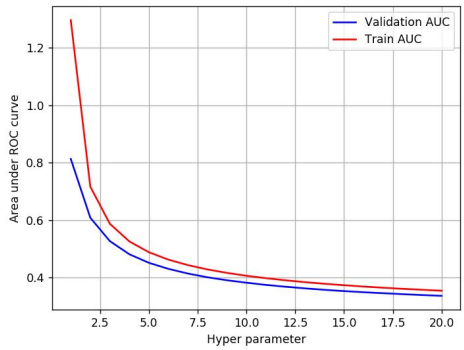
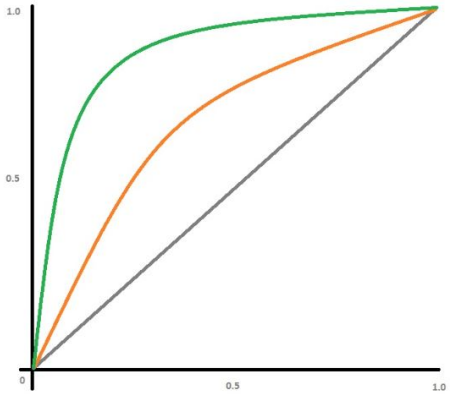
Assignment 6: Apply NB

1. **Apply Multinomial NB on these feature sets**
    - Set 1: categorical, numerical features + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + preprocessed_eassay (TFIDF)
2. **The hyper paramter tuning(find best alpha:smoothing parameter)**
    - Find the best hyper parameter which will give the maximum AUC value
    - find the best hyper paramter using k-fold cross validation(use GridsearchCV or RandomsearchCV)/simple cross validation data (write for loop to iterate over hyper parameter values)
    -
3. **Representation of results**
    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



    - 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 with predicted and original labels of test data points

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

4. fine the top 20 features from either from feature Set 1 or feature Set 2 using absolute 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
5. You need to summarize the results at the end of the notebook, summarize it in the table format

Vectorizer	Model	Hyper parameter	AUC
BOW	Brute	7	0.78
TFIDF	Brute	12	0.79
W2V	Brute	10	0.78

TFIDFW2V	Brute	6	0.78

2. Naive Bayes

In [1]:

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

import pandas as pd
import numpy as np
import nltk
import matplotlib.pyplot as plt
import seaborn as sns
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

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/

import pickle
from tqdm import tqdm
import os

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

1.1 Loading Data

In [2]:

```
import pandas as pd

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

In [3]:

```
project_data.shape
```

Out[3]:

```
(109248, 17)
```

In [4]:

```
project_data.columns
```

Out[4]:

```
Index(['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'],
      dtype='object')
```

In [5]:

```
project_data['project_is_approved'].value_counts()
```

Out[5]:

```
1    92706
0    16542
Name: project_is_approved, dtype: int64
```

In [6]:

```
resource_data.shape
```

Out[6]:

```
(1541272, 4)
```

In [8]:

```
resource_data.columns
```

Out[8]:

```
Index(['id', 'description', 'quantity', 'price'], dtype='object')
```

In [9]:

```
resource_data.head()
```

Out[9]:

	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
2	p069063	Cory Stories: A Kid's Book About Living With Adhd	1	8.45
3	p069063	Dixon Ticonderoga Wood-Cased #2 HB Pencils, Bo...	2	13.59
4	p069063	EDUCATIONAL INSIGHTS FLUORESCENT LIGHT FILTERS...	3	24.95

In [10]:

```
project_data.head()
```

Out[10]:

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

Unnamed:	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate

###2. Preprocessing Categorical Features: project_grade_category

project_grade_category

In [11]:

```
project_data['project_grade_category'].value_counts()
```

Out[11]:

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

In [12]:

```
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[12]:

```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [29]:

```
#we need to remove the spaces, replace the '-' with '_' and convert all the letters to small
```

project_subject_categories

In [13]:

```
project_data['project_subject_categories'].value_counts()
```

Out[13]:

```
Literacy & Language                           23655
Math & Science                                17072
Literacy & Language, Math & Science           14636
Health & Sports                               10177
Music & The Arts                               5180
Special Needs                                  4226
Literacy & Language, Special Needs             3961
Applied Learning                               3771
Math & Science, Literacy & Language            2289
Applied Learning, Literacy & Language          2191
History & Civics                               1851
Math & Science, Special Needs                  1840
Literacy & Language, Music & The Arts          1757
Math & Science, Music & The Arts               1642
Applied Learning, Special Needs                1467
History & Civics, Literacy & Language          1421
Health & Sports, Special Needs                 1391
Warmth, Care & Hunger                          1309
```

```
Math & Science, Applied Learning                1220
Applied Learning, Math & Science                1052
Literacy & Language, History & Civics            809
Health & Sports, Literacy & Language             803
Applied Learning, Music & The Arts               758
Math & Science, History & Civics                 652
Literacy & Language, Applied Learning            636
Applied Learning, Health & Sports                608
Math & Science, Health & Sports                  414
History & Civics, Math & Science                 322
History & Civics, Music & The Arts               312
Special Needs, Music & The Arts                  302
Health & Sports, Math & Science                  271
History & Civics, Special Needs                  252
Health & Sports, Applied Learning                192
Applied Learning, History & Civics               178
Health & Sports, Music & The Arts                155
Music & The Arts, Special Needs                  138
Literacy & Language, Health & Sports              72
Health & Sports, History & Civics                 43
Special Needs, Health & Sports                    42
History & Civics, Applied Learning                42
Health & Sports, Warmth, Care & Hunger            23
Special Needs, Warmth, Care & Hunger              23
Music & The Arts, Health & Sports                 19
Music & The Arts, History & Civics                18
History & Civics, Health & Sports                 13
Math & Science, Warmth, Care & Hunger             11
Music & The Arts, Applied Learning                10
Applied Learning, Warmth, Care & Hunger           10
Literacy & Language, Warmth, Care & Hunger         9
Music & The Arts, Warmth, Care & Hunger            2
History & Civics, Warmth, Care & Hunger            1
Name: project_subject_categories, dtype: int64
```

In [14]:

```
project_data['project_subject_categories'] =
project_data['project_subject_categories'].str.replace(' The ','')
project_data['project_subject_categories'] =
project_data['project_subject_categories'].str.replace(' ','')
project_data['project_subject_categories'] =
project_data['project_subject_categories'].str.replace('&','_')
project_data['project_subject_categories'] =
project_data['project_subject_categories'].str.replace(',','_')
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.lower(
)
project_data['project_subject_categories'].value_counts()
```

Out[14]:

```
literacy_language                       23655
math_science                            17072
literacy_language_math_science          14636
health_sports                           10177
music_arts                               5180
specialneeds                             4226
literacy_language_specialneeds           3961
appliedlearning                          3771
math_science_literacy_language           2289
appliedlearning_literacy_language        2191
history_civics                           1851
math_science_specialneeds                1840
literacy_language_music_arts             1757
math_science_music_arts                  1642
appliedlearning_specialneeds             1467
history_civics_literacy_language         1421
health_sports_specialneeds               1391
warmth_care_hunger                       1309
math_science_appliedlearning             1220
appliedlearning_math_science             1052
literacy_language_history_civics          809
health_sports_literacy_language           803
appliedlearning_music_arts                758
math_science_history_civics               652
literacy_language_appliedlearning         636
```

```
appliedlearning_health_sports              608
math_science_health_sports                 414
history_civics_math_science                322
history_civics_music_arts                  312
specialneeds_music_arts                    302
health_sports_math_science                 271
history_civics_specialneeds                252
health_sports_appliedlearning              192
appliedlearning_history_civics             178
health_sports_music_arts                   155
music_arts_specialneeds                    138
literacy_language_health_sports             72
health_sports_history_civics                43
specialneeds_health_sports                  42
history_civics_appliedlearning              42
health_sports_warmth_care_hunger            23
specialneeds_warmth_care_hunger             23
music_arts_health_sports                    19
music_arts_history_civics                   18
history_civics_health_sports                13
math_science_warmth_care_hunger             11
music_arts_appliedlearning                  10
appliedlearning_warmth_care_hunger          10
literacy_language_warmth_care_hunger         9
music_arts_warmth_care_hunger                2
history_civics_warmth_care_hunger            1
Name: project_subject_categories, dtype: int64
```

In [30]:

```
#remove spaces, 'the'
#replace '&' with '_', and ',' with '_'
```

teacher_prefix

In [15]:

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

Out[15]:

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

In [16]:

```
# check if we have any nan values are there
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 [31]:

```
#numebr of missing values are very less in number, we can replace it with Mrs. as most of the proj
ects are submitted by Mrs.
```

In [17]:

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

In [18]:

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

Out[18]:

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

In [32]:

```
#Remove '.'
#convert all the chars to small
```

In [19]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('.','')
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

Out[19]:

```
mrs        57272
ms         38955
mr         10648
teacher     2360
dr            13
Name: teacher_prefix, dtype: int64
```

project_subject_subcategories

In [20]:

```
project_data['project_subject_subcategories'].value_counts()
```

Out[20]:

```
Literacy                                     9486
Literacy, Mathematics                        8325
Literature & Writing, Mathematics            5923
Literacy, Literature & Writing               5571
Mathematics                                  5379
                                             ...
Economics, Other                                1
Parent Involvement, Warmth, Care & Hunger       1
History & Geography, Warmth, Care & Hunger      1
ESL, Economics                                  1
Economics, Music                                1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

In [21]:

```
project_data['project_subject_subcategories'] = project_data['project_subject_subcategories'].str.
replace(' The ','')
project_data['project_subject_subcategories'] = project_data['project_subject_subcategories'].str.
replace(' ','')
project_data['project_subject_subcategories'] = project_data['project_subject_subcategories'].str.
replace('&','_')
project_data['project_subject_subcategories'] = project_data['project_subject_subcategories'].str.
replace(',','_')
project_data['project_subject_subcategories'] = project_data['project_subject_subcategories'].str.
lower()
project_data['project_subject_subcategories'].value_counts()
```

Out[21]:

```
literacy                                 9486
literacy_mathematics                     8325
literature_writing_mathematics           5923
```

```
literature_writing_mathematics          5923
literacy_literature_writing             5571
mathematics                             5379
                                        ...
economics_nutritioneducation               1
extracurricular_financialliteracy          1
economics_foreignlanguages                 1
gym_fitness_socialsciences                 1
parentinvolvement_warmth_care_hunger       1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

In [36]:

```
# we replace ',' ''&''The' and change all the letters in the lower case
```

school_state

In [22]:

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

Out[22]:

```
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
```

In [38]:

```
#convert all of them into small letters
```

In [23]:

```
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[23]:

```
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
```

project_title

In [24]:

```
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 [25]:

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

In [26]:

```
project_data['project_title'].head(5)
```

Out[26]:

```
0     Educational Support for English Learners at Home
1                Wanted: Projector for Hungry Learners
2    Soccer Equipment for AWESOME Middle School Stu...
3                               Techie Kindergarteners
4                               Interactive Math Tools
Name: project_title, dtype: object
```

In [27]:

```
print("printing some random reviews")
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])
```

```
printing some random reviews
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!
```

In [28]:

```
# Combining all the above stundents
from tqdm import tqdm
def preprocess_text(text_data):
    preprocessed_text = []
    # tqdm is for printing the status bar
    for sentance in tqdm(text_data):
        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        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_text.append(sent.lower().strip())
    return preprocessed_text
```

In [29]:

```
preprocessed_titles = preprocess_text(project_data['project_title'].values)
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:03<00:00, 30063.18it/s]
```

In [30]:

```
print("printing some random reviews")
print(9, preprocessed_titles[9])
print(34, preprocessed_titles[34])
print(147, preprocessed_titles[147])
```

```
printing some random reviews
9 love reading pure pleasure
34 ball
147 needs chromebook
```

essay

In [31]:

```
# 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 [32]:

```
print("printing some random essay")
print(9, project_data['essay'].values[9])
print('-'*50)
print(34, project_data['essay'].values[34])
print('-'*50)
print(147, project_data['essay'].values[147])
```

```
printing some random essay
9 Over 95% of my students are on free or reduced lunch.  I have a few who are homeless, but despit
e that, they come to school with an eagerness to learn.  My students are inquisitive eager
learners who  embrace the challenge of not having great books and other resources  every day.
Many of them are not afforded the opportunity to engage with these big colorful pages of a book on
a regular basis at home and they don't travel to the public library.  \r\nIt is my duty as a
teacher to do all I can to provide each student an opportunity to succeed in every aspect of life.
\r\nReading is Fundamental! My students will read these books over and over again while boosting t
heir comprehension skills. These books will be used for read alouds, partner reading and for
Independent reading. \r\nThey will engage in reading to build their \"Love for Reading\" by
reading for pure enjoyment. They will be introduced to some new authors as well as some old
favorites. I want my students to be ready for the 21st Century and know the pleasure of holding a
```

favorites. I want my students to be ready for the 21st century and know the pleasure of holding a good hard back book in hand. There's nothing like a good book to read! \r\nMy students will soar in Reading, and more because of your consideration and generous funding contribution. This will he lp build stamina and prepare for 3rd grade. Thank you so much for reading our proposal!nannan
---
34 My students mainly come from extremely low-income families, and the majority of them come from homes where both parents work full time. Most of my students are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm in the after-school program), and they all receive free and reduced meals for bre akfast and lunch. \r\n\r\n\r\nI want my students to feel as comfortable in my classroom as they d o at home. Many of my students take on multiple roles both at home as well as in school. They are sometimes the caretakers of younger siblings, cooks, babysitters, academics, friends, and most of all, they are developing who they are going to become as adults. I consider it an essential part of my job to model helping others gain knowledge in a positive manner. As a result, I have a commu nity of students who love helping each other in and outside of the classroom. They consistently lo ok for opportunities to support each other's learning in a kind and helpful way.I am excited to be experimenting with alternative seating in my classroom this school year. Studies have shown that g iving students the option of where they sit in a classroom increases focus as well as motivation. \r\n\r\n\r\nBy allowing students choice in the classroom, they are able to explore and create in a wel coming environment. Alternative classroom seating has been experimented with more frequently in re cent years. I believe (along with many others), that every child learns differently. This does not only apply to how multiplication is memorized, or a paper is written, but applies to the space in which they are asked to work. I have had students in the past ask \"Can I work in the library? Can I work on the carpet?\" My answer was always, \"As long as you're learning, you can work wherever you want!\" \r\n\r\nWith the yoga balls and the lap-desks, I will be able to increase the options for seating in my classroom and expand its imaginable space.nannan
---
147 My students are eager to learn and make their mark on the world.\r\n\r\nThey come from a Title 1 school and need extra love.\r\n\r\nMy fourth grade students are in a high poverty area and still come to school every day to get their education. I am trying to make it fun and educational for th em so they can get the most out of their schooling. I created a caring environment for the student s to bloom! They deserve the best.\r\nThank you!\r\nI am requesting 1 Chromebook to access online interventions, differentiate instruction, and get extra practice. The Chromebook will be used to s upplement ELA and math instruction. Students will play ELA and math games that are engaging and fu n, as well as participate in assignments online. This in turn will help my students improve their skills. Having a Chromebook in the classroom would not only allow students to use the programs at their own pace, but would ensure more students are getting adequate time to use the programs. The online programs have been especially beneficial to my students with special needs. They are able t o work at their level as well as be challenged with some different materials. This is making these students more confident in their abilities.\r\n\r\nThe Chromebook would allow my students to have daily access to computers and increase their computing skills.\r\nThis will change their lives for the better as they become more successful in school. Having access to technology in the classroom would help bridge the achievement gap.nannan

In [33]:

```
preprocessed_essays = preprocess_text(project_data['essay'].values)
```

```
100%|██████████████████████████████████████████████████████████████████| 109248/109248 [01:41<00:00, 1075.82it/s]
```

In [34]:

```
print("printing some random essay")
print(9, preprocessed_essays[9])
print('-'*50)
print(34, preprocessed_essays[34])
print('-'*50)
print(147, preprocessed_essays[147])
```

```
printing some random essay
9 95 students free reduced lunch homeless despite come school eagerness learn students inquisitive eager learners embrace challenge not great books resources every day many not afforded opportunity engage big colorful pages book regular basis home not travel public library duty teacher provide s tudent opportunity succeed every aspect life reading fundamental students read books boosting comp rehension skills books used read alouds partner reading independent reading engage reading build l ove reading reading pure enjoyment introduced new authors well old favorites want students ready 2 1st century know pleasure holding good hard back book hand nothing like good book read students so ar reading consideration generous funding contribution help build stamina prepare 3rd grade thank much reading proposal nannan
--------------------------------------------------
34 students mainly come extremely low income families majority come homes parents work full time s tudents school 7 30 6 00 pm 2 30 6 00 pm school program receive free reduced meals breakfast lunch want students feel comfortable classroom home many students take multiple roles home well school s ometimes caretakers younger siblings cooks babysitters academics friends developing going become a
```

```
dults consider essential part job model helping others gain knowledge positive manner result commu
nity students love helping outside classroom consistently look opportunities support learning kind
helpful way excited experimenting alternative seating classroom school year studies shown giving s
tudents option sit classroom increases focus well motivation allowing students choice classroom ab
le explore create welcoming environment alternative classroom seating experimented frequently rece
nt years believe along many others every child learns differently not apply multiplication
memorized paper written applies space asked work students past ask work library work carpet answer
always long learning work wherever want yoga balls lap desks able increase options seating
classroom expand imaginable space nannan
--------------------------------------------------
147 students eager learn make mark world come title 1 school need extra love fourth grade students
high poverty area still come school every day get education trying make fun educational get school
ing created caring environment students bloom deserve best thank requesting 1 chromebook access on
line interventions differentiate instruction get extra practice chromebook used supplement ela mat
h instruction students play ela math games engaging fun well participate assignments online turn h
elp students improve skills chromebook classroom would not allow students use programs pace would
ensure students getting adequate time use programs online programs especially beneficial students
special needs able work level well challenged different materials making students confident
abilities chromebook would allow students daily access computers increase computing skills change
lives better become successful school access technology classroom would help bridge achievement ga
p nannan
```

price

In [35]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[35]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [36]:

```
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [37]:

```
project_data['price'].head()
```

Out[37]:

```
0    154.60
1    299.00
2    516.85
3    232.90
4     67.98
Name: price, dtype: float64
```

applying StandardScaler

In [38]:

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(project_data['price'].values.reshape(-1, 1))
project_data['std_price']=scaler.transform(project_data['price'].values.reshape(-1, 1) )
```

In [39]:

```
project_data['std_price'].head()
```

Out[39]:

```
0   -0.390533
1    0.002396
2    0.595191
3   -0.177469
4   -0.626236
Name: std_price, dtype: float64
```

applying MinMaxScaler

In [40]:

```
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()
scaler.fit(project_data['price'].values.reshape(-1, 1))
project_data['nrm_price']=scaler.transform(project_data['price'].values.reshape(-1, 1))
```

In [41]:

```
project_data['nrm_price'].head()
```

Out[41]:

```
0    0.015397
1    0.029839
2    0.051628
3    0.023228
4    0.006733
Name: nrm_price, dtype: float64
```

title_counts

In [42]:

```
title_number_words=[]

for x in project_data['project_title']:
    y=len(x.split())
    title_number_words.append(y)
```

In [43]:

```
project_data['title_number_words']=title_number_words
```

essay_counts

In [44]:

```
essay_number_words=[]

for x in project_data['essay']:
    y=len(x.split())
    essay_number_words.append(y)
```

In [45]:

```
project_data['essay_number_words']=essay_number_words
```

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

In [48]:

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data,
project_data['project_is_approved'], test_size=0.33, stratify = project_data['project_is_approved'
],random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train,
random_state=0)
```

In [49]:

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

1.4 Make Data Model Ready: encoding numerical, categorical features

1.4.1 encoding Text features: Essay-BOW

In [50]:

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

print("="*100)


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

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

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



print("NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME")
```

```
(49041, 23) (49041,)
(24155, 23) (24155,)
(36052, 23) (36052,)
====================================================================================================

After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
====================================================================================================

NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME
```

In [119]:

```
vectorizer_essay_bow = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_essay_bow.fit(X_train['essay'].values)
```

Out[119]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
```

```
                dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=5000, min_df=10,
                ngram_range=(1, 4), preprocessor=None, stop_words=None,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, vocabulary=None)
```

1.4.1 encoding Text features: Essay-TFIDF

In [51]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

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

print("="*100)


vectorizer_essay_Tfidf = TfidfVectorizer(min_df=10, max_features=5000)
vectorizer_essay_Tfidf.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted TfidfVectorizer to convert the text to vector
X_train_essay_Tfidf = vectorizer_essay_Tfidf.transform(X_train['essay'].values)
X_cv_essay_Tfidf = vectorizer_essay_Tfidf.transform(X_cv['essay'].values)
X_test_essay_Tfidf = vectorizer_essay_Tfidf.transform(X_test['essay'].values)

print("After vectorizations")
print(X_train_essay_Tfidf.shape, y_train.shape)
print(X_cv_essay_Tfidf.shape, y_cv.shape)
print(X_test_essay_Tfidf.shape, y_test.shape)
print("="*100)



print("NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME")
```

```
(49041, 23) (49041,)
(24155, 23) (24155,)
(36052, 23) (36052,)
====================================================================================================

After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
====================================================================================================

NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME
```

1.4.1 encoding Text features: Essay-Avg W2Vec

In [75]:

```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [76]:

```
avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
```

```
    avg_w2v_vectors_train.append(vector)

print(len(avg_w2v_vectors_train))
print(len(avg_w2v_vectors_train[0]))
print(avg_w2v_vectors_train[0])
```

```
100%|██████████████████████████████████████████████████████████████████████████| 49041/49041
[00:29<00:00, 1671.48it/s]
```

```
49041
300
[-4.81504624e-02 -6.96376980e-02 -6.75092919e-02 -1.67244788e-01
  4.55009062e-02 -3.63718087e-02 -3.53038855e+00  2.14568355e-01
  6.42519884e-02 -1.55032998e-01  1.46054072e-01  5.10826074e-02
 -7.30481503e-02 -1.26345213e-01 -7.93205231e-02 -1.15440792e-01
 -8.66065815e-02 -1.02057400e-01  1.06090202e-01  1.02253513e-01
  5.48120313e-02  1.69298145e-02 -5.92954382e-02  4.93544249e-02
 -3.66171408e-02 -2.55012139e-02  2.98302699e-02 -1.62567702e-01
 -1.12650346e-01 -1.13204887e-01 -2.36546064e-01 -8.67428994e-02
  4.54593665e-02 -3.21474497e-02 -1.36306199e-01 -7.75393353e-03
 -1.20910971e-02 -1.09602115e-01  7.57303966e-02 -8.40817108e-02
 -4.87067647e-02  8.93267879e-02  3.78309121e-02 -2.01257235e-01
 -5.31506647e-02 -3.52255613e-02  7.79028087e-02 -1.66601382e-01
 -1.37675665e-01  2.45329587e-02  3.90471532e-02  9.41483717e-02
 -2.34469965e-02 -4.79321272e-02  6.30726364e-02 -1.14433614e-01
  7.98227150e-02 -2.46039087e-02 -6.46417613e-02  7.81061341e-02
 -4.15729376e-02  6.70791341e-02  3.76362000e-02 -1.13544193e-01
 -6.72277283e-02  1.91462210e-01  7.99065376e-02  2.71086156e-02
  1.85660218e-01 -1.07133983e-01 -2.13331237e-01  4.78215087e-03
 -2.15113983e-02 -7.04178780e-02  1.97596358e-02 -2.40324114e-01
  1.15396225e-01  1.36073306e-02  1.35610002e-01 -1.08026359e-01
  5.86882954e-02 -5.66574209e-01 -9.28727668e-02 -1.58789284e-01
  4.39962448e-02  6.82431896e-02  3.90769355e-02 -1.01018818e-01
  1.09533990e-01 -2.19253543e-02  2.27211293e-02 -8.12973162e-02
 -1.69998046e-02  5.97638514e-02 -4.08562543e-03 -2.42898780e-01
 -2.63798549e+00 -6.15275682e-02  1.09555636e-01  8.76857382e-02
 -6.66988497e-02  1.52541442e-01  2.02361288e-01  7.03569561e-03
 -7.68750156e-02 -1.29391122e-02  1.11750587e-01 -1.49025734e-01
 -5.86507260e-02  5.36100376e-02 -1.90672379e-02  9.78639792e-02
  5.68016630e-02  1.80258873e-01 -1.13963705e-02  1.88951042e-02
 -2.80878220e-02 -3.18960116e-03  1.11103035e-01  5.75805751e-02
 -1.20890199e-01 -2.64726624e-02 -9.53153121e-04 -1.59678561e-01
  1.94861954e-02  1.42859191e-03 -2.73734854e-02 -7.46366746e-02
 -3.07473064e-03  7.89804058e-02  5.45301310e-02  2.38508087e-02
 -1.69581457e-02 -1.11752997e-01  8.23222439e-02  2.16516566e-02
  7.75765044e-02 -8.22167457e-03  2.44237079e-01  2.65827249e-01
  7.71381162e-02  3.27617769e-02 -1.29356396e-02 -1.92105087e-02
 -1.35399295e-02 -6.78832769e-02  8.06506538e-02 -3.90906432e-02
  3.30163775e-01  1.31624908e-01 -3.75681723e-02 -5.50561179e-02
  1.71931521e-02 -2.32684042e-02  3.28931538e-02 -7.48625055e-02
  4.74752607e-02  1.72015029e-02 -1.32693854e-01 -5.45671913e-02
  1.10370410e-01 -9.00208931e-02 -2.12085431e-02 -5.85889173e-02
 -7.28783214e-02  4.44754896e-02 -4.13681029e-02  9.21154468e-02
  1.35107873e-01 -1.00834398e-01 -3.16182254e-02  4.04800434e-02
 -7.59186156e-02 -8.17157844e-02 -1.05212967e-01  2.44601882e-01
 -1.18829621e-01 -9.51923069e-02 -9.24276301e-03 -1.11107040e-02
  1.23421866e-01  1.09983355e-01 -9.37664578e-02 -9.54882913e-02
  7.92411896e-02 -1.84819451e-01  3.50804532e-02  2.09569422e-02
  1.41346873e-01 -4.35895260e-02 -2.45048555e-03 -4.78310919e-02
  1.37811017e-02 -2.97323318e-03  4.56390058e-02 -1.13876612e-01
  6.78940231e-02  1.06860070e-01  1.33323577e-01  6.56578630e-03
  4.57764376e-02 -4.92224211e-02  3.13370545e-02 -1.32662428e-02
  1.50239828e-02  1.33395416e-01  3.90383873e-02 -1.80675723e-02
  1.29137161e-01 -2.17786908e-02  3.94724682e-02 -4.99195104e-02
 -5.70579156e-02 -7.40721543e-02 -7.68729844e-02 -3.99187087e-02
 -5.76343370e-02 -8.62897220e-02 -2.56204173e-02  1.50177152e-01
 -9.99371260e-02 -8.01535665e-02 -4.93496139e-02  3.05870514e-02
 -2.59842009e+00  6.66491549e-02 -5.22028150e-02 -2.01808295e-02
  2.51514480e-02 -8.22859650e-02  8.99183445e-02  3.96558555e-02
  2.21633694e-02 -7.50365873e-02 -1.18931557e-01  1.34325698e-01
 -5.61449942e-03 -8.52783624e-02 -6.74389364e-02  9.36177812e-02
 -1.44942909e-01  8.64188399e-02 -1.45114104e-01  3.99279266e-02
  2.01994763e-02 -6.53910809e-02 -5.26783376e-02 -5.35820266e-02
 -8.37511017e-02  2.11062491e-02 -6.39851971e-02 -8.15694046e-03
  1.28252954e-02 -1.38454318e-02  3.31428497e-02 -1.30689342e-02
```

```
  6.37582213e-02 -1.10993489e-01  1.16859814e-01  5.08639769e-03
  1.13039100e-01  3.48427746e-03 -4.32839555e-02  5.93400526e-02
  1.20318072e-01 -1.37683451e-01 -2.70569246e-01 -8.19515543e-02
  1.58294725e-01 -1.07727150e-02 -5.27946012e-02 -1.15542881e-01
 -1.93086972e-01  1.26465966e-01  9.01770405e-04  8.61173884e-02
  4.22681329e-02  5.91892370e-03 -3.31146133e-02 -4.57095884e-02
  2.50299607e-01  3.91698208e-03 -1.67603202e-02  1.40499461e-01
 -2.12289509e-02  1.40066155e-01  4.76268277e-02  5.58694526e-02
  4.33036012e-03 -5.47094347e-02 -4.43379439e-03 -1.17710382e-01
 -3.52040347e-02 -3.85428353e-02  1.58478156e-02  4.84926665e-02
  2.68926012e-03 -6.17499422e-02  8.98996111e-02  6.02097977e-02]
```

In [77]:

```
avg_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155
[00:14<00:00, 1666.78it/s]
```

In [78]:

```
avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:20<00:00, 1794.08it/s]
```

1.4.1 encoding Text features: Essay-TFIDF W2Vec

In [96]:

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

In [97]:

```
tfidf_w2v_vectors_train = []; # the tfidf-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
```

```
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

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

```
100%|██████████████████████████████████████████████████████████████████████████| 49041/49041 [05:48<00:00, 140.82it/s]
```

```
49041
300
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  6.32615129e-02 -5.24169387e-02 -3.44281180e+00  1.63300096e-01
  8.58279717e-02 -1.27179637e-01  2.01308674e-01  1.60034891e-02
 -1.10808867e-01 -1.47321548e-01 -8.96137094e-02 -1.34737217e-01
 -1.00834070e-01 -1.25979124e-01  1.21675103e-01  1.49560737e-01
  1.99275143e-02  6.28080242e-02 -9.48723013e-02 -6.89930924e-03
 -9.71713177e-02  1.42238464e-02  4.68689933e-02 -1.54657897e-01
 -1.16597834e-01 -1.20062164e-01 -2.03603606e-01 -7.15663790e-02
  2.62403489e-02 -5.57915182e-02 -1.40994364e-01 -1.87230873e-02
  4.37058890e-02 -9.06354818e-02  1.33577135e-01 -8.74996951e-02
 -1.09839664e-02  9.28004129e-02  4.39318200e-02 -1.62534969e-01
 -5.12091334e-02 -5.21427640e-02  1.00652366e-01 -1.82101241e-01
 -1.56745817e-01  6.11073634e-02  6.44576438e-02  1.35466545e-01
 -2.89925318e-02 -6.04708127e-02  4.13553253e-02 -1.00632647e-01
  6.82864405e-02 -2.52207950e-03 -9.35790676e-02  4.62797838e-02
 -1.15577196e-03  1.11880569e-01  4.70715012e-02 -1.79723594e-01
 -1.01259149e-01  2.10982587e-01  1.11642136e-01  4.87169301e-02
  2.14559043e-01 -1.23641349e-01 -2.90260500e-01  2.75175348e-02
 -2.37113568e-02 -1.22933089e-01  6.73358697e-02 -2.81412134e-01
  8.80006023e-02 -5.36141407e-02  1.86131543e-01 -1.23881537e-01
  4.67219087e-02 -5.64298671e-01 -1.09768720e-01 -1.93196888e-01
  1.26059070e-01  1.35427537e-01  2.69003824e-02 -1.31236050e-01
  1.40777261e-01 -5.37157668e-02 -2.74373679e-03 -8.00607927e-02
  1.66333368e-02  6.31074416e-02 -1.59328565e-02 -2.33023476e-01
 -2.74031844e+00 -5.86049019e-02  1.02628717e-01  3.70052601e-02
 -3.24976130e-02  1.91230966e-01  1.65155535e-01  5.55977428e-02
 -1.41981028e-01 -1.52303424e-02  1.20338207e-01 -1.70989801e-01
 -9.98457448e-02  7.15161902e-02 -3.91864133e-03  1.57416637e-01
  1.11917488e-01  2.00129101e-01 -3.29900763e-02  2.37412459e-02
  5.51033899e-02 -4.78277596e-02  9.48436600e-02  7.77183246e-02
 -1.85909621e-01 -3.18291285e-02 -3.61935167e-02 -1.29433601e-01
 -1.15106581e-02 -9.30770845e-03 -6.69788938e-02 -8.25618515e-02
 -1.23696398e-02  7.88797106e-02  1.11472340e-01  2.74019481e-02
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 -3.00972233e-03 -1.85503449e-02 -3.59244349e-02 -1.12686893e-01
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  1.08224251e-01 -5.68083392e-02  5.78771151e-03 -2.56600813e-02
 -9.83455477e-02  4.09632472e-02 -2.81906113e-02  1.47124962e-01
  1.49281656e-01 -8.03067420e-02 -2.64424495e-02  6.29797976e-02
 -1.00709927e-01 -1.60810049e-02 -8.53325959e-02  3.03839098e-01
 -1.22003209e-01 -1.65175289e-01 -9.00005568e-03  1.81308674e-02
  1.29907765e-01  6.29247820e-02 -1.19142617e-01 -1.70756022e-01
  9.97759280e-02 -2.14404142e-01  5.64748262e-02 -4.04756750e-02
  1.68660501e-01 -7.18098346e-02  2.84708674e-02 -5.02999161e-02
  1.42770840e-02 -1.34559786e-02  2.37321009e-02 -7.55841137e-02
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 -1.11394288e-02 -1.31533657e-02  3.60516853e-03 -4.75406446e-02
  4.96080422e-02  1.61548607e-01  6.44507515e-02  3.22668666e-02
  1.49126804e-01  2.14354971e-02  7.78369652e-02 -5.25009146e-02
 -9.99386807e-02 -2.99324973e-02 -9.74296039e-02  1.66470672e-02
 -2.57013065e-02 -5.13221868e-02  3.62742596e-03  1.61699369e-01
 -1.21392635e-01 -1.04983079e-01 -4.60739201e-02  5.39838051e-02
 -2.67055143e+00  1.89292204e-02 -6.06988384e-02 -3.02009796e-02
  7.91566723e-03 -3.84404571e-02  9.46886827e-02  5.43227686e-02
  3.51910157e-02 -6.91096224e-02 -1.24559529e-01  1.16518302e-01
  2.78431724e-02 -7.44680978e-02 -1.39866498e-01  1.26412220e-01
 -1.52161708e-01  1.34044415e-01 -1.08658871e-01  8.27447690e-03
  5.79859383e-02 -9.63250807e-02 -5.68080649e-02 -6.51253945e-02
 -1.19115421e-01  2.74241022e-02 -8.17190092e-02 -7.34496874e-04
  5.07701340e-02 -3.10435667e-02  1.20813227e-02 -9.73730550e-03
```

```
  5.85570671e-02 -7.74782507e-02  1.53061264e-01  4.71772954e-02
  1.95304008e-01  3.84426460e-02 -4.45106984e-02  6.05754232e-02
  1.75232281e-01 -1.75824746e-01 -3.17975833e-01 -5.99350689e-02
  1.47423587e-01 -2.44517687e-02 -9.50426325e-02 -1.56503731e-01
 -2.22481111e-01  1.94470508e-01 -1.06713247e-02  8.47595409e-02
  2.83632828e-02 -2.70410100e-02 -1.01717011e-01 -6.77483826e-02
  3.02951495e-01  2.72927008e-02 -2.69391232e-02  1.62829150e-01
 -3.76784147e-02  1.56580684e-01  3.82787884e-02  2.35164373e-02
  4.47012163e-03 -8.01852803e-02  2.54845376e-02 -1.75930545e-01
  2.14619461e-02  2.51896111e-02  2.04584980e-02  4.92972336e-02
  5.27417043e-02 -1.17373876e-01  1.06799086e-01  5.23172084e-02]
```

In [98]:

```
tfidf_w2v_vectors_test = []; # the tfidf-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 36052/36052 [04:
18<00:00, 139.28it/s]
```

In [99]:

```
tfidf_w2v_vectors_cv = []; # the tfidf-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_cv.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 24155/24155 [03:
02<00:00, 132.11it/s]
```

1.4.1 encoding Text features: Title-BOW

In [52]:

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

print("="*100)


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

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_title_bow = vectorizer.transform(X_train['project_title'].values)
X_cv_project_title_bow = vectorizer.transform(X_cv['project_title'].values)
X_test_project_title_bow = vectorizer.transform(X_test['project_title'].values)

print("After vectorizations")
print(X_train_project_title_bow.shape, y_train.shape)
```

```
print(X_cv_project_title_bow.shape, y_cv.shape)
print(X_test_project_title_bow.shape, y_test.shape)
print("="*100)



print("NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME")
```

```
(49041, 23) (49041,)
(24155, 23) (24155,)
(36052, 23) (36052,)
====================================================================================================

After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
====================================================================================================

NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME
```

In [116]:

```
vectorizer_title_bow = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer_title_bow.fit(X_train['project_title'].values)
```

Out[116]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=5000, min_df=10,
                ngram_range=(1, 4), preprocessor=None, stop_words=None,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, vocabulary=None)
```

1.4.1 encoding Text features: Title-Tfidf

In [53]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

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

print("="*100)


vectorizer_title_Tfidf = TfidfVectorizer(min_df=10, max_features=5000)
vectorizer_title_Tfidf.fit(X_train['project_title'].values) # fit has to happen only on train data

# we use the fitted TfidfVectorizer to convert the text to vector
X_train_project_title_Tfidf = vectorizer_title_Tfidf.transform(X_train['project_title'].values)
X_cv_project_title_Tfidf = vectorizer_title_Tfidf.transform(X_cv['project_title'].values)
X_test_project_title_Tfidf = vectorizer_title_Tfidf.transform(X_test['project_title'].values)

print("After vectorizations")
print(X_train_project_title_Tfidf.shape, y_train.shape)
print(X_cv_project_title_Tfidf.shape, y_cv.shape)
print(X_test_project_title_Tfidf.shape, y_test.shape)
print("="*100)



print("NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME")
```

```
(49041, 23) (49041,)
(24155, 23) (24155,)
(36052, 23) (36052,)
====================================================================================================
```

```
After vectorizations
(49041, 2112) (49041,)
(24155, 2112) (24155,)
(36052, 2112) (36052,)
==========================================================================================================

NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME
```

1.4.1 encoding Text features: Title-Avg W2Vec

In [89]:

```
avg_w2v_project_title_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_project_title_vectors_train.append(vector)

print(len(avg_w2v_project_title_vectors_train))
print(len(avg_w2v_project_title_vectors_train[0]))
print(avg_w2v_project_title_vectors_train[0])
```

```
100%|████████████████████████████████████████████████████████████████████████████| 49041/49041
[00:00<00:00, 105168.18it/s]

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  1.4414250e-01 -5.0458000e-01  1.1050000e-03 -3.1982500e-01
 -3.5685500e-01 -1.7586500e-01  2.8473500e-01 -3.5333000e-01
 -1.0059000e-01  2.2769500e-01 -2.7086500e-02  1.4461300e-01
  2.4896650e-01 -1.5500500e-01 -2.3905000e-02 -1.8937150e-01
 -2.2266323e-01 -3.6061850e-01 -1.6995500e-01 -1.8016500e-01
 -9.3865000e-02  7.4765000e-02 -1.4045750e-01 -1.6811500e-01
  7.6218000e-02  1.1300950e-01 -3.3151300e-02  2.7876000e-01
  4.6675000e-02 -1.8467500e-01  2.5315000e-02 -1.9969950e-01
 -3.4567000e-01 -1.2675000e-01  1.2430000e-02 -4.5979500e-01
 -4.2620500e-02 -3.9868500e-01  1.9268500e-02 -7.0350000e-03
 -2.1759600e-01  2.6683500e-01 -1.3123000e-02  3.9906950e-01
 -5.6853000e-01 -4.0831000e-02  1.8581400e-01 -2.0338500e-01
  1.8546260e-01 -1.2643950e-01  2.7400000e-01  2.6371200e-01
 -9.9646500e-02  2.4919200e-01 -1.3615000e-02  1.4704500e-01
 -2.2670000e-02 -5.9560000e-02 -1.9130000e-02  3.9276000e-01
  1.4870555e-01 -2.5742000e-01 -9.2570000e-02  2.2301500e-02
 -4.3505000e-01  7.3899500e-02 -6.5329500e-02 -3.2726300e-01
  3.2461500e-01  1.0360000e-03 -2.2227000e-01 -2.4818000e-01
 -3.5135000e-01 -5.7140500e-01 -9.7590000e-02 -2.7189685e-01
 -9.6775000e-02  2.7795000e-02 -5.4749000e-01  1.0340750e-01
 -1.3315000e-02  4.3702500e-02  2.9985500e-01 -2.1908100e-01
 -1.8219800e-01  3.1173000e-01 -4.5820000e-02 -5.7039500e-01
 -2.6310000e+00  1.8915000e-02  8.9969000e-02  1.0117500e-01
  1.2690550e-01 -1.2190500e-01  2.6428000e-01 -2.1221000e-01
 -4.1645450e-02 -2.2501500e-01  4.6250000e-02  1.2609740e-01
 -2.2996000e-01 -2.2659600e-01 -6.7940000e-02 -1.8287000e-01
  3.5286500e-01  3.4285000e-02 -2.2578700e-01 -3.3058500e-02
  7.5865500e-01 -1.1065350e-01  1.0208000e-01 -5.0882000e-01
 -7.2183000e-01  2.7957950e-01  1.7704000e-02 -3.9317500e-01
  6.6910000e-02 -1.5628510e-01 -1.2465000e-01  1.5442000e-02
 -2.8304000e-02  2.1781305e-01 -1.4817500e-01  4.5531000e-01
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  1.4529550e-01 -3.8449000e-02  2.8756500e-01  6.7941500e-01
 -3.5150000e-04  1.7594000e-01  3.9059500e-01 -1.7772000e-01
 -1.0894000e-01  2.7297900e-02  4.1431000e-01 -3.5924500e-01
  6.9263500e-01  5.5159500e-01 -5.8140000e-02 -1.4537500e-01
  1.7508505e-01  6.1700000e-03  4.0179500e-01 -4.0816000e-01
```

```
 -9.7450000e-02  1.3130450e-02 -1.8283000e-01 -2.6466500e-01
  4.2035000e-01  5.8260000e-02 -1.7050500e-01  4.0125000e-02
 -1.4662430e-01 -7.3365000e-02 -7.1234500e-02 -1.1982500e-01
  3.1214500e-02 -7.1207900e-02 -2.3151500e-01 -2.9659500e-01
  2.1195000e-01 -2.2474500e-01 -8.5108500e-02 -4.8925000e-02
 -2.3860725e-01 -1.1372550e-01  6.3765000e-02  9.8262500e-02
  2.8711500e-01  3.6239800e-01 -1.5326880e-01  2.1327050e-01
 -1.1212050e-01 -2.2206650e-01 -1.5062715e-01  1.2448500e-01
  1.8462000e-01 -1.4449000e-01  7.7735000e-02 -4.2715000e-01
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 -4.1186500e-01 -7.5100000e-03 -1.5189750e-01  8.7260500e-02
 -1.1192500e-01  1.8685500e-01  5.6490000e-02  1.9922200e-01
 -3.6314000e+00  8.4930000e-02 -2.8582500e-01 -1.8341100e-01
  1.1689500e-01 -7.0247000e-02  3.5591000e-01  2.7824250e-01
 -1.4322950e-01 -1.2196490e-01  1.4183950e-01  1.8657100e-01
 -1.7971200e-01  9.9950000e-02 -2.6499500e-01 -3.7640500e-01
 -2.3522765e-01  1.7056400e-01 -3.9675000e-01  2.6101500e-01
 -2.2069000e-01 -2.0400000e-03  1.0106500e-02 -1.1416335e-01
 -3.0274500e-01  4.6183500e-01 -2.4435000e-02 -1.8769200e-01
  1.0643750e-01  6.0653970e-02  8.6297300e-02  1.4120900e-01
 -5.2490000e-01 -4.8409000e-01  7.5230000e-02 -5.2465000e-02
  4.6150000e-02 -2.4811500e-01  1.8818600e-01  2.9123000e-01
 -4.1595000e-02 -4.3035000e-02 -4.4752000e-01 -4.6059000e-01
  3.4821000e-01 -3.8587500e-02  5.1892000e-01 -1.7719600e-01
 -1.2520500e-01 -9.7050000e-03  3.1443500e-01 -1.1628300e-01
  1.5553350e-01  4.3530000e-02  1.2609500e-01 -3.0214000e-01
  5.6143500e-01 -6.7620000e-02 -1.2555700e-01 -1.2911700e-01
  4.4103200e-01 -1.4802500e-01  3.8171500e-01  5.2673000e-01
 -2.6362500e-01 -2.0410000e-02  1.7817350e-01  1.8785500e-01
 -2.6454000e-01  8.2715000e-02 -1.2020000e-01 -2.8413000e-01
 -2.4539485e-01  7.9815500e-02 -8.8625000e-02 -2.1040000e-02]
```

In [90]:

```
avg_w2v_project_title_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this li
st
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_project_title_vectors_cv.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 24155/24155
[00:00<00:00, 111596.35it/s]
```

In [91]:

```
avg_w2v_project_title_vectors_test = []; # the avg-w2v for each sentence/review is stored in this
list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_project_title_vectors_test.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 36052/36052
[00:00<00:00, 127728.61it/s]
```

1.4.1 encoding Text features: Title-Tfidf W2Vec

In [92]:

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

In [93]:

```
tfidf_w2v_project_title_vectors_train = []; # the tfidf-w2v for each sentence/review is stored in
this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_project_title_vectors_train.append(vector)

print(len(tfidf_w2v_project_title_vectors_train))
print(len(tfidf_w2v_project_title_vectors_train[0]))
print(tfidf_w2v_project_title_vectors_train[0])
```

```
100%|██████████████████████████████████████████████████████████████████████████| 49041/49041
[00:00<00:00, 66075.42it/s]
```

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 -3.6027e+00  4.7811e-01  4.7945e-02 -3.1859e-01 -2.1335e-01 -5.1531e-01
 -1.7142e-01 -2.0035e-01  7.0538e-01 -1.7186e-01 -5.4713e-01  6.8465e-01
 -4.0384e-02  2.4141e-01  5.3936e-01  1.0057e-01 -1.4953e-01 -2.8165e-01
 -4.4468e-01 -6.9436e-01 -1.0518e-01 -3.0014e-01  1.2637e-01  7.1193e-01
 -2.0152e-01 -1.1507e-01  5.3484e-02  1.3611e-01  2.3964e-03  2.4965e-01
 -2.6389e-01 -6.4683e-01 -1.6104e-01 -3.7846e-01 -2.0946e-01 -1.0369e-01
  2.2179e-01 -7.2445e-01 -5.5569e-02 -5.1117e-01 -2.0982e-02  1.4127e-01
 -3.9321e-01  2.2062e-01  8.2094e-02  5.3219e-02 -8.6973e-01 -1.7208e-01
  4.3798e-02 -5.6050e-02  3.6899e-01 -9.2699e-02  1.9369e-01  5.9429e-01
 -1.0439e-01  5.2525e-01  4.1624e-01  1.5565e-01 -1.9486e-01 -4.6395e-01
 -1.6372e-01  3.2242e-01  3.0328e-01 -1.0038e-01 -3.1126e-01 -9.1417e-02
 -4.3295e-01  5.1531e-02  5.9131e-02  9.9654e-02  2.9146e-01  1.9551e-02
 -2.2547e-01 -3.1254e-01 -4.3268e-01 -5.9699e-01  2.5903e-01  6.1463e-03
  2.3724e-01  1.7422e-01 -6.2129e-01  3.0664e-01  1.1598e-01  1.6893e-01
  2.6485e-01 -2.3562e-02 -2.8476e-01  3.2007e-01  3.3411e-01 -7.9123e-01
 -2.5263e+00  7.7887e-01 -3.6362e-02 -2.2488e-01  2.1838e-01 -1.8917e-01
 -1.7813e-01 -1.2703e-01 -9.1610e-02 -2.5722e-01 -2.3141e-01  2.4344e-01
 -2.9977e-01 -3.9411e-01 -3.1091e-01 -7.1663e-01  7.1927e-01  4.0314e-01
 -3.9980e-01 -8.1807e-02  4.8831e-01 -2.6558e-01 -2.4490e-01 -7.2728e-01
 -6.5682e-01  6.1916e-01 -8.2432e-02 -6.6695e-01 -7.1830e-02 -6.0302e-03
 -1.4047e-01  1.0774e-01 -2.9400e-02  4.3884e-01 -1.0434e-01  7.7235e-01
  2.6651e-01 -1.5147e-01 -1.5951e-01  1.1666e-01  3.3501e-02  5.5742e-02
 -7.0720e-02  8.1983e-01 -9.4083e-02  1.7576e-01  3.2675e-01 -5.2920e-02
  2.9963e-01  6.2303e-02  3.0784e-01 -4.8853e-01  8.7214e-01  4.8469e-01
  1.5472e-01 -4.7794e-01  3.5701e-03  2.8510e-01  4.5573e-01 -4.9919e-01
 -3.2528e-01  5.0259e-03 -1.0745e-01 -3.8380e-01  1.8128e-01  3.1121e-01
 -1.6429e-01  2.5904e-01 -2.0586e-03 -4.2063e-01 -6.7520e-02  1.1249e-01
 -6.2841e-02  9.0842e-03 -6.2864e-01 -2.3783e-01  1.6221e-01  2.2003e-01
 -1.3259e-01 -3.4341e-01 -3.8345e-03 -3.1361e-02  2.9267e-01  1.1335e-02
 -1.6943e-01  6.2525e-01  1.8924e-03  3.4430e-01 -7.7261e-02  9.0077e-02
 -2.9513e-01 -3.2870e-01  2.3480e-02 -1.2653e-01  9.3243e-02 -5.8030e-01
 -1.8007e-01 -3.6697e-02 -9.1138e-02  8.0947e-02 -1.3167e-01  6.9933e-02
 -1.9786e-02 -2.6451e-01  9.5616e-02 -3.8800e-02 -2.3523e-01 -1.1224e-01
  2.9692e-01 -1.3358e-01 -1.8443e-02 -5.5351e-01 -7.1414e-02  3.0206e-01
```

```
-4.0702e-02 -9.9249e-02 -6.2182e-01  1.3056e-01  3.7276e-01 -5.1884e-01
-7.2358e-01  1.9346e-01 -7.7715e-02  2.2269e-01 -4.3023e-01 -1.3878e-01
 4.5398e-01  4.0267e-01 -3.7990e+00  2.9864e-01 -1.0014e-01  5.3288e-02
 2.7437e-01 -1.8284e-01  5.9567e-01  5.9842e-01 -3.2466e-01  3.5302e-03
 3.7720e-01 -7.2068e-02 -3.1471e-01 -1.2439e-01 -3.9985e-01 -3.6131e-01
-9.4553e-03  4.1125e-01 -4.4127e-01  1.3517e-01 -1.8269e-01 -4.7905e-01
-5.6259e-02 -2.3687e-01 -2.0079e-01  2.6212e-01  1.8157e-01 -3.5366e-01
 2.3476e-01  1.2185e-01  1.6606e-01  3.5740e-01 -4.5782e-01 -3.5614e-01
 2.9046e-01 -2.9956e-01  2.6952e-01  1.4340e-02 -2.6618e-02  3.1496e-01
 2.1012e-01  1.0300e-01 -5.1883e-01 -5.0328e-01  1.4767e-01 -1.4743e-01
 2.3220e-01  2.9708e-02  1.7360e-01  3.9443e-01  1.9012e-01  5.9954e-02
 4.0225e-01 -1.3333e-01  4.3591e-01 -1.9416e-01  4.9440e-01 -3.5507e-01
-1.7199e-01 -2.7750e-01  2.6634e-02 -1.6227e-01  1.6202e-01  3.7628e-01
-1.9416e-01  2.1528e-01  2.7162e-01  2.7112e-01 -2.7549e-01  2.8545e-01
 1.4925e-01 -2.8046e-01 -4.9446e-01  1.3731e-01  1.3866e-01  3.1400e-01]
```

In [94]:

```
tfidf_w2v_project_title_vectors_test = []; # the tfidf-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_project_title_vectors_test.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:00<00:00, 70149.49it/s]
```

In [95]:

```
tfidf_w2v_project_title_vectors_cv = []; # the tfidf-w2v for each sentence/review is stored in thi
s list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_project_title_vectors_cv.append(vector)
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155
[00:00<00:00, 68944.00it/s]
```

1.4.1 encoding categorical features: Project_subject_categories-ohe

In [94]:

```
my_counter = Counter()
for word in project_data['project_subject_categories'].values:
    my_counter.update(word.split())

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

In [95]:

```
vectorizer_cat=CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
```

In [54]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_subject_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_subject_categories_ohe = vectorizer.transform(X_train['project_subject_categories'].values)
X_cv_project_subject_categories_ohe = vectorizer.transform(X_cv['project_subject_categories'].values)
X_test_project_subject_categories_ohe = vectorizer.transform(X_test['project_subject_categories'].values)

print("After vectorizations")
print(X_train_project_subject_categories_ohe.shape, y_train.shape)
print(X_cv_project_subject_categories_ohe.shape, y_cv.shape)
print(X_test_project_subject_categories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['appliedlearning', 'appliedlearning_health_sports', 'appliedlearning_history_civics',
'appliedlearning_literacy_language', 'appliedlearning_math_science', 'appliedlearning_music_arts',
'appliedlearning_specialneeds', 'appliedlearning_warmth_care_hunger', 'health_sports',
'health_sports_appliedlearning', 'health_sports_history_civics',
'health_sports_literacy_language', 'health_sports_math_science', 'health_sports_music_arts',
'health_sports_specialneeds', 'health_sports_warmth_care_hunger', 'history_civics',
'history_civics_appliedlearning', 'history_civics_health_sports',
'history_civics_literacy_language', 'history_civics_math_science', 'history_civics_music_arts', 'history_civics_specialneeds', 'history_civics_warmth_care_hunger', 'literacy_language',
'literacy_language_appliedlearning', 'literacy_language_health_sports',
'literacy_language_history_civics', 'literacy_language_math_science',
'literacy_language_music_arts', 'literacy_language_specialneeds',
'literacy_language_warmth_care_hunger', 'math_science', 'math_science_appliedlearning',
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'math_science_music_arts', 'math_science_specialneeds', 'math_science_warmth_care_hunger',
'music_arts', 'music_arts_appliedlearning', 'music_arts_health_sports',
'music_arts_history_civics', 'music_arts_specialneeds', 'music_arts_warmth_care_hunger',
'specialneeds', 'specialneeds_health_sports', 'specialneeds_music_arts',
'specialneeds_warmth_care_hunger', 'warmth_care_hunger']
====================================================================================================
```

1.4.1 encoding categorical features: Project_subject_subcategories-ohe

In [89]:

```
my_counter = Counter()
for word in project_data['project_subject_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 t: t[1]))
```

In [91]:

```
vectorizer_subcat=CountVectorizer(vocabulary=list(sub_cat_dict.keys()), lowercase=False, binary=True)
```

In [55]:

```
vectorizer = CountVectorizer()
```

```
vectorizer.fit(X_train['project_subject_subcategories'].values) # fit has to happen only on train
data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_subject_subcategories_ohe =
vectorizer.transform(X_train['project_subject_subcategories'].values)
X_cv_project_subject_subcategories_ohe = vectorizer.transform(X_cv['project_subject_subcategories'
].values)
X_test_project_subject_subcategories_ohe =
vectorizer.transform(X_test['project_subject_subcategories'].values)

print("After vectorizations")
print(X_train_project_subject_subcategories_ohe.shape, y_train.shape)
print(X_cv_project_subject_subcategories_ohe.shape, y_cv.shape)
print(X_test_project_subject_subcategories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 387) (49041,)
(24155, 387) (24155,)
(36052, 387) (36052,)
['appliedsciences', 'appliedsciences_charactereducation', 'appliedsciences_civics_government',
'appliedsciences_college_careerprep', 'appliedsciences_communityservice',
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'appliedsciences_parentinvolvement', 'appliedsciences_performingarts',
'appliedsciences_socialsciences', 'appliedsciences_specialneeds', 'appliedsciences_teamsports', 'a
ppliedsciences_visualarts', 'appliedsciences_warmth_care_hunger', 'charactereducation',
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'environmentalscience_specialneeds', 'environmentalscience_teamsports',
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'extracurricular_literacy', 'extracurricular_literature_writing', 'extracurricular_mathematics', '
extracurricular_music', 'extracurricular_nutritioneducation', 'extracurricular_other',
'extracurricular_parentinvolvement', 'extracurricular_performingarts',
'extracurricular_socialsciences', 'extracurricular_specialneeds', 'extracurricular_teamsports', 'e
xtracurricular_visualarts', 'financialliteracy', 'financialliteracy_foreignlanguages',
'financialliteracy_health_lifescience', 'financialliteracy_health_wellness',
'financialliteracy_history_geography', 'financialliteracy_literacy',
'financialliteracy_literature_writing', 'financialliteracy_mathematics',
'financialliteracy_other', 'financialliteracy_parentinvolvement',
'financialliteracy_socialsciences', 'financialliteracy_specialneeds',
'financialliteracy_visualarts', 'foreignlanguages', 'foreignlanguages_gym_fitness',
'foreignlanguages_health_lifescience', 'foreignlanguages_health_wellness',
'foreignlanguages_history_geography', 'foreignlanguages_literacy',
'foreignlanguages_literature_writing', 'foreignlanguages_mathematics', 'foreignlanguages_music', '
foreignlanguages_other', 'foreignlanguages_socialsciences', 'foreignlanguages_specialneeds',
'foreignlanguages_visualarts', 'gym_fitness', 'gym_fitness_health_lifescience',
'gym_fitness_health_wellness', 'gym_fitness_history_geography', 'gym_fitness_literacy',
'gym_fitness_literature_writing', 'gym_fitness_mathematics', 'gym_fitness_music',
'gym_fitness_nutritioneducation', 'gym_fitness_other', 'gym_fitness_parentinvolvement',
'gym_fitness_performingarts', 'gym_fitness_specialneeds', 'gym_fitness_teamsports',
'gym_fitness_visualarts', 'gym_fitness_warmth_care_hunger', 'health_lifescience',
'health_lifescience_health_wellness', 'health_lifescience_history_geography',
'health_lifescience_literacy', 'health_lifescience_literature_writing',
'health_lifescience_mathematics', 'health_lifescience_music',
'health_lifescience_nutritioneducation', 'health_lifescience_other',
'health_lifescience_parentinvolvement', 'health_lifescience_performingarts',
'health_lifescience_socialsciences', 'health_lifescience_specialneeds',
'health_lifescience_teamsports', 'health_lifescience_visualarts',
'health_lifescience_warmth_care_hunger', 'health_wellness', 'health_wellness_history_geography', '
health_wellness_literacy', 'health_wellness_literature_writing', 'health_wellness_mathematics', 'h
ealth_wellness_music', 'health_wellness_nutritioneducation', 'health_wellness_other',
'health_wellness_parentinvolvement', 'health_wellness_performingarts',
'health_wellness_socialsciences', 'health_wellness_specialneeds', 'health_wellness_teamsports', 'h
ealth_wellness_visualarts', 'health_wellness_warmth_care_hunger', 'history_geography',
'history_geography_literacy', 'history_geography_literature_writing',
'history_geography_mathematics', 'history_geography_music', 'history_geography_other',
'history_geography_parentinvolvement', 'history_geography_performingarts',
'history_geography_socialsciences', 'history_geography_specialneeds',
'history_geography_teamsports', 'history_geography_visualarts',
'history_geography_warmth_care_hunger', 'literacy', 'literacy_literature_writing',
'literacy_mathematics', 'literacy_music', 'literacy_nutritioneducation', 'literacy_other',
'literacy_parentinvolvement', 'literacy_performingarts', 'literacy_socialsciences',
'literacy_specialneeds', 'literacy_teamsports', 'literacy_visualarts',
'literacy_warmth_care_hunger', 'literature_writing', 'literature_writing_mathematics',
'literature_writing_music', 'literature_writing_nutritioneducation', 'literature_writing_other', '

```
literature_writing_parentinvolvement', 'literature_writing_performingarts',
'literature_writing_socialsciences', 'literature_writing_specialneeds',
'literature_writing_teamsports', 'literature_writing_visualarts',
'literature_writing_warmth_care_hunger', 'mathematics', 'mathematics_music',
'mathematics_nutritioneducation', 'mathematics_other', 'mathematics_parentinvolvement',
'mathematics_performingarts', 'mathematics_socialsciences', 'mathematics_specialneeds',
'mathematics_teamsports', 'mathematics_visualarts', 'mathematics_warmth_care_hunger', 'music', 'mu
sic_other', 'music_parentinvolvement', 'music_performingarts', 'music_socialsciences',
'music_specialneeds', 'music_teamsports', 'music_visualarts', 'nutritioneducation',
'nutritioneducation_other', 'nutritioneducation_socialsciences',
'nutritioneducation_specialneeds', 'nutritioneducation_teamsports',
'nutritioneducation_visualarts', 'nutritioneducation_warmth_care_hunger', 'other',
'other_parentinvolvement', 'other_performingarts', 'other_socialsciences', 'other_specialneeds', '
other_teamsports', 'other_visualarts', 'other_warmth_care_hunger', 'parentinvolvement',
'parentinvolvement_performingarts', 'parentinvolvement_socialsciences',
'parentinvolvement_specialneeds', 'parentinvolvement_teamsports', 'parentinvolvement_visualarts',
'performingarts', 'performingarts_socialsciences', 'performingarts_specialneeds',
'performingarts_teamsports', 'performingarts_visualarts', 'socialsciences',
'socialsciences_specialneeds', 'socialsciences_teamsports', 'socialsciences_visualarts',
'specialneeds', 'specialneeds_teamsports', 'specialneeds_visualarts',
'specialneeds_warmth_care_hunger', 'teamsports', 'teamsports_visualarts', 'visualarts',
'visualarts_warmth_care_hunger', 'warmth_care_hunger']
==========================================================================================
```

1.4.1 encoding categorical features: School State-ohe

In [85]:

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


school_state_cat_dict = dict(my_counter)
sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lambda t: t[1]))
```

In [86]:

```
vectorizer_state=CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lowercase=F
alse, binary=True)
```

In [56]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on train data

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

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

```
After vectorizations
(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', 'k
s', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm',
'nv', 'ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv
', 'wy']
==========================================================================================
```

1.4.2 encoding categorical features: teacher_prefix-ohe

In [87]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

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

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

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

In [104]:

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


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

In [106]:

```
vectorizer_teacher=CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=F
alse, binary=True)
```

1.4.3 encoding categorical features: project_grade_category-ohe

In [58]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

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

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

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

In [96]:

```
my_counter = Counter()
for grade in project_data['project_grade_category'].values:
    my_counter.update(grade.split())

project_grade_cat_dict = dict(my_counter)
sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.items(), key=lambda t: t[1]))
```

In [97]:

```
vectorizer_grade=CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys()), lowercase=
False, binary=True)
```

1.4.4 encoding numerical features: Price

In [59]:

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

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



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

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

1.4.4 encoding numerical features: quantity

In [60]:

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

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



print("After vectorizations")
```

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

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

1.4.4 encoding numerical features: Projects_previously_proposed_by_teacher

In [61]:

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

X_train_num_prev_projects_norm =
normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_cv_num_prev_projects_norm =
normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_test_num_prev_projects_norm =
normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))



print("After vectorizations")
print(X_train_num_prev_projects_norm.shape, y_train.shape)
print(X_cv_num_prev_projects_norm.shape, y_cv.shape)
print(X_test_num_prev_projects_norm.shape, y_test.shape)
print("="*100)
```

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

1.4.4 encoding numerical features: title_count

In [62]:

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

X_train_title_number_words_norm =
normalizer.transform(X_train['title_number_words'].values.reshape(-1,1))
X_cv_title_number_words_norm = normalizer.transform(X_cv['title_number_words'].values.reshape(-1,1)
)
X_test_title_number_words_norm = normalizer.transform(X_test['title_number_words'].values.reshape(
-1,1))
```

```
print("After vectorizations")
print(X_train_title_number_words_norm.shape, y_train.shape)
print(X_cv_title_number_words_norm.shape, y_cv.shape)
print(X_test_title_number_words_norm.shape, y_test.shape)
print("="*100)
```

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

1.4.4 encoding numerical features: essay_count

In [63]:

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

X_train_essay_number_words_norm =
normalizer.transform(X_train['essay_number_words'].values.reshape(-1,1))
X_cv_essay_number_words_norm = normalizer.transform(X_cv['essay_number_words'].values.reshape(-1,1)
)
X_test_essay_number_words_norm = normalizer.transform(X_test['essay_number_words'].values.reshape(
-1,1))



print("After vectorizations")
print(X_train_essay_number_words_norm.shape, y_train.shape)
print(X_cv_essay_number_words_norm.shape, y_cv.shape)
print(X_test_essay_number_words_norm.shape, y_test.shape)
print("="*100)
```

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

1.5 Appling NB on different kind of featurization as mentioned in the instructions

Set 1: categorical, numerical features + project_title(BOW) + Essay (BOW)

In [64]:

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

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

num_prev_projects_train = (X_train['teacher_number_of_previously_posted_projects'].values.reshape(
-1,1))
num_prev_projects_cv = (X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
```

```
num_prev_projects_test = (X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))

title_number_word_train = (X_train['title_number_words'].values.reshape(-1,1))
title_number_word_cv = (X_cv['title_number_words'].values.reshape(-1,1))
title_number_word_test = (X_test['title_number_words'].values.reshape(-1,1))


essay_number_word_train = (X_train['essay_number_words'].values.reshape(-1,1))
essay_number_word_cv = (X_cv['essay_number_words'].values.reshape(-1,1))
essay_number_word_test = (X_test['essay_number_words'].values.reshape(-1,1))
```

Concatinating all the features

In [143]:

```
from scipy.sparse import hstack
X_tr = hstack((X_train_project_title_bow,X_train_essay_bow, X_train_project_subject_categories_ohe
, X_train_project_subject_subcategories_ohe, X_train_state_ohe, X_train_teacher_ohe,
X_train_grade_ohe, X_train_price_norm, X_train_quantity_norm, X_train_num_prev_projects_norm,
X_train_title_number_words_norm , X_train_essay_number_words_norm)).tocsr()
X_te = hstack((X_test_project_title_bow,X_test_essay_bow, X_test_project_subject_categories_ohe,
X_test_project_subject_subcategories_ohe, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe,
X_test_price_norm, X_test_quantity_norm, X_test_num_prev_projects_norm,
X_test_title_number_words_norm , X_test_essay_number_words_norm)).tocsr()
X_cr = hstack((X_cv_project_title_bow,X_cv_essay_bow, X_cv_project_subject_categories_ohe,
X_cv_project_subject_subcategories_ohe, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe,
X_cv_price_norm, X_cv_quantity_norm, X_cv_num_prev_projects_norm, X_cv_title_number_words_norm , X
_cv_essay_number_words_norm)).tocsr()

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

```
Final Data matrix
(49041, 10503) (49041,)
(24155, 10503) (24155,)
(36052, 10503) (36052,)
====================================================================================================
```

In [66]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive 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 tr_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
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

RandomsearchCV

In [144]:

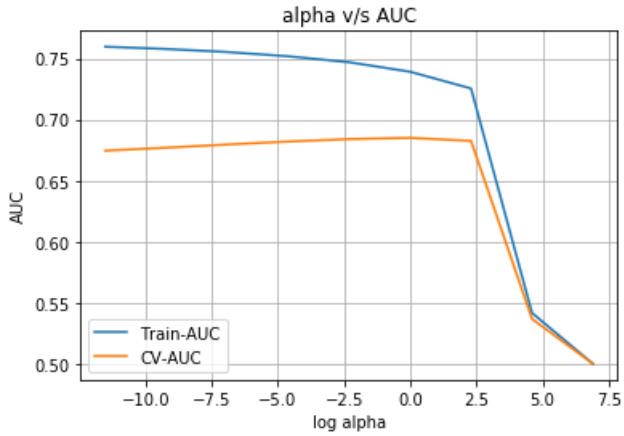
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math
```

```
train= []
cv= []
log_alphas = []

alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10,  100,  1000]

for i in tqdm(alphas):
    NB = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    NB.fit(X_tr, y_train)

    y_pred_train = batch_predict(NB, X_tr)
    y_pred_cv = batch_predict(NB, X_cr)


    train.append(roc_auc_score(y_train,y_pred_train))
    cv.append(roc_auc_score(y_cv, y_pred_cv))

for x in tqdm(alphas):
    y = math.log(x)
    log_alphas.append(y)
```

```
100%|██████████| 9/9 [00
:05<00:00,  1.63it/s]
100%|██████████| 9/9
[00:00<00:00, 9022.16it/s]
```

In [145]:

```
plt.plot(log_alphas, train, label='Train-AUC')
plt.plot(log_alphas, cv, label='CV-AUC')
plt.legend()
plt.xlabel("log alpha")
plt.ylabel("AUC")
plt.title("alpha v/s AUC")
plt.grid()
plt.show()
```



Summary

1. Since the values of the hyperparamter belongs to a wide range grom 0.0001 to 1000. This could not have been plotted in the same graph so easily. Hence we used log of the hyperparameter to plot the graphs successfully.
2. For log alpha 7 we can see that Train AUC and CV AUC meet at a point

Gridsearch CV

In [146]:

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

from sklearn.model_selection import GridSearchCV
```

```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math


nb = MultinomialNB(class_prior=[0.5,0.5])

parameters = {'alpha':[0.00001, 0.0001,0.001, 0.01, 0.1,0.5,0.8, 1, 10,  100,  1000]}

clf = GridSearchCV(nb, parameters, cv= 10, scoring='roc_auc',return_train_score=True,verbose=2)

clf.fit(X_tr, y_train)

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

```
Fitting 10 folds for each of 11 candidates, totalling 110 fits
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

```
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.4s remaining:    0.0s
```

```
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.4s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.3s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.2s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .....................................................
[CV] ..................................... alpha=1e-05, total=   0.2s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.2s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.2s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.2s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.1s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.2s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.3s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.3s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.3s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.3s
[CV] alpha=0.0001 ....................................................
[CV] .................................... alpha=0.0001, total=   0.3s
[CV] alpha=0.001 .....................................................
[CV] ..................................... alpha=0.001, total=   0.3s
[CV] alpha=0.001 .....................................................
[CV] ..................................... alpha=0.001, total=   0.3s
[CV] alpha=0.001 .....................................................
[CV] ..................................... alpha=0.001, total=   0.3s
[CV] alpha=0.001 .....................................................
[CV] ..................................... alpha=0.001, total=   0.1s
```

```
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.001 .....................................................
[CV] ...................................... alpha=0.001, total=   0.1s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.1s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.1s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
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[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.01 ......................................................
[CV] ....................................... alpha=0.01, total=   0.3s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.2s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.1s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.1s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.1s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.3s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.3s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.3s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.4s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.3s
[CV] alpha=0.1 .......................................................
[CV] ........................................ alpha=0.1, total=   0.3s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.3s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.3s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.3s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.2s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.5 .......................................................
[CV] ........................................ alpha=0.5, total=   0.1s
[CV] alpha=0.8 .......................................................
[CV] ........................................ alpha=0.8, total=   0.2s
[CV] alpha=0.8 .......................................................
[CV] ........................................ alpha=0.8, total=   0.2s
[CV] alpha=0.8 .......................................................
```

```
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=0.8 ..........................................................
[CV] ........................................... alpha=0.8, total=   0.3s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.3s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.3s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.1s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.2s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.2s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.2s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.1s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.1s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.1s
[CV] alpha=1 ............................................................
[CV] ............................................. alpha=1, total=   0.1s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.1s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
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[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.3s
[CV] alpha=10 ...........................................................
[CV] ............................................ alpha=10, total=   0.2s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.3s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.1s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.1s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   1.1s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.7s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.2s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.1s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.1s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.2s
[CV] alpha=100 ..........................................................
[CV] ........................................... alpha=100, total=   0.1s
[CV] alpha=1000 .........................................................
[CV] .......................................... alpha=1000, total=   0.1s
```
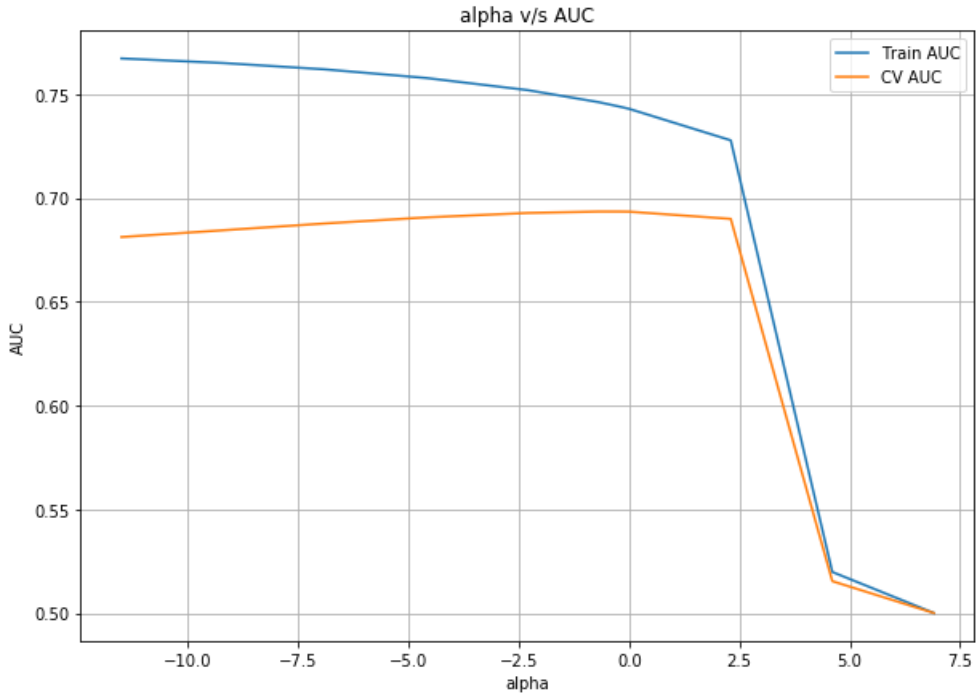

```
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.1s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.1s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.2s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
[CV] alpha=1000 ......................................................
[CV] ..................................... alpha=1000, total=   0.3s
```

```
[Parallel(n_jobs=1)]: Done 110 out of 110 | elapsed:   41.5s finished
```

In [147]:

```
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1,0.5,0.8, 1, 10,  100,  1000]
log_alphas =[]

for x in tqdm(alphas):
    y = math.log(x)
    log_alphas.append(y)

plt.figure(figsize=(10,7))
plt.plot(log_alphas, train_auc, label='Train AUC')

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

plt.legend()
plt.xlabel("alpha")
plt.ylabel("AUC")
plt.title("alpha v/s AUC")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 11/11
[00:00<00:00, 216.00it/s]
```



Summary

1. We have taken wide range of values for the hyperparameter. It was difficult to plot these values on a graph, hence logarithm of the alpha values have plotted instead of alpha.
2. Using this graph we can see Train AUC and CV AUC converge at 7

0.5 has been selected as the best hyperparameter from girdsearch cv

In [150]:

```
#best_alpha0=0.5
```

Testing the performance of the model on test data, plotting ROC Curves

In [148]:

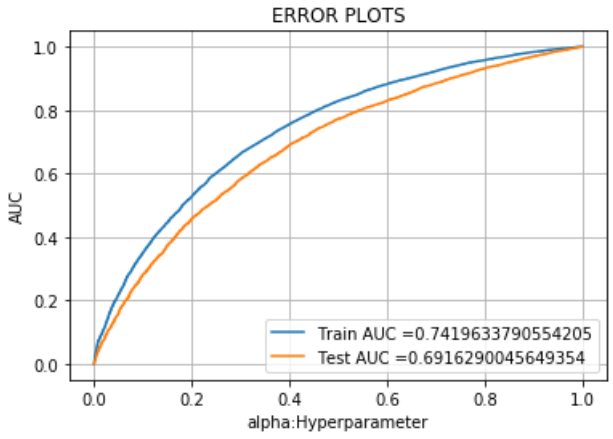
```
best_alpha=clf.best_params_
best_alpha
```

Out[148]:

```
{'alpha': 0.5}
```

In [149]:

```
from sklearn.metrics import roc_curve, auc

NB_bow = MultinomialNB(alpha = 0.5,class_prior=[0.5,0.5])

NB_bow.fit(X_tr, y_train)


y_train_pred = batch_predict(NB_bow, X_tr)
y_test_pred = batch_predict(NB_bow, X_te)

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("alpha:Hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



Summary

Summary

For BOW the best paramter value is Train AUC is 0.7419 and Test AUC is 0.6916

Confusion Matrix

In [151]:

```
def find_best_threshold(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))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [152]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

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

the maximum value of tpr*(1-fpr) 0.4650788512902781 for threshold 0.463
Train confusion matrix
[[ 5172  2254]
 [13826 27789]]
Test confusion matrix
[[ 3428  2031]
 [10461 20132]]
```

Summary

For train and test both True positives are high. But False Negatives are also very high and True Negatives are very low.

Select best 20 features for Positive and negative class

In [155]:

```
for x in vectorizer_cat.get_feature_names() :
    bow_feature.append(x)

for y in vectorizer_subcat.get_feature_names() :
    bow_feature.append(y)

for z in vectorizer_state.get_feature_names() :
    bow_feature.append(z)

for u in vectorizer_grade.get_feature_names() :
    bow_feature.append(u)

for v in vectorizer_teacher.get_feature_names() :
    bow_feature.append(v)
```

In [154]:

In [154]:

```
bow_feature = []
```

In [156]:

```
bow_feature.append("price")

bow_feature.append("quantity")


bow_feature.append("teacher_number_of_previously_posted_projects")

bow_feature.append("title_number_words")

bow_feature.append("essay_number_words")

len(bow_feature)
```

Out[156]:

517

In [157]:

```
for w in vectorizer_title_bow.get_feature_names() :
    bow_feature.append(w)
```

In [158]:

```
len(bow_feature)
```

Out[158]:

5517

In [159]:

```
for p in vectorizer_essay_bow.get_feature_names() :
    bow_feature.append(p)
```

In [160]:

```
len(bow_feature)
```

Out[160]:

10517

Top 20 positive features BOW

In [161]:

```
pos_class_feature = NB_bow.feature_log_prob_[1, :].argsort()[::-1][:10517]
for i in pos_class_feature[:20]:
    print(bow_feature[i])
```

```
takes
we ve got
selected
practice their
learning in
excited about learning
instructional
wobbling
students feel
sport
title school where
college and
```

college and
make my
ipad
school my students
dry
for years
to get the
of new
across

Top 20 negative features BOW

In [162]:

```
neg_class_feature = NB_bow.feature_log_prob_[0, :].argsort()[::-1][:10517]
for i in neg_class_feature[0:20]:
    print(bow_feature[i])
```

takes
we ve got
selected
practice their
learning in
excited about learning
instructional
wobbling
students feel
sport
title school where
school my students
college and
for years
dry
make my
ipad
to get the
of new
across

Summary

Most words are similar but their ordering is different

Set 2 : categorical, numerical features + project_title(TFIDF) + Essay (TFIDF)

Concating all features

In [125]:

```
from scipy.sparse import hstack
X_tr = hstack((X_train_project_title_Tfidf,X_train_essay_Tfidf,
X_train_project_subject_categories_ohe, X_train_project_subject_subcategories_ohe,
X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe, X_train_price_norm,
X_train_quantity_norm, X_train_num_prev_projects_norm, X_train_title_number_words_norm ,
X_train_essay_number_words_norm)).tocsr()
X_te = hstack((X_test_project_title_Tfidf,X_test_essay_Tfidf,
X_test_project_subject_categories_ohe, X_test_project_subject_subcategories_ohe, X_test_state_ohe,
X_test_teacher_ohe, X_test_grade_ohe, X_test_price_norm, X_test_quantity_norm,
X_test_num_prev_projects_norm, X_test_title_number_words_norm , X_test_essay_number_words_norm)).t
ocsr()
X_cr = hstack((X_cv_project_title_Tfidf,X_cv_essay_Tfidf, X_cv_project_subject_categories_ohe,
X_cv_project_subject_subcategories_ohe, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe,
X_cv_price_norm, X_cv_quantity_norm, X_cv_num_prev_projects_norm, X_cv_title_number_words_norm , X
_cv_essay_number_words_norm)).tocsr()

print("Final Data matrix")
```

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

```
Final Data matrix
(49041, 7615) (49041,)
(24155, 7615) (24155,)
(36052, 7615) (36052,)
====================================================================================================
```

RandomSearchCV

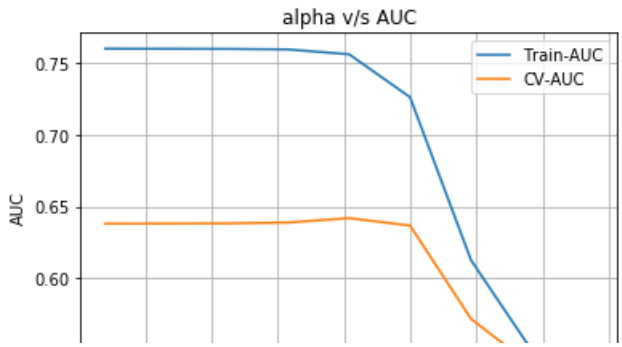
In [126]:

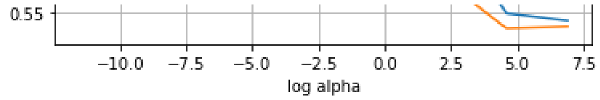
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math

train= []
cv= []
log_alphas = []

alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10,  100,  1000]

for i in tqdm(alphas):
    NB = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    NB.fit(X_tr, y_train)

    y_pred_train = batch_predict(NB, X_tr)
    y_pred_cv = batch_predict(NB, X_cr)


    train.append(roc_auc_score(y_train,y_pred_train))
    cv.append(roc_auc_score(y_cv, y_pred_cv))

for x in tqdm(alphas):
    y = math.log(x)
    log_alphas.append(y)
```

```
100%|██████████| 9/9 [00:04<00:00,  1.91it/s]
100%|██████████| 9/9 [00:00<00:00, 225.61it/s]
```

In [127]:

```
plt.plot(log_alphas, train, label='Train-AUC')
plt.plot(log_alphas, cv, label='CV-AUC')
plt.legend()
plt.xlabel("log alpha")
plt.ylabel("AUC")
plt.title("alpha v/s AUC")
plt.grid()
plt.show()
```





Summary

1. We have taken wide range of values for the hyperparameter. It was difficult to plot these values on a graph, hence logarithm of the alpha values have plotted instead of alpha.
2. Using this graph we can see Train AUC and CV AUC converge at 7

GridSearchCV

In [128]:

```
from sklearn.model_selection import GridSearchCV
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math


nb = MultinomialNB(class_prior=[0.5,0.5])

parameters = {'alpha':[0.00001, 0.0001,0.001, 0.01, 0.1,0.5,0.8, 1, 10,  100,  1000]}

clf = GridSearchCV(nb, parameters, cv= 10, scoring='roc_auc',return_train_score=True,verbose=2)

clf.fit(X_tr, y_train)

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

```
Fitting 10 folds for each of 11 candidates, totalling 110 fits
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

```
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.4s
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.4s remaining:    0.0s
```

```
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .......................................................
[CV] ........................................ alpha=1e-05, total=   0.1s
[CV] alpha=0.0001 ......................................................
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[CV] ....................................... alpha=1000, total=   0.2s
```
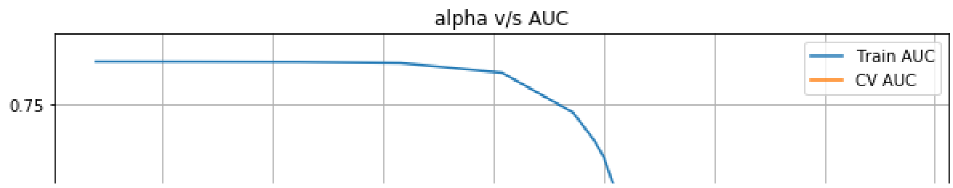
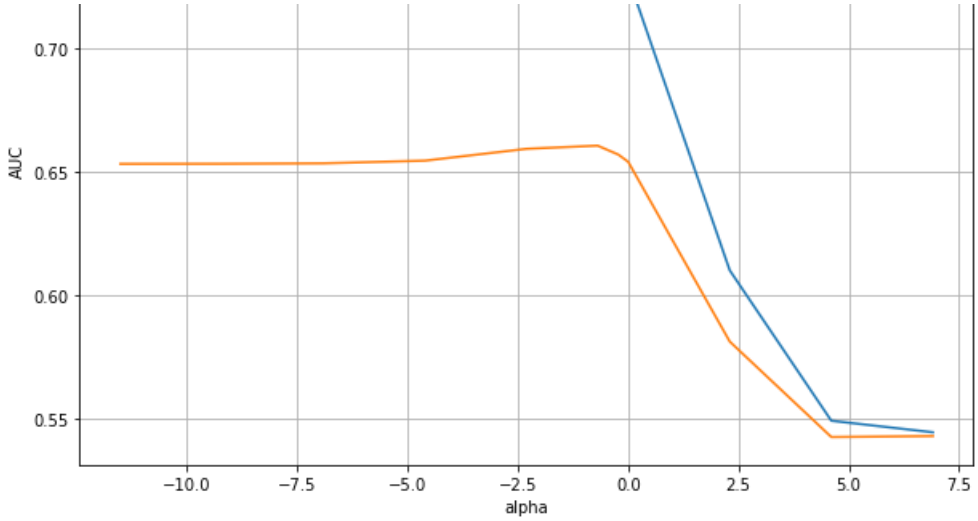

```
[Parallel(n_jobs=1)]: Done 110 out of 110 | elapsed:   24.5s finished
```

In [129]:

```python
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1,0.5,0.8, 1, 10,  100,  1000]
log_alphas =[]

for x in tqdm(alphas):
    y = math.log(x)
    log_alphas.append(y)

plt.figure(figsize=(10,7))
plt.plot(log_alphas, train_auc, label='Train AUC')

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

plt.legend()
plt.xlabel("alpha")
plt.ylabel("AUC")
plt.title("alpha v/s AUC")
plt.grid()
plt.show()
```

```
100%|█████████████████████████████████████████████████████████████████████████████████| 11/11
[00:00<00:00, 216.16it/s]
```





Summary

1. We have taken wide range of values for the hyperparameter. It was difficult to plot these values on a graph, hence logarithm of the alpha values have plotted instead of alpha.
2. Using this graph we can see Train AUC and CV AUC converge at 7

0.5 has been selected as the best hyperparameter from girdsearch cv

Train model using the best value of alpha

In [130]:

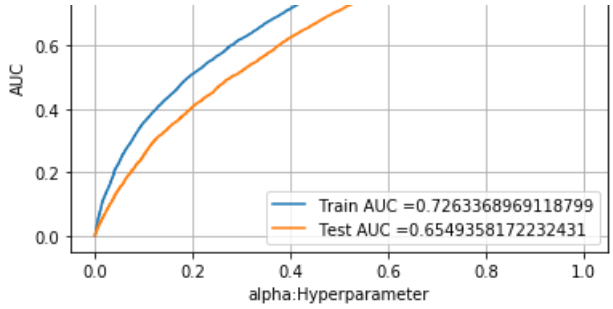
```
best_alpha2=clf.best_params_
best_alpha2
```

Out[130]:

```
{'alpha': 0.5}
```

In [131]:

```
from sklearn.metrics import roc_curve, auc

NB_bow = MultinomialNB(alpha = 1,class_prior=[0.5,0.5])

NB_bow.fit(X_tr, y_train)


y_train_pred = batch_predict(NB_bow, X_tr)
y_test_pred = batch_predict(NB_bow, X_te)

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("alpha:Hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



Summary

For TFIDF the best paramter value is Train AUC is 0.7263 and Test AUC is 0.6549

Confusion Matrix

In [132]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

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

the maximum value of tpr*(1-fpr) 0.43685451187590035 for threshold 0.515
Train confusion matrix
[[ 4859  2567]
 [13831 27784]]
Test confusion matrix
[[ 3068  2391]
 [10491 20102]]
```

Summary

For train and test both True positives are high. But False Negatives are also very high and True Negatives are very low.

tfidf top features

In [133]:

```
tfidf_feature = []



for x in vectorizer_cat.get_feature_names() :
    tfidf_feature.append(x)

for y in vectorizer_subcat.get_feature_names() :
    tfidf_feature.append(y)

for z in vectorizer_state.get_feature_names() :
    tfidf_feature.append(z)

for u in vectorizer_grade.get_feature_names() :
    tfidf_feature.append(u)

for v in vectorizer_teacher.get_feature_names() :
    tfidf_feature.append(v)
```

In [134]:

```
len(tfidf_feature)
```

Out[134]:

512

In [135]:

```
tfidf_feature.append("price")

tfidf_feature.append("quantity")


tfidf_feature.append("teacher_number_of_previously_posted_projects")

tfidf_feature.append("title_number_words")

tfidf_feature.append("essay_number_words")

len(tfidf_feature)
```

Out[135]:

517

In [136]:

```
for w in vectorizer_title_Tfidf.get_feature_names() :
    tfidf_feature.append(w)
```

In [137]:

```
for p in vectorizer_essay_Tfidf.get_feature_names() :
    tfidf_feature.append(p)
```

In [138]:

```
len(tfidf_feature)
```

Out[138]:

7629

Top 20 positive features of tfidf

In [141]:

```
pos_class_tfidf = NB.feature_log_prob_[1, :].argsort()[::-1][:7629]
for i in pos_class_tfidf[0:20]:
    print(tfidf_feature[i])
```

```
yet
years
yearning
yesterday
yes
www
yearn
xylophones
year
that
shelter
technical
yearbook
themed
seems
```

```
witnessed
their
retain
yearly
wrote
```

Top 20 Negative features from Tfidf

In [142]:

```
neg_class_tfidf = NB.feature_log_prob_[0, :].argsort()[::-1][:7629]
for i in neg_class_tfidf[0:20]:
    print(tfidf_feature[i])
```

```
yet
yesterday
years
yearning
yes
www
yearn
xylophones
year
themed
that
shelter
yearbook
technical
seems
witnessed
retain
their
yearly
wrote
```

Conclusions

In [163]:

```
from prettytable import PrettyTable

y = PrettyTable()
y.field_names = ["Vectorizer", "Model", "Alpha", " Test AUC"]

y.add_row(["BOW", "Naive Bayes", 0.5, 0.69])
y.add_row(["TFIDF", "Naive Bayes", 0.5, 0.65])

print(y)
```

```
+------------+-------------+-------+-----------+
| Vectorizer |    Model    | Alpha |  Test AUC |
+------------+-------------+-------+-----------+
|    BOW     | Naive Bayes |  0.5  |    0.69   |
|   TFIDF    | Naive Bayes |  0.5  |    0.65   |
+------------+-------------+-------+-----------+
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]: