFrame(con_matrix,index=class_label,columns=class_label)
df
```

Out[334]:

	negatve	positive
negatve	2905	2554
positive	11108	19485

In [335]:

```
# how can i plot confusion matrix //https://stackoverflow.com/questions/35572000/how-can-i-
sns.heatmap(df,annot=True,fmt='d')
plt.title('Confusion_matrix')
plt.xlabel("prediction")
plt.ylabel("actual")
plt.show()
```



- TN=2905
- FP=2554
- FN=11108
- TP=19485

In [336]:

```
# creating dataframe for y_test
y_Test=pd.DataFrame(y_test)
```

In [337]:

```
# add pred values in that dataframe
y_Test["pred"]=pred
```

In [338]:

```
# selecting rows which are actually false
g=y_Test[y_Test['project_is_approved']==0]
```

In [339]:

```
#now select rows which are correctly pred from all actual false
h=g[g['pred']==1]
```

In [340]:

```
k=h.index
```

In [341]:

```
index_fp=list(k)
```

In [342]:

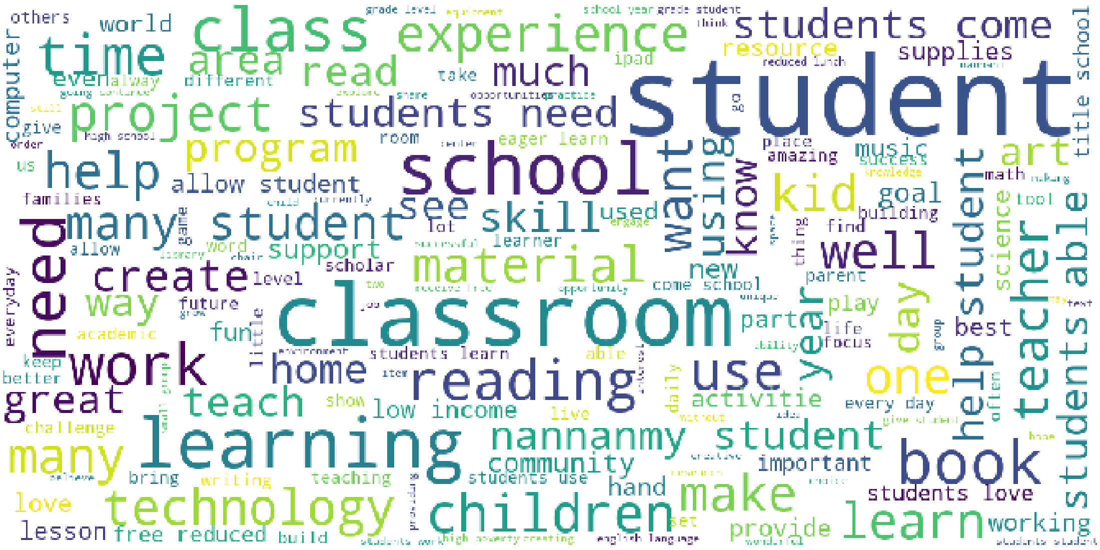
```
t=""

for i in index_fp:
    '''concat all the features'''

    t=t+X.loc[i,"clean_essay"]
```

In [343]:

```
# how to plot word cloud
#https://github.com/premvardhan/Amazon-fine-food-review-analysis/blob/master/DecisionTree_a
#https://stackoverflow.com/questions/342687/algorithm-to-implement-a-word-cloud-like-wordle
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
stopwords = set(STOPWORDS)

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()
```

In [345]:

```
show_wordcloud(t)
```



In [346]:

```
price=[]
clas=[]
prev=[]
for i in index_fp:
    clas.append(y_Test.loc[i,'pred'])

    price.append(X.loc[i,"price"])
    prev.append(X.loc[i,"teacher_number_of_previously_posted_projects"])
```

In [347]:

```
cd=pd.DataFrame(columns=['price','prev','clas'])
```

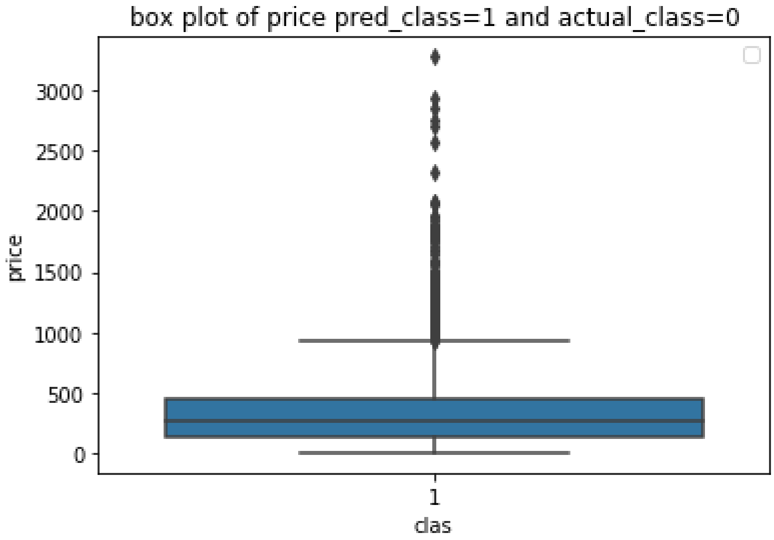
In [348]:

```
cd['price']=price
cd['prev']=prev
cd['clas']=clas
```

In [349]:

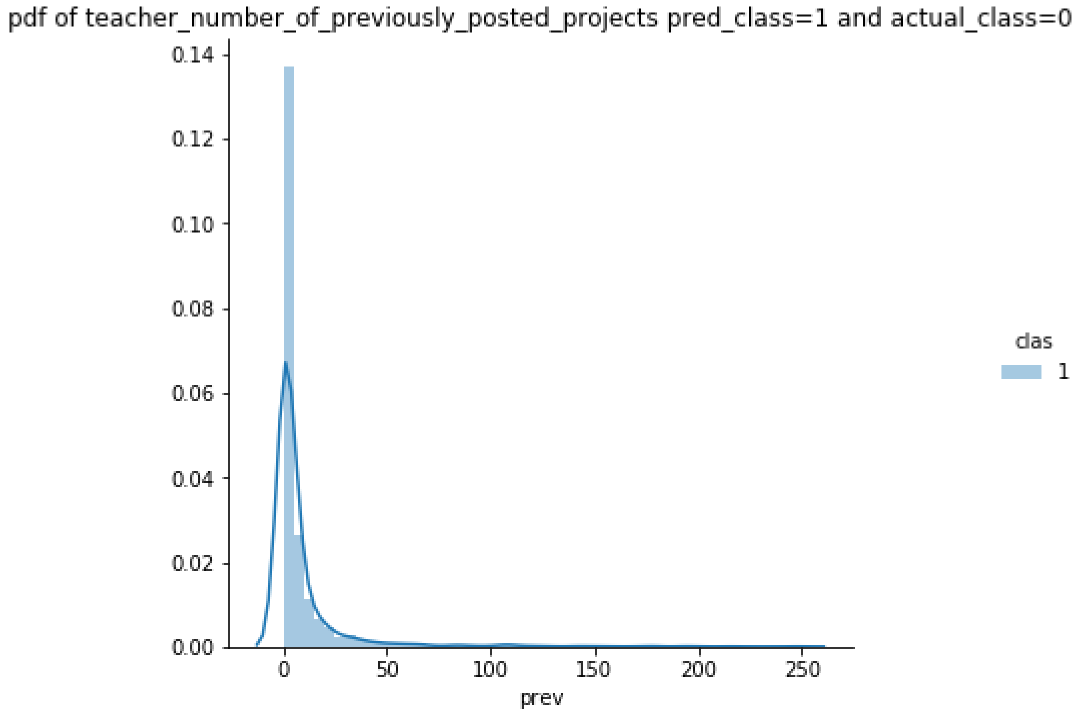
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
import seaborn as sns

sns.boxplot(x='clas',y='price', data=cd)


plt.title("box plot of price pred_class=1 and actual_class=0")
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



In [350]:

```
#pdf
sns.FacetGrid(cd, hue="clas", size=5) \
   .map(sns.distplot, "prev") \
   .add_legend();
plt.title("pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_clas
plt.show();
```


pdf of teacher_number_of_previously_posted_projects pred_class=1 and actual_class=0

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

In [83]:

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

# applying feature_importance
parameter=dc.feature_importances_
```

In [110]:

```

from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *

# Importing libraries



tuned_parameters = {'C': [5**-5,10**-4,5**-4 ,10**-3,5**-3, 10**-2,5**-2, 10**-1,5**-1,0.5,
```

In [111]:

```
#Log of c
from math import log
R=[]
for i in tuned_parameters['C'] :
    R.append(log(i))
```

In [84]:

```
parameter.shape
```

Out[84]:

```
(17046,)
```

In [85]:

```
# reverse sort the parameter on the basis of their value
rev_or=np.sort(parameter)[::-1]
```

In [86]:

```
#taking threshold of best 5000 features
threshold=best_feat=rev_or[:5000]
th=threshold[4999]# last one is our threshold value beyond this all are discarded
```

In [87]:

```
#5k best features and datapoints
# MACHINELEARNINGMASTERY.COM
from sklearn.feature_selection import SelectFromModel

selection=SelectFromModel(dc,threshold=th,prefit=True)
select_X_train=selection.transform(X_tr)
select_X_test=selection.transform(X_te)
## train model


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

In [93]:

```
from sklearn.preprocessing import StandardScaler
'''COLUMN STANDARDISED THE DATA MATRIX'''
# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.
# Reshape your data either using array.reshape(-1, 1)

scalar_1 = StandardScaler(with_mean=False)
scalar_1.fit(select_X_train) # finding the mean and standard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0]

# Now standardize the data with above maen and variance.
standardized_1 = scalar_1.transform(select_X_train)

standardized_2 = scalar_1.transform(select_X_test)
```

In [94]:

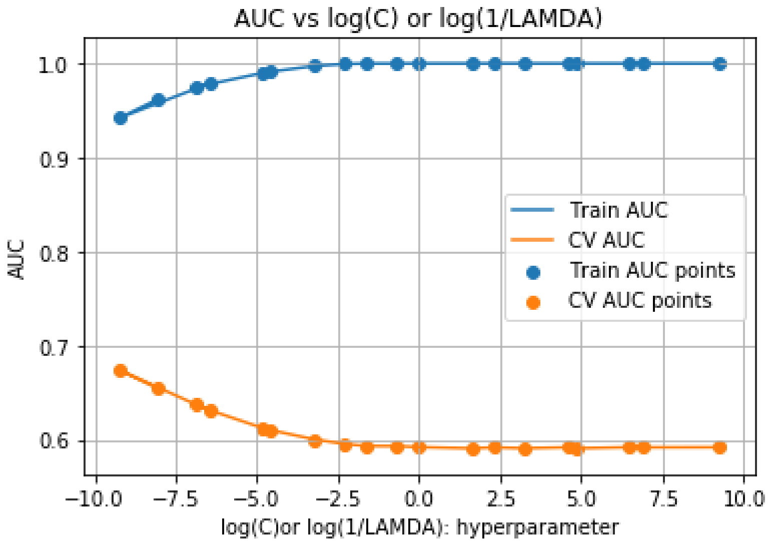
```
X_tr=standardized_1
X_te=standardized_2
```

In [112]:

```
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
from sklearn.linear_model import LogisticRegression
#def gd(X_tr,X_te):
from sklearn.model_selection import GridSearchCV
def best(X_tr,X_te):
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.ht

    '''function to predict best hyper parameter and plot cv auc and train auc with log(C)''
    logistic=LogisticRegression(class_weight='balanced')

    clf = GridSearchCV(logistic, tuned_parameters, cv=3, scoring='roc_auc',n_jobs=-1)
    clf.fit(X_tr, y_train)

    train_auc= clf.cv_results_['mean_train_score']

    cv_auc = clf.cv_results_['mean_test_score']


    plt.plot(R, train_auc, label='Train AUC')


    plt.plot(R, cv_auc, label='CV AUC')


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


    plt.legend()
    plt.xlabel("log(C)or log(1/LAMDA): hyperparameter")
    plt.ylabel("AUC")
    plt.title("AUC vs log(C) or log(1/LAMDA)")
    plt.grid()
    plt.show()

    # test AUC
    print(clf.score(X_te, y_test))
    print(clf.best_estimator_)# to know best parameters
```

In [113]:

```
best(X_tr,X_te)
```



```
0.6841174116656429
LogisticRegression(C=0.0001, class_weight='balanced', dual=False,
          fit_intercept=True, intercept_scaling=1, max_iter=100,
          multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
          solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

- AUC score=0.6841174116656429
- best C=0.0001

In [114]:

```
z=LogisticRegression(C=0.0001, class_weight='balanced', dual=False,
          fit_intercept=True, intercept_scaling=1, max_iter=100,
          multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
          solver='warn', tol=0.0001, verbose=0, warm_start=False)
z.fit(X_tr,y_train)
pred = z.predict(X_te)
acc = accuracy_score(y_test, pred, normalize=True)*float(100)

print('\n****Test accuracy is %f%%' % ( acc))
```

```
****Test accuracy is 71.213802%
```

In [115]:

```
pred_proba_te=z.predict_proba(X_te)
pred_proba_te  = pred_proba_te[:, 1]
```

In [116]:

```
# OTHER MEASURING PARAMETER
from sklearn.metrics import classification_report
print("classification_report")
print(classification_report(y_test, pred))
```

```
classification_report
              precision    recall  f1-score   support

           0       0.27      0.52      0.35      5459
           1       0.90      0.75      0.81     30593

   micro avg       0.71      0.71      0.71     36052
   macro avg       0.58      0.63      0.58     36052
weighted avg       0.80      0.71      0.75     36052
```

In [117]:

```
pred_proba_tr=z.predict_proba(X_tr)
pred_proba_tr  = pred_proba_tr[:, 1]
```

In [118]:

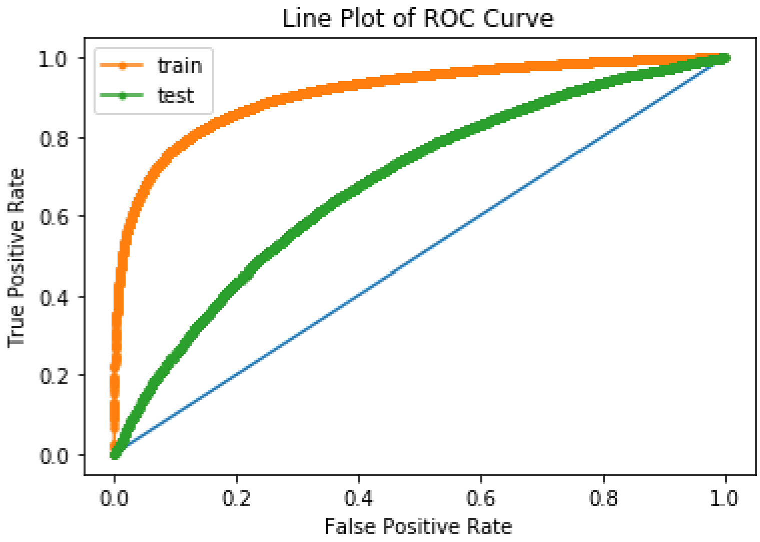
```
fpr, tpr, thresholds = roc_curve(y_test,pred_proba_te )
a=fpr
b=tpr
c=thresholds
```

In [119]:

```
fpr, tpr, thresholds = roc_curve(y_train,pred_proba_tr )
```

In [120]:

```
#TO PLOT ROC PLOT
    # plot no skill
plt.plot([0, 1], [0, 1])
    # plot the roc curve for the model
plt.plot(fpr, tpr, marker='.',label="train")
plt.plot(a,b, marker='.',label='test')
    #plt.plot(k,pred_cv)
plt.title("Line Plot of ROC Curve")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend()
plt.show()
```



In [121]:

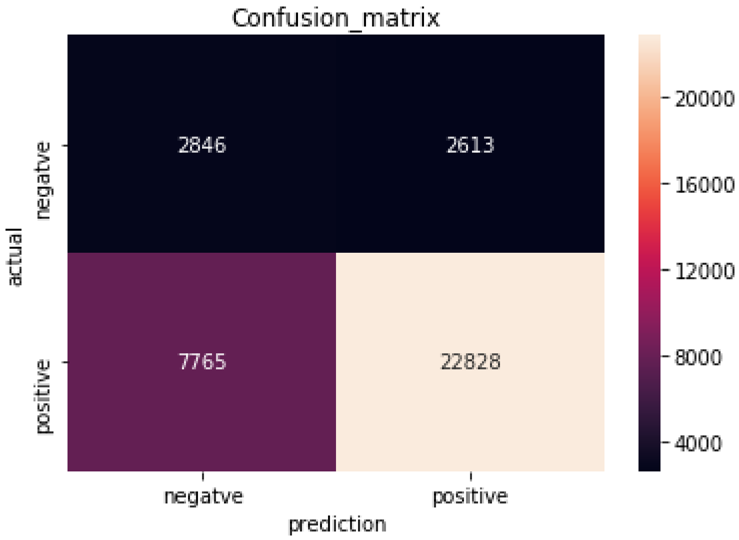
```
#confusion matrices
#https://pandas-ml.readthedocs.io/en/latest/conf_mat.html
#confusion matrices
con_matrix=confusion_matrix(y_test, pred)
class_label=['negatve','positive']
df=pd.DataFrame(con_matrix,index=class_label,columns=class_label)
df
```

Out[121]:

	negatve	positive
negatve	2846	2613
positive	7765	22828

In [122]:

```
# how can i plot confusion matrix //https://stackoverflow.com/questions/35572000/how-can-i-
sns.heatmap(df,annot=True,fmt='d')
plt.title('Confusion_matrix')
plt.xlabel("prediction")
plt.ylabel("actual")
plt.show()
```



- TN=2846
- FP=2613
- FN=7765
- TP=22828

3. Conclusion

In [125]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "depth","min_sample_split","AUC"]
```

In [127]:

```
x.add_row(['bow','decision_tree',10,500,0.6234644800046839])
x.add_row(['tfidf','decision_tree',13, 500,0.6318168510915642])
x.add_row(['average_word_','decision_tree',5,5,0.6093645957883238])
x.add_row(['tfidf_word_','decision_tree',5,500,0.6210380634696877])
```

In [128]:

```
print(x)
```

```
+---------------+---------------+-------+------------------+----------------
----+
|   Vectorizer  |     Model     | depth | min_sample_split |        AUC
    |
+---------------+---------------+-------+------------------+----------------
----+
|      bow      | decision_tree |   10  |       500        | 0.6234644800046
839 |
|     tfidf     | decision_tree |   13  |       500        | 0.6318168510915
642 |
|      bow      | decision_tree |   10  |       500        | 0.6234644800046
839 |
|     tfidf     | decision_tree |   13  |       500        | 0.6318168510915
642 |
| average_word_ | decision_tree |   5   |        5         | 0.6093645957883
238 |
|  tfidf_word_  | decision_tree |   5   |       500        | 0.6210380634696
877 |
+---------------+---------------+-------+------------------+----------------
----+
```

In [ ]:

```

```

In [130]:

```
from prettytable import PrettyTable
x_1 = PrettyTable()
x_1.field_names = ["Vectorizer", "Model", "Hyperparameter C=1\lamda","AUC"]
```

In [131]:

```
x_1.add_row(['added Features Set 5','logistic_reg',0.0001,0.6841174116656429])
```

In [132]:

```
print(x_1)
```

```
+----------------------+--------------+--------------------------+----------
----------+
|      Vectorizer      |    Model     | Hyperparameter C=1\lamda |        AU
C         |
+----------------------+--------------+--------------------------+----------
----------+
| added Features Set 5 | logistic_reg |          0.0001          | 0.6841174
116656429 |
+----------------------+--------------+--------------------------+----------
----------+
```

In [ ]:

```

```