DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_codes)). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!</code`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*

Feature	Description
project_essay_4	Fourth application essay*
project_submitted_datetime	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
teacher_id	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
teacher_prefix	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

In [2]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [3]:
```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [4]:
```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

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

In [5]:
```
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[5]:

	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 [6]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "M
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e remo
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Ma
        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 [7]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "M
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e remo
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Ma
        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]))
```

1.5 Preprocessing project grade category

In [8]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-on-
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[8]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

1.2 preprocessing of `Teacher prefix`

In [9]:
```
# check if we have any nan values are there in the column
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
True
number of nan values 3
```

In [10]:
```
#Replacing the Nan values with most frequent value in the column
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna('Mrs.')
```

In [11]:
```
#Converting teacher prefix text into smaller case
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

Out[11]:
```
mrs.       57272
ms.        38955
mr.        10648
teacher     2360
dr.           13
Name: teacher_prefix, dtype: int64
```

Preprocessing State feature

In [12]:
```
#Converting states text into smaller case
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[12]:
```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

1.3 Text preprocessing

In [13]:
```
# 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 [14]:
```
project_data.head(2)
```

Out[14]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr

In [15]:
```
# 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 sc
hool. \r\n\r\n We have over 24 languages represented in our English Learner program with students at eve
ry level of mastery.  We also have over 40 countries represented with the families within our school.  E
ach student brings a wealth of knowledge and experiences to us that open our eyes to new cultures, belie
fs, and respect.\"The limits of your language are the limits of your world.\"-Ludwig Wittgenstein  Our E
nglish learner's have a strong support system at home that begs for more resources.  Many times our pare
nts are learning to read and speak English along side of their children.  Sometimes this creates barrier
s for parents to be able to help their child learn phonetics, letter recognition, and other reading skil
ls.\r\n\r\nBy providing these dvd's and players, students are able to continue their mastery of the Engl
ish 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 educational videos will be spec
ially chosen by the English Learner Teacher and will be sent home regularly to watch.  The videos are to
help the child develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will
have the opportunity to check out a dvd player to use for the year.  The plan is to use these videos and
educational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at least m
ost of the time. At our school, 97.3% of the students receive free or reduced price lunch. Of the 560 st
udents, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together a
nd celebrate. Around Halloween there is a whole school parade to show off the beautiful costumes that st
udents wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and gam
es. At the end of the year the school hosts a carnival to celebrate the hard work put in during the scho
ol year, with a dunk tank being the most popular activity.My students will use these five brightly color
ed Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in
the classroom and not enough for each student to have an individual one, they will be used in a variety
of ways. During independent reading time they will be used as special chairs students will each use on o
ccasion. I will utilize them in place of chairs at my small group tables during math and reading times.
The rest of the day they will be used by the students who need the highest amount of movement in their l
ife in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students
always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the studen
ts are sitting in group with me on the Hokki Stools, they are always moving, but at the same time doing
their work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are disapp
ointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The H
okki stools will be a compromise 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 allowing them to activate their
core muscles for balance while they sit. For many of my students, these chairs will take away the barrie
r that exists in schools for a child who can't sit still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desk
s, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to cr
eate a warm inviting themed room for my students look forward to coming to each day.\r\n\r\nMy class is
made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I sch
ool, which means there is a high enough percentage of free and reduced-price lunch to qualify. Our schoo
l is an \"open classroom\" concept, which is very unique as there are no walls separating the classroom
s. These 9 and 10 year-old students are very eager learners; they are like sponges, absorbing all the in
formation and experiences and keep on wanting more.With these resources such as the comfy red throw pill
ows and the whimsical nautical hanging decor and the blue fish nets, I will be able to help create the m
ood in our classroom setting to be one of a themed nautical environment. Creating a classroom environmen
t is very important in the success in each and every child's education. The nautical photo props will be
used with each child as they step foot into our classroom for the first time on Meet the Teacher evenin
g. I'll take pictures of each child with them, have them developed, and then hung in our classroom ready
for their first day of 4th grade.  This kind gesture will set the tone before even the first day of scho
ol! The nautical thank you cards will be used throughout the year by the students as they create thank y
ou cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a
fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on
resources to get our classroom ready. Please consider helping with this project to make our new school y
ear a very successful one. Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
```

```
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced 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 were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 don't want to sit and do w
orksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our suc
cess. The number toss and color and shape mats can make that happen. My students will forget they are do
ing 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 teac
her inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-Americ
an, making up the largest segment of the student body. A typical school in Dallas is made up of 23.2% Af
rican-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 min
ds of young children and we focus not only on academics but one smart, effective, efficient, and discipl
ined students with good character.In our classroom we can utilize the Bluetooth for swift transitions du
ring class. I use a speaker which doesn't amplify the sound enough to receive the message. Due to the vo
lume of my speaker my students can't hear videos or books clearly and it isn't making the lessons as mea
ningful. But with the bluetooth speaker my students will be able to hear and I can stop, pause and repla
y it at any time.\r\nThe cart will allow me to have more room for storage of things that are needed for
the day and has an extra part to it I can use.  The table top chart has all of the letter, words and pic
tures for students to learn about different letters and it is more accessible.nannan
==================================================
```

In [16]:
```python
# 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 [17]:
```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced 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 were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 do not want to sit and do
worksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [18]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.     The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou ever felt like you had ants in your pants and you needed to groove and move as you were in a meeting?
This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble c
hairs 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 works
heets. They want to learn to count by jumping and playing. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My students will forget they are doing
work and just have the fun a 6 year old deserves.nannan
```

In [19]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitive dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd 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 were in a meeting This is how m
y kids feel all the time The want to be able to move as they learn or so they say Wobble chairs are the
answer and I love then because they develop their core which enhances gross motor and in Turn fine motor
skills They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves nannan
```

In [20]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'befor
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [21]:
```
# 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 [01:08<00:0
0, 1603.98it/s]
```

In [22]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[22]:
```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gross fine
motor delays autism they eager beavers always strive work hardest working past limitations the materials
ones i seek students i teach title i school students receive free reduced price lunch despite disabiliti
es limitations students love coming school come eager learn explore have ever felt like ants pants neede
d groove move meeting this kids feel time the want able move learn say wobble chairs answer i love devel
op core enhances gross motor turn fine motor skills they also want learn games kids not want sit workshe
ets they want learn count jumping playing physical engagement key success the number toss color shape ma
ts make happen my students forget work fun 6 year old deserves nannan'
```

1.4 Preprocessing of `project_title`

In [23]:
```
# similarly you can preprocess the titles also
project_data.head(2)
```

Out[23]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr

In [24]:
```
# printing some random project titles.
print(project_data['project_title'].values[54])
print("="*50)
print(project_data['project_title'].values[89])
print("="*50)
print(project_data['project_title'].values[999])
print("="*50)
print(project_data['project_title'].values[11156])
print("="*50)
print(project_data['project_title'].values[89436])
print("="*50)
```

```
Swim For Life At YMCA!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [25]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta", "Got to", 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 [26]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [27]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [28]:
```
#Removing numbers & symbols form the titles
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
Classroom Supplies Help a New Teacher Organize the Classroom
```

In [29]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [30]:
```
#Combining all the above preprocessed statements
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<00:0
0, 30343.72it/s]
```

In [31]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles[54])
print("="*50)
print(preprocessed_titles[89])
print("="*50)
print(preprocessed_titles[999])
print("="*50)
print(preprocessed_titles[11156])
print("="*50)
print(preprocessed_titles[89436])
```

```
swim for life at ymca
==================================================
education through technology
==================================================
focus pocus
==================================================
making math interactive
==================================================
classroom supplies help new teacher organize classroom
```

In [32]:
```
project_data.columns
```

Out[32]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay'],
      dtype='object')
```

1.5.1 Vectorizing Categorical data

In [33]:
```
# 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, binary=True)
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)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', 'Health_Spo
rts', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (109248, 9)
```

In [34]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular', 'Civics_G
overnment', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger', 'SocialSciences', 'Perfor
mingArts', 'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_Geograph
y', 'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArt
s', 'Health_Wellness', 'AppliedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literac
y']
Shape of matrix after one hot encodig  (109248, 30)
```

In [35]:
```
# Applying count vectorizer on school state feature & one hot encoding School_state feature
vectorizer = CountVectorizer(binary=True)
school_state_count = vectorizer.fit_transform(project_data['school_state'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",school_state_count.shape)
```

```
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks',
'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'n
y', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
Shape of matrix after one hot encodig  (109248, 51)
```

In [36]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-onp
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[36]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [37]:
```
#One hot encoding project grade category feature
vectorizer = CountVectorizer(binary=True)
project_grade_one = vectorizer.fit_transform(project_data['project_grade_category'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encoding ",project_grade_one.shape)
```

```
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
Shape of matrix after one hot encoding  (109248, 4)
```

In [38]:
```
#One hot encoding the teacher prefix column
vectorizer = CountVectorizer(binary=True)
teacher_prefix_one = vectorizer.fit_transform(project_data['teacher_prefix'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",teacher_prefix_one.shape)
```

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
Shape of matrix after one hot encodig  (109248, 5)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [39]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
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 [40]:
```
# you can vectorize the title also
vectorizer = CountVectorizer(min_df=10)
title_bow = vectorizer.fit_transform(preprocessed_titles)
print("Shape of matrix after one hot encodig ",title_bow.shape)
# before you vectorize the title make sure you preprocess it
```

```
Shape of matrix after one hot encodig  (109248, 3328)
```

1.5.2.2 TFIDF vectorizer

In [41]:
```
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)
```

In [42]:
```
# you can vectorize the title also
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
title_tfidf = vectorizer.fit_transform(preprocessed_titles)
print("Shape of matrix after one hot encodig ",title_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 3328)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [43]:
```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

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

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

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

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

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


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

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


'''
```

Out[43]:
```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef (https://stackoverflow.com/a/38230349/4084039\ndef) loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n        word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        model[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n# ============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus", len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words that are present in both glove vectors and our coupus", len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\nprint("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport (http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport) pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n\''
```

In [44]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l
# 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 [45]:
```
# 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 [00:48<00:0
0, 2274.10it/s]

109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [46]:
```
# 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 [47]:
```
# 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((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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 [05:20<00:
00, 341.37it/s]

109248
300
```

In [48]:
```
# Similarly you can vectorize for title also
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles)
# 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_titles = set(tfidf_model.get_feature_names())
```

In [49]:
```
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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 [00:05<00:0
0, 19908.72it/s]

109248
300
```

1.5.3 Vectorizing Numerical features

In [50]:
```
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 [51]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Standar
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.73   5.5
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standard deviation of
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

In [52]:
```
price_standardized
```

Out[52]:
```
array([[-0.3905327 ],
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

In [53]:
```
#Normalizing price
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96 96.01 ... 368.98 80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1) if it contains a single sample.
normalizer.fit(project_data['price'].values.reshape(1,-1))
price_norm = normalizer.transform(project_data['quantity'].values.reshape(1, -1))
print("After vectorizations")
print(price_norm.shape)
```

```
After vectorizations
(1, 109248)
```

In [54]:
```
price_norm = price_norm.T
```

In [55]:
```
price_norm.shape
```

Out[55]:
```
(109248, 1)
```

In [56]:
```
#Normalizing quantity
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96 96.01 ... 368.98 80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1) if it contains a single sample.
normalizer.fit(project_data['quantity'].values.reshape(1,-1))
quantity_norm = normalizer.transform(project_data['quantity'].values.reshape(1, -1))
print("After vectorizations")
print(quantity_norm.shape)
```

```
After vectorizations
(1, 109248)
```

In [57]:
```
quan_norm = quantity_norm.T
quan_norm.shape
```

Out[57]:
```
(109248, 1)
```

In [58]:
```
# Normalizing teacher previously posted projects
#Normalizing quantity
from sklearn.preprocessing import Normalizer
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(project_data['teacher_number_of_previously_posted_projects'].values.reshape(1, -1))
tpp_norm = normalizer.transform(project_data['teacher_number_of_previously_posted_projects'].values.resha
print("After vectorizations")
print(tpp_norm.shape)
```

```
After vectorizations
(1, 109248)
```

In [59]:
```
tpp_norm = quantity_norm.T
tpp_norm.shape
```

Out[59]:
```
(109248, 1)
```

1.5.4 Merging all the following features

In [60]:
```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 16623)
(109248, 1)
```

In [61]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape
```

Out[61]: (109248, 16663)

Assignment 4: Naive Bayes

1. **Apply Multinomial NaiveBayes 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)
2. **The hyper paramter tuning(find best Alpha)**
   - 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
   - Consider a wide range of alpha values for hyperparameter tuning, start as low as 0.00001
   - 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. **Feature importance**
   - Find the top 10 features of positive class and top 10 features of negative class for both feature sets Set 1 and Set 2 using values of `feature_log_prob_` parameter of MultinomialNB (https://scikit-learn.org/stable/modules/generated/sklearn.naive_bayes.MultinomialNB.html) and print their corresponding feature names
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. Here on X-axis you will have alpha values, since they have a wide range, just to represent those alpha values on the graph, apply log function on those alpha values.
   
   - 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. Please visualize your confusion matrices using seaborn heatmaps.
   
   (https://seaborn.pydata.org/generated/seaborn.heatmap.html)
5. **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/)

1.7 Test Train split

In [62]:
```
data = project_data
data.head(5)
```

Out[62]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

In [63]:
```
y = data['project_is_approved'].values
data.drop(['project_is_approved'], axis=1, inplace=True)
data.head(1)
```

Out[63]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_c
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grades

In [64]:
```
X = data
```

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

In [65]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
#Splitting data into test & train set
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
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 [66]:
```
#Splitting training data into training & cross validation sets
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train,
                                                stratify= y_train,
                                                test_size = 0.33)
```

1.3 Text preprocessing

In [67]:
```
# printing some random reviews
print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[100])
print("="*50)
print(X_train['essay'].values[300])
print("="*50)
print(X_train['essay'].values[5000])
print("="*50)
print(X_train['essay'].values[20000])
print("="*50)
```

```
I am a Kindergarten ESL (English as a Second Language) teacher at a small East Texas Title I school with
over 80% of our population labeled as economically disadvantaged.  This year I have a group of 19 studen
ts, all at various economic and academic levels.  Our school is designed to love and nurture our student
s while providing them with a positive educational experience. \r\n\r\nWe are an active group of learner
s and I strive to keep them focused and having fun.  I am constantly exploring new meaningful activities
for my students to keep their little hands and minds busy.  My room is a student lead learning environme
nt and these little ones are always ready to learn.\r\n\r\n \r\nWobble chairs are fun and safe stools th
at are perfect for my overly active kids.  They provide a safe learning, sitting environment for student
s with restlessness and extra energy.  A wobble chair means a student doesn't have to sit still. Since r
esearch shows that students learn better when they can pay attention and focus, we really need these cha
irs!  \r\nWobble Chairs transform the boring conventional seat into a chair that really ROCKS!  Some st
udents need a little more help than others when it comes to paying attention, focusing and learning.  Wo
bble chairs allow children to move and flex without leaving their seat.nannan
==================================================
My students are all new to personal finance with many of them never having any type of finance discussio
n at home. This class is an elective so I try to make it as fun as possible by using interactive lesson
s. The majority of my students get free or reduced-price lunch and I hope to break the cycle of poverty
for some of them by making sure they know all the components of what the world holds for them after they
graduate whether they go to college or not.My students are learning to create spending plans during the
budgeting portion of the personal finance class.  One way people create spending plans is to use Financi
al Technology to make it easier for every day life.  My students need to explore different apps availabl
e to consumers such as YNAB and Mint.  The best way to see these apps is through a tablet.  My students
will share this tablet during group time to compare and contrast different financial technology avenues.
The iPad will get students excited about creating budgets and hopefully will allow them to continue usin
g these techniques once they have jobs and money to spend.nannan
==================================================
My students come to school eager to learn and excited about what the day has in store. \r\nI teach at a
Title 1 school in Oklahoma City where 100% of our students receive free breakfast and lunch, for some th
is will be the only meals they eat.  \r\nMany of my students are ELL students, where Spanish is their fi
rst language. My students may face many obstacles but they don't let that stop them.  They want to be in
school because they want to learn so that they can be successful one day.\r\nHands on activities are the
best for all students, especially kindergarteners. Having these stem items in my class room will allow m
y students to explore science through hands on leaning and exploration.\r\nThe art of teaching is the ar
t of assisting discovery. - Mark Van Doren. \r\nWater, magents, and how things move are very intriguing
to young children. The stem science station will provide my students the opportunity to explore magnets,
explore objects that sink and float, and explore motion. \r\nThe fairy tale stem kit will give my studen
ts the chance to see fairy tales in a whole new way. They will be able to retell the fairytales through
hands on activities.nannan
==================================================
Majority, if not all, of our students come from low-socioeconomic backgrounds. All students are eligible
for free breakfast and lunch. Yet, once they come in our school they are the richest students around. \r
\n\r\nOur boys and girls become the future of our community regardless of their backgrounds.\r\n\r\nOur
students work their hardest through cold winters at home, through hungry nights, and through what many a
dults couldn't face on a daily basis, the what if's. It's only fair we try to work our hardest too.\r\n
\r\nMy students will be able to create concrete objects by using a 3Doodler pen in various aspects in th
e classroom. My student's will be able to engage in reading by using the pen to create objects found in
the story, they will be able to use it to create 3D figures in math, and even depict various concepts in
science.\r\n\r\nMy students will enjoy drawing not with paper and pencil, but a with a very evolving asp
ect in our generation, technology. Who would have that that we would be able to create these vocabulary
words that are necessary for learning into concrete objects they can actually touch?!nannan
==================================================
My fourth grade students enter the classroom knowing their school year will be full of excitement.  They
know that Mr. B. makes it a priority to make learning fun and relevant.  Throughout the year I try and a
pply outdoor sports within the curriculum.  We take what we learned in class and apply it it to team spo
rts in a way that is engaging.  The outdoor events help keep the students motivated while retaining the
basics of what was taught in class through constant repetition.My students always try and get me to take
them outside.  I usually take them to read and write outside along with doing various science experiment
s too.  However, most kids just want to play!  So we came up with a great compromise.  \r\n\r\nMy studen
ts said we need to \"Sharpen the Saw\" based on our Leader in Me training from Franklin Covey's 7 Habits
of Highly Effective People.  I couldn't argue with their reasoning.  We began playing Multiplication Bas
eball.  Basically it is whiffleball using multiplication facts as my pitches.  The kids have to get the
problem right before I pitch the ball.  They love it!  So we decided to take it a step further.  This is
```

```
where Academic Athletes was born.  It is my goal to form an after-school health and sports program while integrating academics as well.  Kids will learn about nutrition, team sports, and physical exercise thro
ugh various units.  They will know that it is OK to PLAY!!nannan
==================================================
```

In [68]:
```python
# 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 [69]:
```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced 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 were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 do not want to sit and do
worksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [70]:
```python
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.      The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou ever felt like you had ants in your pants and you needed to groove and move as you were in a meeting?
This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble c
hairs 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 works
heets. They want to learn to count by jumping and playing. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My students will forget they are doing
work and just have the fun a 6 year old deserves.nannan
```

In [71]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitive dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd 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 were in a meeting This is how m
y kids feel all the time The want to be able to move as they learn or so they say Wobble chairs are the
answer and I love then because they develop their core which enhances gross motor and in Turn fine motor
skills They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves nannan
```

In [72]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing for Train Data

In [73]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xtr.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 49041/49041 [00:32<00:0
0, 1498.16it/s]
```

In [74]:
```
# after preprocesing
preprocessed_essays_xtr[300]
```

Out[74]:
```
'students come school eager learn excited day store teach title 1 school oklahoma city 100 students rece
ive free breakfast lunch meals eat many students ell students spanish first language students may face m
any obstacles not let stop want school want learn successful one day hands activities best students espe
cially kindergarteners stem items class room allow students explore science hands leaning exploration ar
t teaching art assisting discovery mark van doren water magents things move intriguing young children st
em science station provide students opportunity explore magnets explore objects sink float explore motio
n fairy tale stem kit give students chance see fairy tales whole new way able retell fairytales hands ac
tivities nannan'
```

In [75]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xcv.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155 [00:16<00:0
0, 1485.88it/s]
```

In [76]:
```
# after preprocesing
preprocessed_essays_xcv[300]
```

Out[76]:
```
'students come walks life many different experiences come range prior knowledge skills beliefs backgroun
ds languages half class speaks spoken home another language would like offer students ability learn life
despite differences school distinctive fact despite differences students teachers parents family science
important classroom answer questions young minds children exposed science able learn must communicate ot
hers listen others patience set minds knowing help solve problems within world students also learn impor
tance life cycles water animals plants life would different not donation project would teach students ev
en though may small able help world big way nannan'
```

In [77]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xte.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052 [00:22<00:0
0, 1578.74it/s]
```

In [78]:
```
# after preprocesing
preprocessed_essays_xte[300]
```

Out[78]:
```
'participate no excuses university class college bound every morning start day eagles chant school also
heavily focused arts academy creative expression students busily preparing middle school want everything
need successful enjoy positive role models younger students campus school serves diverse population majo
rity students low income families always arrive eager learn full curiosity desire showcase knowledge new
creative ways students love athletics morning full learning ready play teachers school rotate running di
fferent sporting events tournaments lunch students materials project go towards lunchtime soccer games b
asketball tournaments kick ball tournaments football games lunchtime yoga classes need equipment expand
number students participate types tournaments hold students must work completed exemplary behavior parti
cipate team tournaments contributing project promoting staying active learning teamwork promoting good c
itizenship nannan'
```

1.4 Preprocessing of `project_title`

In [79]:
```
# similarly you can preprocess the titles also
#printing random titles
print(data['project_title'].values[49])
print("="*50)
print(data['project_title'].values[89])
print("="*50)
print(data['project_title'].values[999])
print("="*50)
print(data['project_title'].values[11156])
print("="*50)
print(data['project_title'].values[20000])
print("="*50)
```

```
Rainy Day Run Around!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
We Need To Move It While We Input It!
==================================================
```

In [80]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta",  "Got to",  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 [81]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [82]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [83]:
```
#Removing stop words from the preprocessed titles
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 't
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while',
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'agai
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [84]:
```
preprocessed_titles_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xtr.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 49041/49041 [00:01<00:0
0, 30363.78it/s]
```

In [85]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles_xtr[89])
print("="*50)
```

```
science math technology
==================================================
```

In [86]:
```
preprocessed_titles_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xcv.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155 [00:00<00:0
0, 28549.36it/s]
```

In [87]:
```
print(preprocessed_titles_xcv[89])
print("="*50)
```

```
tiny hands big indoor garden
==================================================
```

In [88]:
```
preprocessed_titles_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xte.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052 [00:01<00:0
0, 29048.42it/s]
```

In [89]:
```
print(preprocessed_titles_xte[89])
print("="*50)
```

```
stem supplies kippsters
==================================================
```

1.5 Preparing data for models

In [90]:
```
data.columns
```

Out[90]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'price', 'quantity'],
      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/)

2.2.1 One hot encoding categorical feature : State

In [91]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

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

#We use fit only for train data
vectorizer_state = CountVectorizer(binary=True)
vectorizer_state.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_state.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer_state.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer_state.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer_state.get_feature_names())
print("="*75)
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks',
'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'n
y', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
===========================================================================
```

2.2.2 One hot encoding the categorical features : teacher_prefix

In [92]:
```
# we use count vectorizer to convert the values into one
#We use fit only for train data
vectorizer_tp = CountVectorizer(binary=True)
vectorizer_tp.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_tp.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer_tp.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer_tp.transform(X_test['teacher_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer_tp.get_feature_names())
print("="*50)
```

```
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
==================================================
```

2.2.3 One hot encoding the categorical features : grades

In [93]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-on-
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[93]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [94]:
```
#We use fit only for train data
vectorizer_grade = CountVectorizer()
vectorizer_grade.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_grade.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer_grade.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer_grade.transform(X_test['project_grade_category'].values)

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer_grade.get_feature_names())
print("="*70)
```

```
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
======================================================================
```

2.2.4 One hot encoding the categorical features : project subject category

In [95]:
```
#We use fit only for train data
vectorizer_category = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), binary=True)
vectorizer_category.fit(X_train['clean_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat_ohe = vectorizer_category.transform(X_train['clean_categories'].values)
X_cv_cat_ohe = vectorizer_category.transform(X_cv['clean_categories'].values)
X_test_cat_ohe = vectorizer_category.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_cat_ohe.shape, y_train.shape)
print(X_cv_cat_ohe.shape, y_cv.shape)
print(X_test_cat_ohe.shape, y_test.shape)
print(vectorizer_category.get_feature_names())
print("="*70)
```

```
After vectorizations
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', 'Health_Spo
rts', 'Math_Science', 'Literacy_Language']
======================================================================
```

2.2.5 One hot encoding the categorical features : project subject sub-category

In [96]:
```
#We use fit only for train data
vectorizer_subcat = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), binary=True)
vectorizer_subcat.fit(X_train['clean_subcategories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat_ohe = vectorizer_subcat.transform(X_train['clean_subcategories'].values)
X_cv_subcat_ohe = vectorizer_subcat.transform(X_cv['clean_subcategories'].values)
X_test_subcat_ohe = vectorizer_subcat.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcat_ohe.shape, y_train.shape)
print(X_cv_subcat_ohe.shape, y_cv.shape)
print(X_test_subcat_ohe.shape, y_test.shape)
print(vectorizer_subcat.get_feature_names())
print("="*70)
```

```
After vectorizations
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular', 'Civics_G
overnment', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger', 'SocialSciences', 'Perfor
mingArts', 'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_Geograph
y', 'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArt
s', 'Health_Wellness', 'AppliedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literac
y']
======================================================================
```

1.5.2 Vectorizing Text data

i) BoW encoding

1.5.2.1 Bag of words on Essay Feature

In [97]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
#Applying BoW on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import CountVectorizer
vectorizer_essay_bow = CountVectorizer(min_df=10)
vectorizer_essay_bow.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xtr)
X_cv_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xcv)
X_test_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xte)

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

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12056) (49041,)
(24155, 12056) (24155,)
(36052, 12056) (36052,)
====================================================================================================
```

1.5.2.2 Bag of words on Project Title feature

In [98]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
#Applying BoW on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import CountVectorizer
vectorizer_titles_bow = CountVectorizer(min_df=10)
vectorizer_titles_bow.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xtr)
X_cv_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xcv)
X_test_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_bow.shape, y_train.shape)
print(X_cv_titles_bow.shape, y_cv.shape)
print(X_test_titles_bow.shape, y_test.shape)
print("="*100)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2103) (49041,)
(24155, 2103) (24155,)
(36052, 2103) (36052,)
====================================================================================================
```

ii) TFIDF Vectorization

TFIDF vectorizer on essay feature

In [99]:
```
#Applying TF-IDF on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)
vectorizer_essay_tfidf.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xtr)
X_cv_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xcv)
X_test_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xte)

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

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12056) (49041,)
(24155, 12056) (24155,)
(36052, 12056) (36052,)
====================================================================================================
```

TFIDF on Project Title feature

In [100]:
```
#Applying Tfidf on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xtr)
X_cv_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xcv)
X_test_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_tfidf.shape, y_train.shape)
print(X_cv_titles_tfidf.shape, y_cv.shape)
print(X_test_titles_tfidf.shape, y_test.shape)
print("="*100)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2103) (49041,)
(24155, 2103) (24155,)
(36052, 2103) (36052,)
====================================================================================================
```

1.5.3 Vectorizing Numerical features

For Price feature

In [101]:
```
from sklearn.preprocessing import Normalizer
price_normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
price_normalizer.fit(X_train['price'].values.reshape(1,-1))

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

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

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [102]:
```
X_train_price_norm = X_train_price_norm.T
X_cv_price_norm = X_cv_price_norm.T
X_test_price_norm = X_test_price_norm.T

print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

For Quantity

In [103]:
```
#Normalizing quantity
from sklearn.preprocessing import Normalizer
quan_normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
quan_normalizer.fit(X_train['quantity'].values.reshape(1,-1))

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

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

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [104]:
```
X_train_quantity_norm = X_train_quantity_norm.T
X_cv_quantity_norm = X_cv_quantity_norm.T
X_test_quantity_norm = X_test_quantity_norm.T

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

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

For teacher previously posted projects

In [105]:
```
# Normalizing teacher previously posted projects
from sklearn.preprocessing import Normalizer
tpp_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.
tpp_normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

X_train_tpp_norm = tpp_normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values
X_cv_tpp_norm = tpp_normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.resha
X_test_tpp_norm = tpp_normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.

print("After vectorizations")
print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [106]:
```
X_train_tpp_norm = X_train_tpp_norm.T
X_cv_tpp_norm = X_cv_tpp_norm.T
X_test_tpp_norm = X_test_tpp_norm.T

print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

```
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

1.5.4 Merging Numerical & Categorical features

- we need to merge all the numerical vectors & catogorical features

In [107]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_numcat = hstack((X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe, X_train_price_norm, X_tra
X_cv_numcat = hstack((X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, X_cv_price_norm, X_cv_cat_ohe, X_(
X_te_numcat = hstack((X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe, X_test_price_norm, X_test_ca

print("Final Data matrix")
print(X_tr_numcat.shape, y_train.shape)
print(X_cv_numcat.shape, y_cv.shape)
print(X_te_numcat.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 102) (49041,)
(24155, 102) (24155,)
(36052, 102) (36052,)
====================================================================================================
```

In [108]:
```
"""
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape"""
```

Out[108]:
```
'"\n# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039\nfrom (https://stackoverfl
ow.com/a/19710648/4084039\nfrom) scipy.sparse import hstack\n# with the same hstack function we are conc
atinating a sparse matrix and a dense matirx :)\nX = hstack((categories_one_hot, sub_categories_one_hot,
text_bow, price_standardized))\nX.shape'
```

In [109]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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 Naive Bayes on BOW, SET 1

Consider Set 1 :- categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

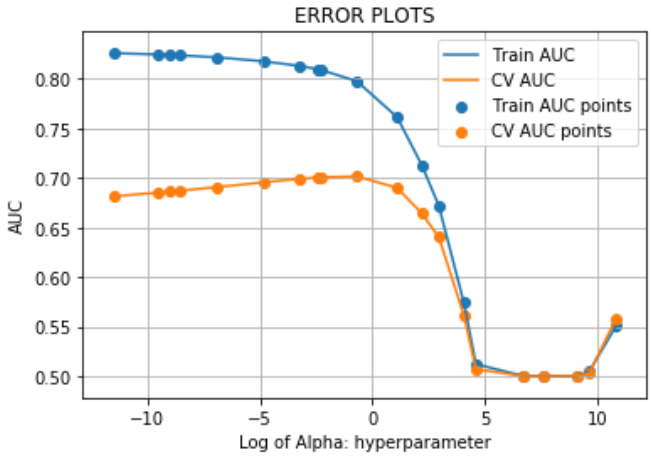
In [110]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set1 = hstack((X_train_essay_bow, X_train_titles_bow, X_tr_numcat )).tocsr()
X_cv_set1 = hstack((X_cv_essay_bow, X_cv_titles_bow, X_cv_numcat)).tocsr()
X_te_set1 = hstack((X_test_essay_bow, X_test_titles_bow, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set1.shape, y_train.shape)
print(X_cv_set1.shape, y_cv.shape)
print(X_te_set1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14261) (49041,)
(24155, 14261) (24155,)
(36052, 14261) (36052,)
====================================================================================================
```

In [111]:
```
def batch_predict(clf, data):
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class

# not the predicted outputs

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

    return y_data_pred
```

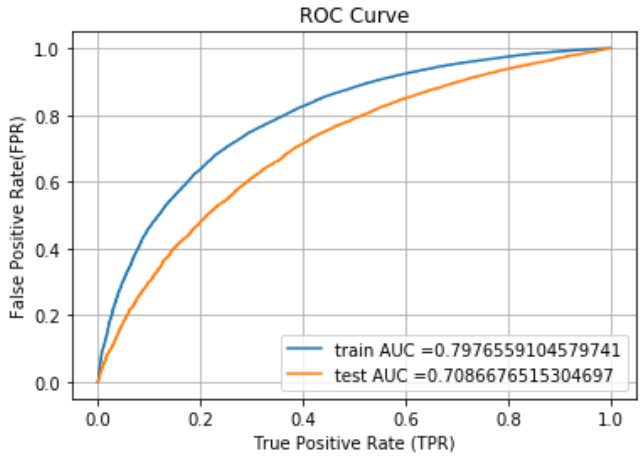
In [112]:
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math

alpha = [0.00001, 0.00007, 0.00012, 0.00019, 0.001, 0.008, 0.04, 0.09, 0.1, 0.5, 3, 9, 19, 58, 99, 825, 2

train_auc = []
cv_auc = []
a = []
b = []

for i in tqdm(alpha):
    naive = MultinomialNB(alpha=i, class_prior=[0.5,0.5])
    naive.fit(X_tr_set1, y_train)
    y_train_pred = batch_predict(naive, X_tr_set1)
    y_cv_pred = batch_predict(naive, X_cv_set1)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    a.append(y_train_pred)
    b.append(y_cv_pred)

log_alpha = []
for z in tqdm(alpha):
    y= math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)
alpha = np.array(alpha)

plt.plot(log_alpha, train_auc, label='Train AUC')
plt.plot(log_alpha, cv_auc, label='CV AUC')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Log of Alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|████████████████████████████████████████████████████████████████████████████| 20/20 [00:05<0
0:00,  5.11it/s]
100%|████████████████████████████████████████████████████████████████████████████| 20/20 [00:00<00:0
0, 20006.22it/s]
```



In [113]:
```
# from the error plot we choose alpha such that, we will have maximum AUC on cv data and gap between the t
best_a = 0.5
```

In [114]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_cur
from sklearn.metrics import roc_curve, auc

naive = MultinomialNB(alpha=best_a, class_prior=[0.5,0.5])
naive.fit(X_tr_set1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(naive, X_tr_set1)
y_test_pred = batch_predict(naive, X_te_set1)

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

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



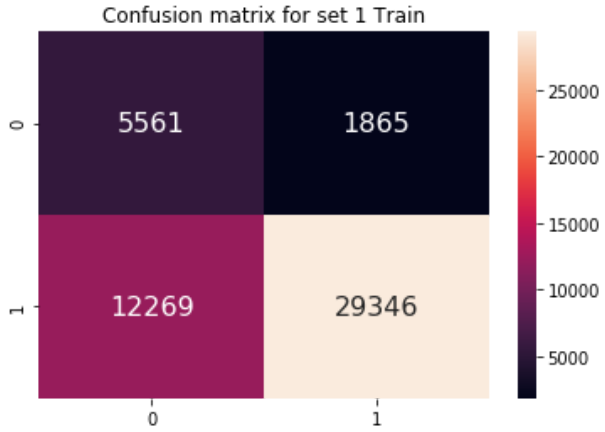
In [115]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [117]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.52807664968067 for threshold 0.575
[[ 5561  1865]
 [12269 29346]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.52807664968067 for threshold 0.575
[[ 3465  1994]
 [ 9774 20819]]
```

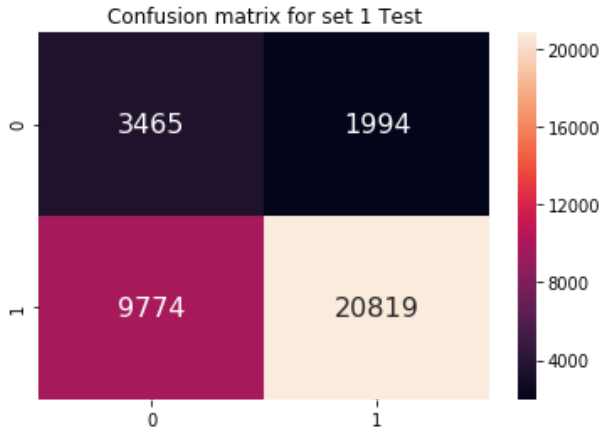
In [118]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5561,1865],
        [12269,29346]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 1 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[118]: <matplotlib.axes._subplots.AxesSubplot at 0x1e436530358>



In [119]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3465,1994],
        [9774,20819]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 1 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[119]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1e4921ffeb8>
```



2.4.1.1 Top 10 important features of positive class from SET 1

In [120]:
```
#how to calculate feature probability score in naive bayes python - https://www.datacamp.com/community/tut
#how to calculate feature probability score in naive bayes python- https://towardsdatascience.com/naive-ba
nb_bow = MultinomialNB(alpha = 0.5)
nb_bow.fit(X_tr_set1, y_train)
```

Out[120]:
```
MultinomialNB(alpha=0.5, class_prior=None, fit_prior=True)
```

In [121]:
```
bow_features_probs = []

for x in range(14261) :
    y = naive.feature_log_prob_[1,x]
    bow_features_probs.append(y)

len(bow_features_probs)
```

Out[121]:
```
14261
```

In [122]:
```
bow_features_names = []
```

In [123]:
```
for _ in vectorizer_state.get_feature_names() :
    bow_features_names.append(_)
```

In [124]:
```
for _ in vectorizer_tp.get_feature_names() :
    bow_features_names.append(_)
```

In [125]:
```
for _ in vectorizer_grade.get_feature_names() :
    bow_features_names.append(_)
```

In [126]:
```
for _ in  vectorizer_category.get_feature_names() :
    bow_features_names.append(_)
```

In [127]:
```
for _ in vectorizer_subcat.get_feature_names() :
    bow_features_names.append(_)
```

In [128]:
```
for _ in vectorizer_essay_bow.get_feature_names() :
    bow_features_names.append(_)
```

In [129]:
```
for _ in vectorizer_titles_bow.get_feature_names() :
    bow_features_names.append(_)
```

In [130]:
```
bow_features_names.append('price')
bow_features_names.append('quantity')
bow_features_names.append('teacher_number_of_previously_posted')
```

In [131]:
```
len(bow_features_names)
```

Out[131]: 14261

In [132]:
```
final_bow_features_set1_pos = pd.DataFrame({'feature_prob_estimates' : bow_features_probs, 'feature_names
```

In [133]:
```
final_bow_features_set1_pos.sort_values(by = ['feature_prob_estimates'], ascending = True, inplace=True)
```

In [134]:
```
final_bow_features_set1_pos.head(10)
```

Out[134]:

	feature_prob_estimates	feature_names
14246	-16.297731	year
14230	-16.297731	working
14247	-16.297731	yearbook
14220	-16.297731	wobbles
14236	-16.297731	worms
14245	-16.297731	ye
14221	-16.297731	wobbling
14222	-16.297731	wobbly
14244	-16.297731	xylophone
14223	-16.297731	wonder

2.4.1.2 Top 10 important features of negative class from SET 1

In [135]:
```
bow_features_neg_probs1 = []
for z in range(14261) :
    z1 = naive.feature_log_prob_[0,z]
    bow_features_neg_probs1.append(z1)
```

In [136]:
```
final_features_bow_set1_neg = pd.DataFrame({'feature_prob_estimates' : bow_features_neg_probs1,'feature_na
```

In [137]:
```
final_features_bow_set1_neg.sort_values(by = ['feature_prob_estimates'], ascending=True,inplace=True)
```

In [138]:
```
final_features_bow_set1_neg.head(10)
```

Out[138]:

	feature_prob_estimates	feature_names
11122	-14.524942	touchpad
8206	-14.524942	portland
9927	-14.524942	skin
2703	-14.524942	cozy
13619	-14.524942	pretend
6860	-14.524942	menu
13618	-14.524942	presentations
2692	-14.524942	cousins
796	-14.524942	appalachian
5145	-14.524942	hardware

2.4.2 Applying Naive Bayes on TFIDF, SET 2

Consider Set 2 :- categorical, numerical features + project_title(TFIDF) + preprocessed_essay (TFIDF)

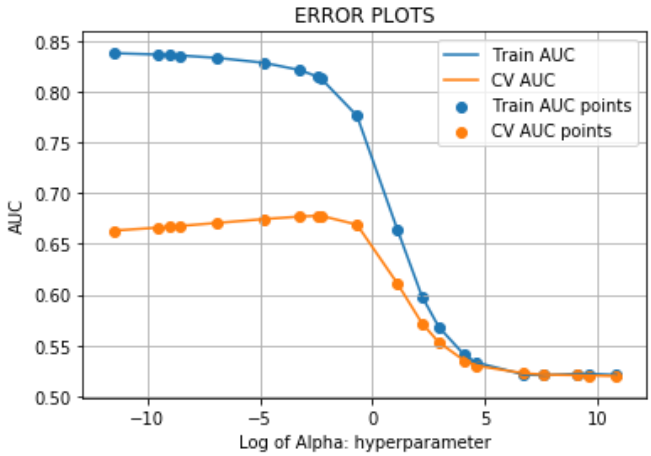
In [139]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set2 = hstack((X_train_essay_tfidf, X_train_titles_tfidf, X_tr_numcat )).tocsr()
X_cv_set2 = hstack((X_cv_essay_tfidf, X_cv_titles_tfidf, X_cv_numcat)).tocsr()
X_te_set2 = hstack((X_test_essay_tfidf, X_test_titles_tfidf, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set2.shape, y_train.shape)
print(X_cv_set2.shape, y_cv.shape)
print(X_te_set2.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14261) (49041,)
(24155, 14261) (24155,)
(36052, 14261) (36052,)
====================================================================================================
```

In [140]:
```
def batch_predict(clf, data):
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

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

    return y_data_pred
```

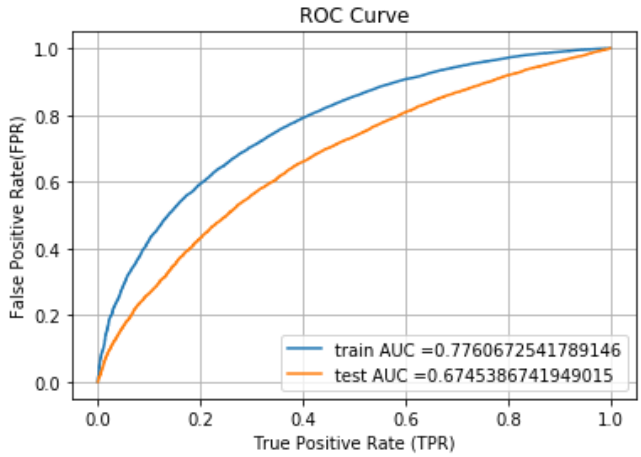
In [141]:
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math

alpha = [0.00001, 0.00007, 0.00012, 0.00019, 0.001, 0.008, 0.04, 0.09, 0.1, 0.5, 3, 9, 19, 58, 99, 825, 2

train_auc = []
cv_auc = []
a = []
b = []

for i in tqdm(alpha):
    naive = MultinomialNB(alpha=i, class_prior=[0.5,0.5])
    naive.fit(X_tr_set2, y_train)
    y_train_pred = batch_predict(naive, X_tr_set2)
    y_cv_pred = batch_predict(naive, X_cv_set2)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    a.append(y_train_pred)
    b.append(y_cv_pred)

log_alpha = []
for z in tqdm(alpha):
    y= math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)
alpha = np.array(alpha)

plt.plot(log_alpha, train_auc, label='Train AUC')
plt.plot(log_alpha, cv_auc, label='CV AUC')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Log of Alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████| 20/20 [00:04<0
0:00,  5.09it/s]
100%|██████████| 20/20 [00:00<00:0
0, 19987.15it/s]
```



In [142]:
```
# from the error plot we choose alpha such that, we will have maximum AUC on cv data and gap between the t
best_a = 0.5
```

In [143]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_cur
from sklearn.metrics import roc_curve, auc

naive = MultinomialNB(alpha=best_a, class_prior=[0.5,0.5])
naive.fit(X_tr_set2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(naive, X_tr_set2)
y_test_pred = batch_predict(naive, X_te_set2)

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

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



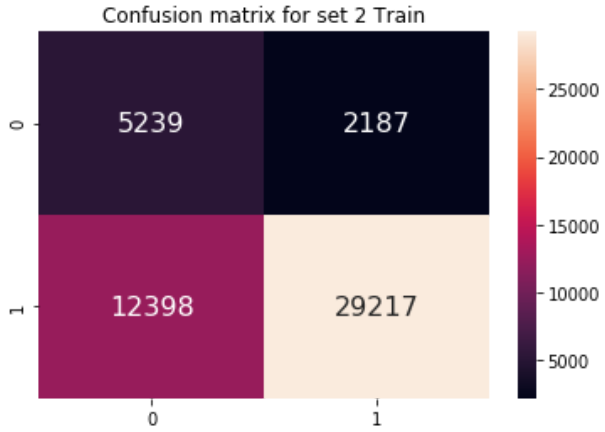
In [144]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [146]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.49531237101902936 for threshold 0.52
[[ 5239  2187]
 [12398 29217]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.49531237101902936 for threshold 0.52
[[ 3151  2308]
 [ 9779 20814]]
```

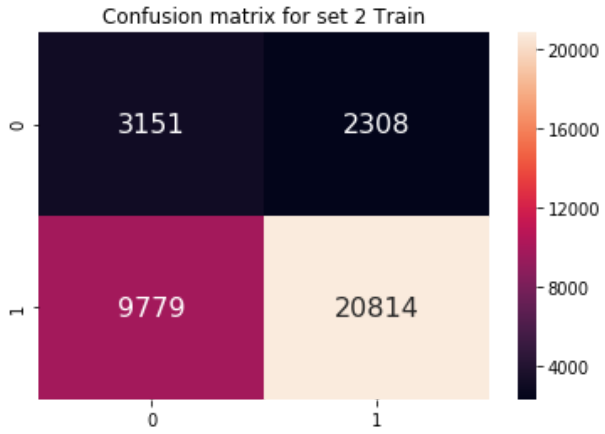
In [147]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5239,2187],
        [12398,29217]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 2 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[147]: <matplotlib.axes._subplots.AxesSubplot at 0x1e49227a940>



In [148]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3151,2308],
        [9779,20814]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 2 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[148]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1e402087390>
```



2.4.2.1 Top 10 important features of positive class from SET 2

In [149]:
```
#how to calculate feature probability score in naive bayes python - https://www.datacamp.com/community/tut
#how to calculate feature probability score in naive bayes python- https://towardsdatascience.com/naive-ba
nb_tfidf = MultinomialNB(alpha = 0.5)
nb_tfidf.fit(X_tr_set2, y_train)
```

Out[149]:
```
MultinomialNB(alpha=0.5, class_prior=None, fit_prior=True)
```

In [150]:
```
tfidf_features_probs = []
```

In [151]:
```
for c in range(14261) :
    d = naive.feature_log_prob_[1,c]
    tfidf_features_probs.append(d)
```

In [152]:
```
len(tfidf_features_probs)
```

Out[152]:
```
14261
```

In [153]:
```
tfidf_features_names = []
```

In [154]:
```
for _ in vectorizer_state.get_feature_names() :
    tfidf_features_names.append(_)
```

In [155]:
```
for _ in vectorizer_tp.get_feature_names() :
    tfidf_features_names.append(_)
```

In [156]:
```
for _ in vectorizer_grade.get_feature_names() :
    tfidf_features_names.append(_)
```

In [157]:
```
for _ in  vectorizer_category.get_feature_names() :
    tfidf_features_names.append(_)
```

In [158]:
```
for _ in vectorizer_subcat.get_feature_names() :
    tfidf_features_names.append(_)
```

In [159]:
```
for _ in vectorizer_essay_tfidf.get_feature_names() :
    tfidf_features_names.append(_)
```

In [160]:
```
for _ in vectorizer_tfidf_title.get_feature_names() :
    tfidf_features_names.append(_)
```

In [161]:
```
tfidf_features_names.append('price')
tfidf_features_names.append('quantity')
tfidf_features_names.append('teacher_number_of_previously_posted')
```

In [162]:
```
len(tfidf_features_names)
```

Out[162]: 14261

In [163]:
```
final_tfidf_features_set2_pos = pd.DataFrame({'feature_prob_estimates' : tfidf_features_probs, 'feature_na
```

In [164]:
```
final_tfidf_features_set2_pos.sort_values(by = ['feature_prob_estimates'], ascending = True, inplace=True)
```

In [165]:
```
final_tfidf_features_set2_pos.head(10)
```

Out[165]:

	feature_prob_estimates	feature_names
14245	-13.94023	ye
14233	-13.94023	workshop
14244	-13.94023	xylophone
14243	-13.94023	writing
14242	-13.94023	writers
14241	-13.94023	writer
14220	-13.94023	wobbles
14240	-13.94023	write
14239	-13.94023	wow
14238	-13.94023	would

2.4.2.2 Top 10 important features of negative class from SET 2

In [168]:
```
tfidf_features_neg_probs = []
for a in range(14261) :
    bn = naive.feature_log_prob_[0,a]
    tfidf_features_neg_probs.append(bn)
```

In [169]:
```
final_features_tfidf_neg = pd.DataFrame({'feature_prob_estimates' : tfidf_features_neg_probs,'feature_name
```

In [170]:
```
final_features_tfidf_neg.sort_values(by = ['feature_prob_estimates'], ascending = True,inplace=True)
```

In [171]:
```
final_features_tfidf_neg.head(10)
```

Out[171]:

	feature_prob_estimates	feature_names
5067	-12.261929	gun
6838	-12.261929	membership
12728	-12.261929	easier
12725	-12.261929	ease
6771	-12.261929	may
3329	-12.261929	dismissal
6767	-12.261929	maximized
11264	-12.261929	tricycles
3331	-12.261929	disorder
708	-12.261929	amplified

3. Conclusions

In [172]:
```
# Please compare all your models using Prettytable library
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyper Parameter-Alpha value", "AUC"]
x.add_row(["BOW", "Naive Bayes", 0.5, 0.70])
x.add_row(["TFIDF", "Naive Bayes", 0.5, 0.67])
print(x)
```

```
+------------+-------------+-----------------------------+------+
| Vectorizer |    Model    | Hyper Parameter-Alpha value | AUC  |
+------------+-------------+-----------------------------+------+
|    BOW     | Naive Bayes |             0.5             | 0.7  |
|   TFIDF    | Naive Bayes |             0.5             | 0.67 |
+------------+-------------+-----------------------------+------+
```