DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

- Literature & Writing, Social Sciences

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

your neighborhood, and your school are all helpful."

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

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

In [1]:

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

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

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn import cross_validation
from sklearn.metrics import accuracy_score
from sklearn.cross_validation import cross_val_score
from sklearn.cross_validation import train_test_split
import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

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

from tqdm import tqdm
import os

from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
os.chdir('C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose')
```

```
C:\Users\kingsubham27091995\Anaconda3\lib\site-packages\sklearn\cross_validation.py:41:
DeprecationWarning: This module was deprecated in version 0.18 in favor of the model_selection
module into which all the refactored classes and functions are moved. Also note that the interface
of the new CV iterators are different from that of this module. This module will be removed in 0.2
0.
  "This module will be removed in 0.20.", DeprecationWarning)
```

1.1 Reading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

Out[4]:

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

In [6]:

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

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

Out[6]:

	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

Preprocessing project_grade_categories

In [7]:

```
project_grade_category = []

for i in range(len(project_data)):
    a = project_data["project_grade_category"][i].replace(" ", "_")
    project_grade_category.append(a)
```

In [8]:

```
project_grade_category[0:5]
```

Out[8]:

```
['Grades_PreK-2', 'Grades_6-8', 'Grades_6-8', 'Grades_PreK-2', 'Grades_PreK-2']
```

In [9]:

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

In [10]:

```
project_data["project_grade_category"] = project_grade_category
```

In [11]:

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

Out[11]:

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

1.2 preprocessing of `project_subject_categories`

In [12]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [13]:

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

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

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

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

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

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

1.3 Text preprocessing

Cleaning Titles(Text Preprocessing)

In [14]:

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

In [15]:

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

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

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [16]:

```
clean_titles = []

for titles in tqdm(project_data["project_title"]):
    title = decontracted(titles)
    title = title.replace('\\r', ' ')
    title = title.replace('\\"', ' ')
    title = title.replace('\\n', ' ')
    title = re.sub('[^A-Za-z0-9]+', ' ', title)
    title = ' '.join(f for f in title.split() if f not in stopwords)
    clean_titles.append(title.lower().strip())
```

```
100%|██████████████████████████████████| 109248/109248 [00:03<00:00, 28704.10it/s]
```

In [17]:

```
project_data["clean_titles"] = clean_titles
```

In [18]:

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

Finding number of words in title and introducing it in a new column

- This can be used as Numerical Feature for Vectorisation

In [19]:

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

In [20]:

```
project_data["title_word_count"] = title_word_count
project_data.head(5)
```

Out[20]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My Eng that
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our arriv scho lea.
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\ cha alwa th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I wo uniq fille ESL
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our grad nex m...

Combining 4 Essays into 1 Essay Feature

In [21]:

```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [22]:

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves
to get together and celebrate. Around Halloween there is a whole school parade to show off the bea
utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by
the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t
he hard work put in during the school year, with a dunk tank being the most popular activity.My st
udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged
chairs. As I will only have a total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During independent reading time they
will be used as special chairs students will each use on occasion. I will utilize them in place of
chairs at my small group tables during math and reading times. The rest of the day they will be us
ed by the students who need the highest amount of movement in their life in order to stay focused
on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki
Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i
n group with me on the Hokki Stools, they are always moving, but at the same time doing their
work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are
disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours
a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th
e same time. These stools will help students to meet their 60 minutes a day of movement by
allowing them to activate their core muscles for balance while they sit. For many of my students,
these chairs will take away the barrier that exists in schools for a child who can't sit
still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of
desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work
hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n
\r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in
Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq
ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage
r learners; they are like sponges, absorbing all the information and experiences and keep on wanti
ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin
g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to
be one of a themed nautical environment. Creating a classroom environment is very important in the
success in each and every child's education. The nautical photo props will be used with each child
as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic
tures of each child with them, have them developed, and then hung in our classroom ready for their
first day of 4th grade.  This kind gesture will set the tone before even the first day of school!
The nautical thank you cards will be used throughout the year by the students as they create thank
you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our
classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of
my own pocket on resources to get our classroom ready. Please consider helping with this project t
o make our new school year a very successful one. Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju
mping and playing. Physical engagement is the key to our success. The number toss and color and sh
ape mats can make that happen. My students will forget they are doing work and just have the fun a
6 year old deserves.nannan
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The grea
t teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% Af
rican-American, making up the largest segment of the student body. A typical school in Dallas is m
ade up of 23.2% African-American students. Most of the students are on free or reduced lunch. We a
ren't receiving doctors, lawyers, or engineers children from rich backgrounds or neighborhoods. As
an educator I am inspiring minds of young children and we focus not only on academics but one smar
t, effective, efficient, and disciplined students with good character In our classroom we can util
```

```
t, effective, efficient, and disciplined students with good character.In our classroom we can util
ize the Bluetooth for swift transitions during class. I use a speaker which doesn't amplify the so
und enough to receive the message. Due to the volume of my speaker my students can't hear videos o
r books clearly and it isn't making the lessons as meaningful. But with the bluetooth speaker my s
tudents will be able to hear and I can stop, pause and replay it at any time.\r\nThe cart will all
ow me to have more room for storage of things that are needed for the day and has an extra part to
it I can use.  The table top chart has all of the letter, words and pictures for students to learn
about different letters and it is more accessible.nannan
==================================================
```

Cleaning Essays(Text Preprocessing)

In [23]:

```python
clean_essay = []

for ess in tqdm(project_data["essay"]):
    ess = decontracted(ess)
    ess = ess.replace('\\r', ' ')
    ess = ess.replace('\\"', ' ')
    ess = ess.replace('\\n', ' ')
    ess = re.sub('[^A-Za-z0-9]+', ' ', ess)
    ess = ' '.join(f for f in ess.split() if f not in stopwords)
    clean_essay.append(ess.lower().strip())
```

```
100%|██████████████████████████████| 109248/109248 [01:24<00:00, 1287.91it/s]
```

In [24]:

```python
project_data["clean_essays"] = clean_essay
```

In [25]:

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

Finding number of words in title and introducing it in a new column

- This can be used as Numerical Feature for Vectorisation

In [26]:

```python
essay_word_count = []
for ess in project_data["clean_essays"] :
    c = len(ess.split())
    essay_word_count.append(c)
```

In [27]:

```python
project_data["essay_word_count"] = essay_word_count
project_data.head(5)
```

Out[27]:

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

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\ cha alwa th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I wo uniq fille ESL
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our grad nex m...

Calculating Sentiment Scores for the Essays Feature

In [28]:

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

In [29]:

```
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\kingsubham27091995\AppData\Roaming\nltk_data.
[nltk_data]     ..
[nltk_data]   Package vader_lexicon is already up-to-date!
```

Out[29]:

```
True
```

In [30]:

```
analyser = SentimentIntensityAnalyzer()
```

In [31]:

```
## http://t-redactyl.io/blog/2017/04/using-vader-to-handle-sentiment-analysis-with-social-media-te
xt.html
neg = []
pos = []
neu = []
compound = []

for a in tqdm(project_data["clean_essays"]) :
    b = analyser.polarity_scores(a)['neg']
    c = analyser.polarity_scores(a)['pos']
    d = analyser.polarity_scores(a)['neu']
    e = analyser.polarity_scores(a)['compound']
    neg.append(b)
    pos.append(c)
    neu.append(d)
    compound.append(e)
```

```
100%|██████████████████████████████████| 109248/109248 [19:10<00:00, 94.92it/s]
```

In [32]:

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

```
project_data["compound"] = compound

project_data.head(5)
```

Out[32]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My Eng that
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our arriv sch lea.
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\ cha alwa th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I wo unic fille ESL
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our grac nex m...

5 rows × 24 columns

Splitting Project_Data into Train and Test Datasets

In [33]:

```
from sklearn.model_selection import train_test_split
#Splitting into Train and Test Data
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'
])
#Splitting Train data into Train and Cross Validation Data
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

We don't need the 'project_is_approved' feature now

In [34]:

```
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)
```

1.5 Preparing data for models

In [35]:

```
project_data.columns
```

Out[35]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'project_grade_category', 'clean_categories', 'clean_subcategories',
       'clean_titles', 'title_word_count', 'clean_essays', 'essay_word_count',
       'pos', 'neg', 'neu', 'compound'],
      dtype='object')
```

we are going to consider

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

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

      - quantity : numerical (optinal)
      - teacher_number_of_previously_posted_projects : numerical
      - price : numerical
         - title_word_count : numerical
         - essay_word_count : numerical
         - essay sentiment [positive] : numerical
         - essay sentiment [negative] : numerical
         - essay sentiment [neutral] : numerical
         - essay sentiment [compound] : numerical
```

1.5.1 Vectorizing Categorical data

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

One Hot Encoding of Clean_Categories

In [36]:

```
from sklearn.feature_extraction.text import CountVectorizer

vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True
)
vectorizer.fit(X_train['clean_categories'].values)

categories_one_hot_train = vectorizer.transform(X_train['clean_categories'].values)
categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)
categories_one_hot_cv = vectorizer.transform(X_cv['clean_categories'].values)

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",categories_one_hot_test.shape)
print("Shape of matrix of CV data after one hot encoding ",categories_one_hot_cv.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix of Train data after one hot encoding  (49041, 9)
Shape of matrix of Test data after one hot encoding  (36052, 9)
Shape of matrix of CV data after one hot encoding  (24155, 9)
```

One Hot Encoding of Clean_Sub_Categories

In [37]:

```
# we use count vectorizer to convert the values into one

vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=
True)
vectorizer.fit(X_train['clean_subcategories'].values)

sub_categories_one_hot_train = vectorizer.transform(X_train['clean_subcategories'].values)
sub_categories_one_hot_test = vectorizer.transform(X_test['clean_subcategories'].values)
sub_categories_one_hot_cv = vectorizer.transform(X_cv['clean_subcategories'].values)


print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_hot_test.shape)
print("Shape of matrix of Cross Validation data after one hot encoding ",sub_categories_one_hot_cv
.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix of Train data after one hot encoding  (49041, 30)
Shape of matrix of Test data after one hot encoding  (36052, 30)
Shape of matrix of Cross Validation data after one hot encoding  (24155, 30)
```

Performing One-Hot-Encoding for School-State

In [38]:

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

In [39]:

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

In [40]:

```
## we use count vectorizer to convert the values into one hot encoded features

vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercase=False, bi
nary=True)
vectorizer.fit(X_train['school_state'].values)

school_state_categories_one_hot_train = vectorizer.transform(X_train['school_state'].values)
school_state_categories_one_hot_test = vectorizer.transform(X_test['school_state'].values)
school_state_categories_one_hot_cv = vectorizer.transform(X_cv['school_state'].values)

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",school_state_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",school_state_categories_one_hot_test.
shape)
print("Shape of matrix of Cross Validation data after one hot encoding
",school_state_categories_one_hot_cv.shape)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM', 'KS', 'I
A', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'NV', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'WA', 'MA', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX
', 'CA']
Shape of matrix of Train data after one hot encoding  (49041, 51)
Shape of matrix of Test data after one hot encoding  (36052, 51)
Shape of matrix of Test data after one hot encoding  (36052, 51)
Shape of matrix of Cross Validation data after one hot encoding  (24155, 51)
```

Performing One-Hot-Encoding for Project_Grade_Category

In [41]:

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

In [42]:

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

In [43]:

```
## we use count vectorizer to convert the values into one hot encoded features

vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()), lowercase
=False, binary=True)
vectorizer.fit(X_train['project_grade_category'].values)

project_grade_categories_one_hot_train = vectorizer.transform(X_train['project_grade_category'].va
lues)
project_grade_categories_one_hot_test =
vectorizer.transform(X_test['project_grade_category'].values)
project_grade_categories_one_hot_cv = vectorizer.transform(X_cv['project_grade_category'].values)

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",project_grade_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",project_grade_categories_one_hot_test
.shape)
print("Shape of matrix of Cross Validation data after one hot encoding
",project_grade_categories_one_hot_cv.shape)
```

```
['Grades_9-12', 'Grades_6-8', 'Grades_3-5', 'Grades_PreK-2']
Shape of matrix of Train data after one hot encoding  (49041, 4)
Shape of matrix of Test data after one hot encoding  (36052, 4)
Shape of matrix of Cross Validation data after one hot encoding  (24155, 4)
```

Performing One-Hot_encoding for Teacher_Prefix

In [44]:

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

In [45]:

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

In [46]:

```
## ValueError: np.nan is an invalid document, expected byte or unicode string.
## The link below explains h0w to tackle such discrepancies.
## https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-valueerror-np-nan-
is-an-invalid-document/39308809#39308809

vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=Fal
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=False,
binary=True)
vectorizer.fit(X_train['teacher_prefix'].values.astype("U"))

teacher_prefix_categories_one_hot_train =
vectorizer.transform(X_train['teacher_prefix'].values.astype("U"))
teacher_prefix_categories_one_hot_test =
vectorizer.transform(X_test['teacher_prefix'].values.astype("U"))
teacher_prefix_categories_one_hot_cv =
vectorizer.transform(X_cv['teacher_prefix'].values.astype("U"))

print(vectorizer.get_feature_names())

print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_train.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_test.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_cv.shape)
```

```
['nan', 'Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of matrix after one hot encoding  (49041, 6)
Shape of matrix after one hot encoding  (36052, 6)
Shape of matrix after one hot encoding  (24155, 6)
```

1.5.2 Vectorizing Text data

A) Bag of Words (BOW) with bi-grams with min_df=10 and max_features=5000

BoW- Training Data-Essay Feature

In [47]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_bow_essay = CountVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_bow_essay.fit(X_train["clean_essays"])
text_bow_train = vectorizer_bow_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 5000)
```

BoW- Test Data-Essay Feature

In [48]:

```
text_bow_test = vectorizer_bow_essay.transform(X_test["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 5000)
```

BoW- Cross Validation Data-Essay Feature

In [49]:

```
text_bow_cv = vectorizer_bow_essay.transform(X_cv["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (24155, 5000)
```

BoW- Training Data-Titles Feature

In [50]:

```
vectorizer_bow_title = CountVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_bow_title.fit(X_train["clean_titles"])
title_bow_train = vectorizer_bow_title.transform(X_train["clean_titles"])
```

```
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 1662)
```

BoW- Test Data-Titles Feature

In [51]:

```
title_bow_test = vectorizer_bow_title.transform(X_test["clean_titles"])
print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 1662)
```

BoW- Cross Validation Data-Titles Feature

In [52]:

```
title_bow_cv = vectorizer_bow_title.transform(X_cv["clean_titles"])
print("Shape of matrix after one hot encoding ",title_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (24155, 1662)
```

B) TFIDF vectorizer with bi-grams with min_df=10 and max_features=5000

TFIDF- Training Data-Essays Feature

In [53]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essay = TfidfVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_tfidf_essay.fit(X_train["clean_essays"])
text_tfidf_train = vectorizer_tfidf_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 5000)
```

TFIDF- Test Data-Essays Feature

In [54]:

```
text_tfidf_test = vectorizer_tfidf_essay.transform(X_test["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 5000)
```

TFIDF - Cross Validation Data - Essays Feature

In [55]:

```
text_tfidf_cv = vectorizer_tfidf_essay.transform(X_cv["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (24155, 5000)
```

TFIDF - Training Data - Titles Feature

In [56]:

```
vectorizer_tfidf_titles = TfidfVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_tfidf_titles.fit(X_train["clean_titles"])
title_tfidf_train = vectorizer_tfidf_titles.transform(X_train["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 1662)
```

TFIDF - Test Data - Titles Feature

In [57]:

```
title_tfidf_test = vectorizer_tfidf_titles.transform(X_test["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 1662)
```

TFIDF - Cross Validation Data - Titles Feature

In [58]:

```
title_tfidf_cv = vectorizer_tfidf_titles.transform(X_cv["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (24155, 1662)
```

Using Pretrained Models: Avg W2V

In [59]:

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

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

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

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

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

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

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

words_courpus = {}
```

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


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

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


'''
```

Out[59]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef
loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\',
encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n
word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        m
odel[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel =
loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n#
============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\'
\'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the
coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus",
len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words tha
t are present in both glove vectors and our coupus",       len(inter_words),"
(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove =
set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\n
print("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python
: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pic
kle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [60]:

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

Avg_W2V for Train Data(Essays feature)

In [61]:

```python
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

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

```
100%|██████████| 49041/49041 [00:20<00:00, 2359.39it/s]
```

```
49041
300
```

Avg_W2V for Test Data(Essays feature)

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)

print(len(avg_w2v_vectors_test))
print(len(avg_w2v_vectors_test[0]))
```

```
100%|██████████████████████████████████████████| 36052/36052 [00:15<00:00, 2321.37it/s]
```

```
36052
300
```

Avg_W2V for Cross Validation Data(Essays feature)

In [63]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)

print(len(avg_w2v_vectors_cv))
print(len(avg_w2v_vectors_cv[0]))
```

```
100%|██████████████████████████████████████████| 24155/24155 [00:10<00:00, 2324.39it/s]
```

```
24155
300
```

Avg_W2V for Train Data(Titles feature)

In [64]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_titles"]): # 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
        vector /= cnt_words
    avg_w2v_vectors_titles_train.append(vector)

print(len(avg_w2v_vectors_titles_train))
print(len(avg_w2v_vectors_titles_train[0]))
```

```
100%|█████████████████████████████████| 49041/49041 [00:01<00:00, 41333.87it/s]
```

```
49041
300
```

Avg_W2V for Test Data(Titles feature)

In [65]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_titles"]): # 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_titles_test.append(vector)

print(len(avg_w2v_vectors_titles_test))
print(len(avg_w2v_vectors_titles_test[0]))
```

```
100%|█████████████████████████████████| 36052/36052 [00:00<00:00, 36278.96it/s]
```

```
36052
300
```

Avg_W2V for Cross Validation Data(Titles feature)

In [66]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["clean_titles"]): # 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_titles_cv.append(vector)

print(len(avg_w2v_vectors_titles_cv))
print(len(avg_w2v_vectors_titles_cv[0]))
```

```
100%|█████████████████████████████████| 24155/24155 [00:00<00:00, 43098.02it/s]
```

```
24155
300
```

TFIDF weighted W2V for Train Data(Essays feature)

In [67]:

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

In [68]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

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

```
100%|████████████████████████████████████| 49041/49041 [02:18<00:00, 355.17it/s]
```

```
49041
300
```

TFIDF weighted W2V for Test Data(Essays feature)

In [69]:

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

In [70]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)

print(len(tfidf_w2v_vectors_test))
print(len(tfidf_w2v_vectors_test[0]))
```

```
100%|████████████████████████████████████| 36052/36052 [01:41<00:00, 354.78it/s]
```

```
36052
300
```

TFIDF weighted W2V for Cross Validation Data(Essays feature)

In [71]:

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

In [72]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_cv.append(vector)

print(len(tfidf_w2v_vectors_cv))
print(len(tfidf_w2v_vectors_cv[0]))
```

```
100%|████████████████████████████████████| 24155/24155 [01:09<00:00, 347.69it/s]
```

```
24155
300
```

TFIDF weighted W2V for Train Data(Titles feature)

In [73]:

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

In [74]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_titles"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_train.append(vector)

print(len(tfidf_w2v_vectors_titles_train))
print(len(tfidf_w2v_vectors_titles_train[0]))
```

```
100%|█████████████████████████████████| 49041/49041 [00:02<00:00, 16952.92it/s]
```

```
49041
300
```

TFIDF weighted W2V for Test Data(Titles feature)

In [75]:

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

In [76]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_titles"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_test.append(vector)

print(len(tfidf_w2v_vectors_titles_test))
print(len(tfidf_w2v_vectors_titles_test[0]))
```

```
100%|█████████████████████████████████| 36052/36052 [00:01<00:00, 18102.51it/s]
```

```
36052
300
```

TFIDF weighted W2V for Cross Validation Data(Titles feature)

In [77]:

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

In [78]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["clean_titles"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_cv.append(vector)

print(len(tfidf_w2v_vectors_titles_cv))
print(len(tfidf_w2v_vectors_titles_cv[0]))
```

```
100%|█████████████████████████████████| 24155/24155 [00:01<00:00, 18233.74it/s]
```

```
24155
300
```

1.5.3 Vectorizing Numerical features

In [79]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
#Now join price data to Train,Test and Cross Validation Data
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

Price Feature

In [80]:

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

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

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

# Now standardize the data with above maen and variance.
price_standardized_train = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
price_standardized_test = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
price_standardized_cv = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(price_standardized_train.shape, y_train.shape)
print(price_standardized_cv.shape, y_cv.shape)
print(price_standardized_test.shape, y_test.shape)
```

```
Mean : 299.3180224709937, Standard deviation : 368.97016560622063
Mean : 299.3160224709937, Standard deviation : 368.97016560622065
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Quantity Feature

In [81]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

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

# Now standardize the data with above maen and variance.
quantity_standardized_train = quantity_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
quantity_standardized_test = quantity_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_cv = quantity_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(quantity_standardized_train.shape, y_train.shape)
print(quantity_standardized_cv.shape, y_cv.shape)
print(quantity_standardized_test.shape, y_test.shape)
```

```
Mean : 16.96647702942436, Standard deviation : 26.11622630328957
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Number of Previosly Proposed Project by Teacher Feature

In [82]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

ppt_scalar = StandardScaler()
ppt_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # find
ing the mean and standard deviation of this data
print(f"Mean : {ppt_scalar.mean_[0]}, Standard deviation : {np.sqrt(ppt_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
ppt_standardized_train =
ppt_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))
ppt_standardized_test = ppt_scalar.transform(X_test['teacher_number_of_previously_posted_projects'
].values.reshape(-1, 1))
ppt_standardized_cv = ppt_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].va
lues.reshape(-1, 1))

print("After Column Standardisation: ")
print(ppt_standardized_train.shape, y_train.shape)
print(ppt_standardized_cv.shape, y_cv.shape)
print(ppt_standardized_test.shape, y_test.shape)
```

```
Mean : 11.251911665749066, Standard deviation : 27.93376925296967
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Title Word Count Feature

In [83]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

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

# Now standardize the data with above maen and variance.
twc_standardized_train = twc_scalar.transform(X_train['title_word_count'].values.reshape(-1, 1))
twc_standardized_test = twc_scalar.transform(X_test['title_word_count'].values.reshape(-1, 1))
twc_standardized_cv = twc_scalar.transform(X_cv['title_word_count'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(twc_standardized_train.shape, y_train.shape)
print(twc_standardized_cv.shape, y_cv.shape)
print(twc_standardized_test.shape, y_test.shape)
```

```
Mean : 4.335290879060378, Standard deviation : 1.7875122883447452
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay Word Count Feature

In [84]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

ewc_scalar = StandardScaler()
```

```
ewc_scalar.fit(X_train['essay_word_count'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {ewc_scalar.mean_[0]}, Standard deviation : {np.sqrt(ewc_scalar.var_[0])}")

# Now standardize the data with above mean and variance.
ewc_standardized_train = ewc_scalar.transform(X_train['essay_word_count'].values.reshape(-1, 1))
ewc_standardized_test = ewc_scalar.transform(X_test['essay_word_count'].values.reshape(-1, 1))
ewc_standardized_cv = ewc_scalar.transform(X_cv['essay_word_count'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(ewc_standardized_train.shape, y_train.shape)
print(ewc_standardized_cv.shape, y_cv.shape)
print(ewc_standardized_test.shape, y_test.shape)
```

```
Mean : 151.18233722803367, Standard deviation : 38.87705243799132
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay Sentiments - positives

In [85]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

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

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

# Now standardize the data with above mean and variance.
pos_standardized_train = pos_scalar.transform(X_train['pos'].values.reshape(-1, 1))
pos_standardized_test = pos_scalar.transform(X_test['pos'].values.reshape(-1, 1))
pos_standardized_cv = pos_scalar.transform(X_cv['pos'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(pos_standardized_train.shape, y_train.shape)
print(pos_standardized_cv.shape, y_cv.shape)
print(pos_standardized_test.shape, y_test.shape)
```

```
Mean : 0.2666698272873718, Standard deviation : 0.07401803481210616
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay Sentiments - negatives

In [86]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

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

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

# Now standardize the data with above mean and variance.
neg_standardized_train = neg_scalar.transform(X_train['neg'].values.reshape(-1, 1))
neg_standardized_test = neg_scalar.transform(X_test['neg'].values.reshape(-1, 1))
neg_standardized_cv = neg_scalar.transform(X_cv['neg'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(neg_standardized_train.shape, y_train.shape)
print(neg_standardized_cv.shape, y_cv.shape)
print(neg_standardized_test.shape, y_test.shape)
```

```
Mean : 0.04505485206255991, Standard deviation : 0.03389284998087501
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay Sentiments - neutrals

In [87]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

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

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

# Now standardize the data with above mean and variance.
neu_standardized_train = neu_scalar.transform(X_train['neu'].values.reshape(-1, 1))
neu_standardized_test = neu_scalar.transform(X_test['neu'].values.reshape(-1, 1))
neu_standardized_cv = neu_scalar.transform(X_cv['neu'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(neu_standardized_train.shape, y_train.shape)
print(neu_standardized_cv.shape, y_cv.shape)
print(neu_standardized_test.shape, y_test.shape)
```

```
Mean : 0.6882760343386147, Standard deviation : 0.0724886774241773
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay Sentiments - compound

In [88]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
```

```
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

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

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

# Now standardize the data with above mean and variance.
com_standardized_train = com_scalar.transform(X_train['compound'].values.reshape(-1, 1))
com_standardized_test = com_scalar.transform(X_test['compound'].values.reshape(-1, 1))
com_standardized_cv = com_scalar.transform(X_cv['compound'].values.reshape(-1, 1))

print("After Column Standardisation: ")
print(com_standardized_train.shape, y_train.shape)
print(com_standardized_cv.shape, y_cv.shape)
print(com_standardized_test.shape, y_test.shape)
```

```
Mean : 0.9596843661426152, Standard deviation : 0.14838078287736606
After Column Standardisation:
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Assignment 5: Logistic Regression

1. **[Task-1] Logistic Regression(either SGDClassifier with log loss, or LogisticRegression) on these feature sets**

   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (`BOW with bi-grams` with `min_df=10` and `max_features=5000`)
   - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (`TFIDF with bi-grams` with `min_df=10` and `max_features=5000`)
   - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
   - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning (find best hyper parameters corresponding the algorithm that you choose)**

   - Find the best hyper parameter which will give the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **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. Please visualize your confusion matrices using seaborn heatmaps.

4. **[Task-2] Apply Logistic Regression on the below feature set Set 5 by finding the best hyper parameter as suggested in step 2 and step 3.**
5. Consider these set of features Set 5 :

   - **school_state** : categorical data
   - **clean_categories** : categorical data
   - **clean_subcategories** : categorical data
   - **project_grade_category** :categorical data
   - **teacher_prefix** : categorical data
   - **quantity** : numerical data

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

And apply the Logistic regression on these features by finding the best hyper paramter as suggested in step 2 and step 3

6. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakage, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

2. Logistic Regression

Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay (BOW with bi-grams with min_df=10 and max_features=5000)

In [89]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_standardized_train, quantity_standardized_train, pp
t_standardized_train, twc_standardized_train, ewc_standardized_train, title_bow_train,
text_bow_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_standardized_test, quantity_standardized_test,
ppt_standardized_test, twc_standardized_test, ewc_standardized_test, text_bow_test, title_bow_test)
).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv,price_standardized_cv, quantity_standardized_cv,
ppt_standardized_cv, twc_standardized_cv, ewc_standardized_cv, title_bow_cv, text_bow_cv)).tocsr()
```

In [90]:

```
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)
```

```
Final Data matrix
(49041, 6767) (49041,)
(24155, 6767) (24155,)
(36052, 6767) (36052,)
```

A) Finding the Best Hyperparameter(lambda)

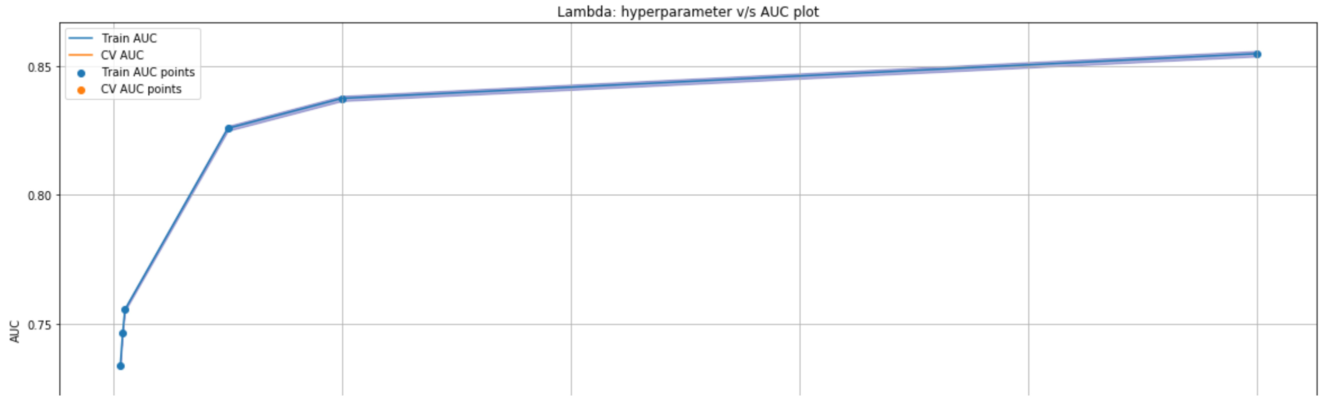
In [91]:

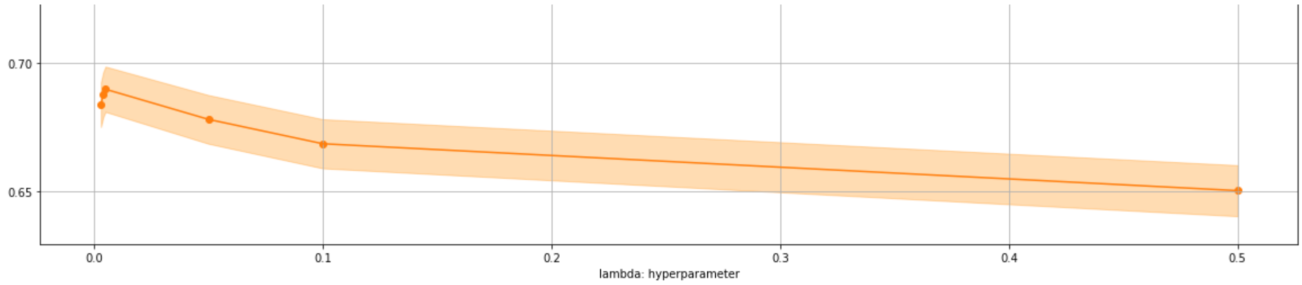
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

GridSearchCV (10 Folds CV)

In [92]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

parameters = {'C':[0.003, 0.004, 0.005, 0.05, 0.1, 0.5]}


clf = GridSearchCV(lr, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr, y_train)

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




plt.figure(figsize=(20,10))

plt.plot(parameters['C'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['C'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='dar
korange')

plt.scatter(parameters['C'], train_auc, label='Train AUC points')
plt.scatter(parameters['C'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("Lambda: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```





Find the best Lambda

In [93]:

```
print([0.003, 0.004, 0.005, 0.05, 0.1, 0.5])
print(cv_auc)
```

```
[0.003, 0.004, 0.005, 0.05, 0.1, 0.5]
[0.68370566 0.68755604 0.68968393 0.67801363 0.66856857 0.6504117 ]
```

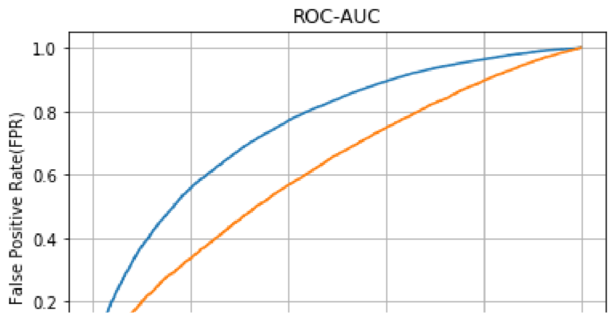
In [94]:

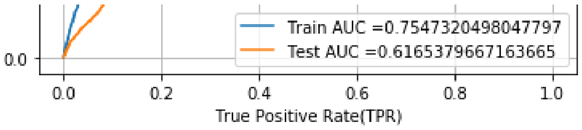
```
best_lambda=0.005
```

B) Train the model using the best hyper parameter value

In [95]:

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


model = LogisticRegression(C = best_lambda)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, 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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC-AUC")
plt.grid()
plt.show()
```





C)Confusion Matrix

In [96]:

```
def predict(proba, threshould, fpr, tpr):

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

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

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

Training Data

In [97]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999818661462 for threshold 0.791
[[ 3714  3712]
 [ 6776 34839]]
```

In [98]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

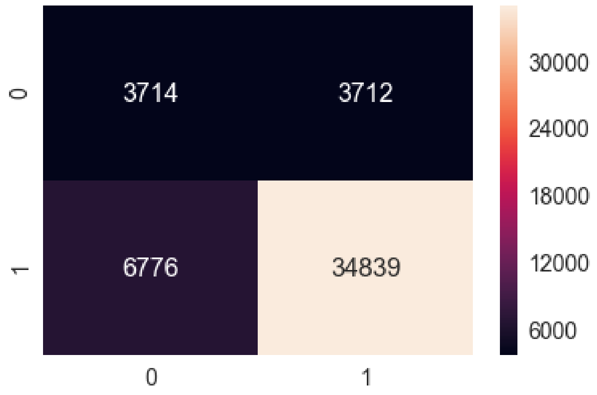
```
the maximum value of tpr*(1-fpr) 0.2499999818661462 for threshold 0.791
```

In [99]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[99]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3ab763c8>
```



Test Data

In [100]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999244983697 for threshold 0.821
[[ 3685  1774]
 [15713 14880]]
```

In [101]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

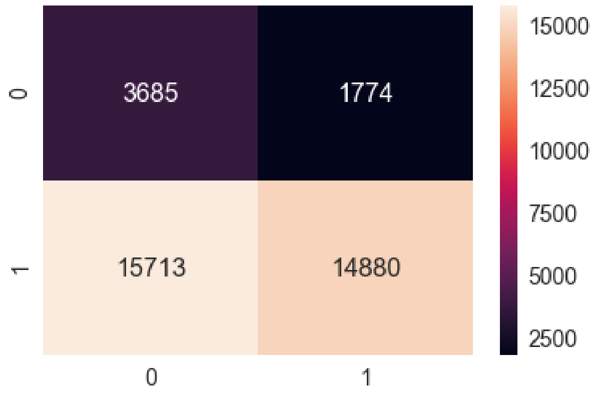
```
the maximum value of tpr*(1-fpr) 0.2499999244983697 for threshold 0.821
```

In [102]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[102]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3f7a3e48>
```



Set 2 : Categorical, Numerical features + Project_title(TFIDF) + Preprocessed_essay (TFIDF with bi-grams with min_df=10 and max_features=5000)

In [103]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_standardized_train, quantity_standardized_train, pp
t_standardized_train, twc_standardized_train, ewc_standardized_train, title_tfidf_train,
text_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_standardized_test, quantity_standardized_test,
ppt_standardized_test, twc_standardized_test, ewc_standardized_test, text_tfidf_test,
title_tfidf_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv,price_standardized_cv, quantity_standardized_cv,
ppt_standardized_cv, twc_standardized_cv, ewc_standardized_cv, title_tfidf_cv, text_tfidf_cv)).tocs
```

```
ppc_standardized_cv, cwc_standardized_cv, swc_standardized_cv, title_tfidf_cv, text_tfidf_cv)).tocs
r()
```

In [104]:

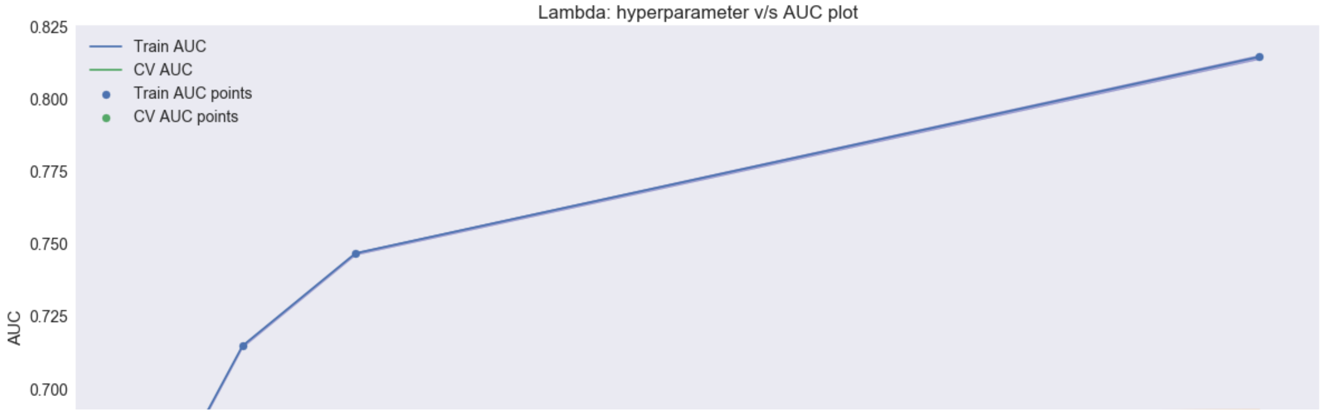
```
print("Final Tfidf Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

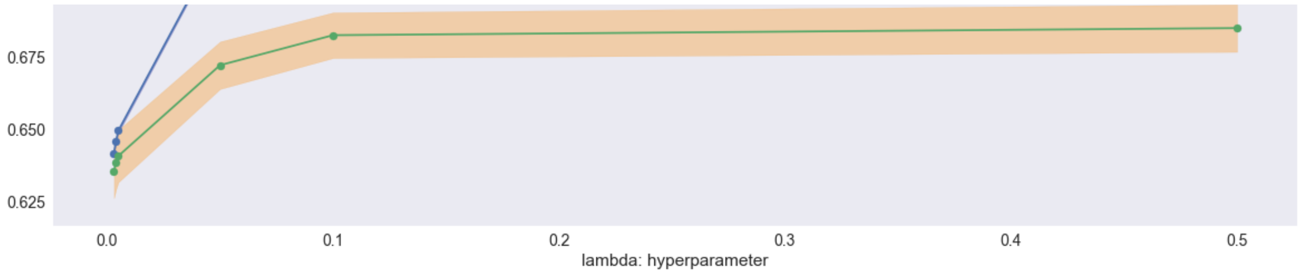
```
Final Tfidf Data matrix
(49041, 6767) (49041,)
(24155, 6767) (24155,)
(36052, 6767) (36052,)
```

A] Grid Search (10 Folds CV)

In [105]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

parameters = {'C':[0.003, 0.004, 0.005, 0.05, 0.1, 0.5]}

clf = GridSearchCV(lr, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr, y_train)

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

plt.figure(figsize=(20,10))

plt.plot(parameters['C'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['C'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='dar
korange')

plt.scatter(parameters['C'], train_auc, label='Train AUC points')
plt.scatter(parameters['C'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("Lambda: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```





In [107]:

```
print([0.003, 0.004, 0.005, 0.05, 0.1, 0.5])
print(cv_auc)
```

```
[0.003, 0.004, 0.005, 0.05, 0.1, 0.5]
[0.63558305 0.63859202 0.64085563 0.67217316 0.68252655 0.68497632]
```

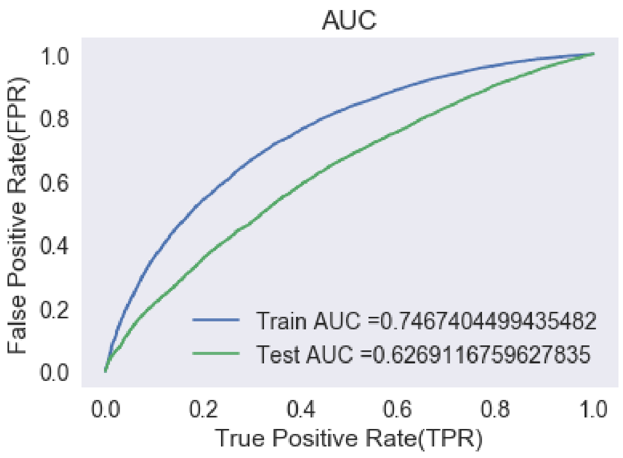
In [108]:

```
best_lambda_2=0.1
```

B) Train the model using the best hyper parameter value

In [109]:

```
model = LogisticRegression(C = best_lambda_2)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, 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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C) Confusion Matrix

Training Data

In [110]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.803
[[ 3713  3713]
 [ 6968 34647]]
```

In [111]:

```
conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

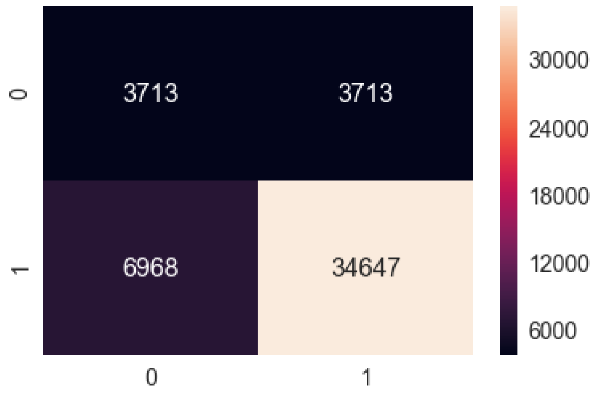
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.803
```

In [112]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[112]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3bba3d68>
```



Test Data

In [113]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.831
[[ 2766  2693]
 [10011 20582]]
```

In [114]:

```
conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

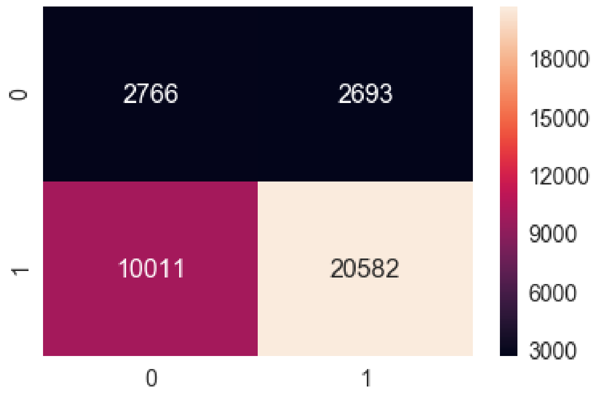
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.831
```

In [115]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[115]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f43b93e48>
```



Set 3 : Categorical, Numerical features + Project_title(AVG W2V) + Preprocessed_essay (AVG W2V)

In [116]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_standardized_train, quantity_standardized_train, pp
t_standardized_train, twc_standardized_train, ewc_standardized_train, avg_w2v_vectors_train,
avg_w2v_vectors_titles_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_standardized_test, quantity_standardized_test,
ppt_standardized_test, twc_standardized_test, ewc_standardized_test, avg_w2v_vectors_test,
avg_w2v_vectors_titles_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv,price_standardized_cv, quantity_standardized_cv,
ppt_standardized_cv, twc_standardized_cv, ewc_standardized_cv, avg_w2v_vectors_cv, avg_w2v_vectors_
titles_cv)).tocsr()
```

In [117]:

```
print("Final Avg W2V Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

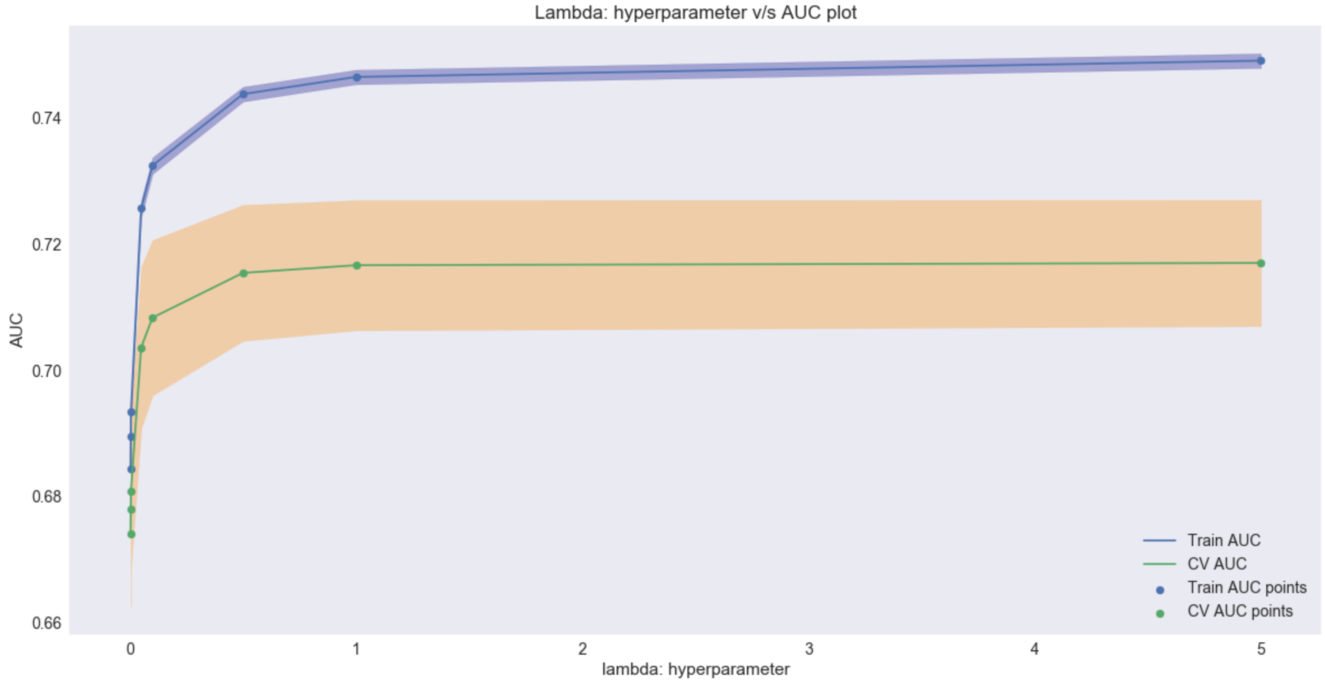
```
Final Avg W2V Data matrix
(49041, 705) (49041,)
(24155, 705) (24155,)
(36052, 705) (36052,)
```

GridSearchCV(10 Folds CV)

In [118]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

parameters = {'C':[0.003, 0.004, 0.005, 0.05, 0.1, 0.5,1.0,5.0]}
```

```
clf = GridSearchCV(lr, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr, y_train)

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

plt.figure(figsize=(20,10))

plt.plot(parameters['C'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['C'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='darkorange')

plt.scatter(parameters['C'], train_auc, label='Train AUC points')
plt.scatter(parameters['C'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("Lambda: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



In [119]:

```
print([0.003, 0.004, 0.005, 0.05, 0.1, 0.5,1.0,5.0])
print(cv_auc)
```

```
[0.003, 0.004, 0.005, 0.05, 0.1, 0.5, 1.0, 5.0]
[0.67416294 0.67803127 0.68092404 0.70363726 0.70835568 0.71545257
 0.71667103 0.7170292 ]
```

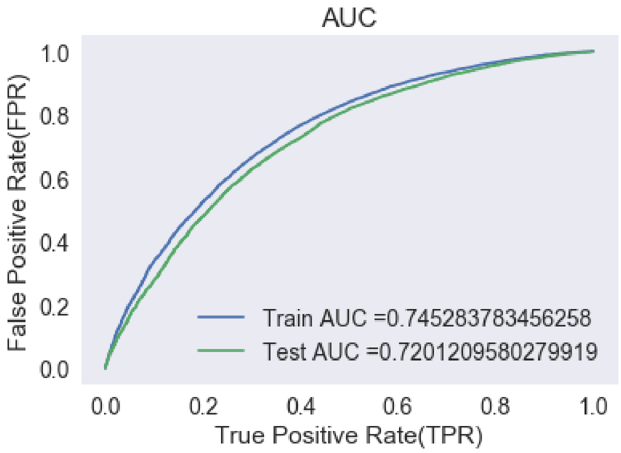
In [120]:

```
best_lambda_3=1.0
```

B) Train the model using the best hyper parameter value

In [121]:

```
model = LogisticRegression(C = best_lambda_3)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, 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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C) Confusion Matrix

Training Data

In [122]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.777
[[ 3713  3713]
 [ 6650 34965]]
```

In [123]:

```
conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

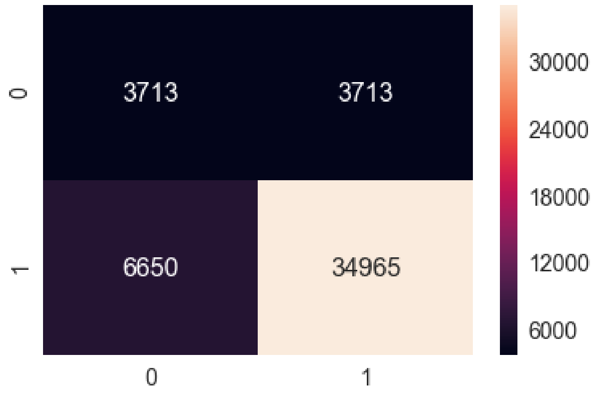
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.777
```

In [124]:

```
sns.set(font_scale=1.4)#for label size
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[124]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f413bc588>
```



Test Data

In [125]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.828
[[ 3318  2141]
 [ 8563 22030]]
```

In [126]:

```
conf_matr_df_test_3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

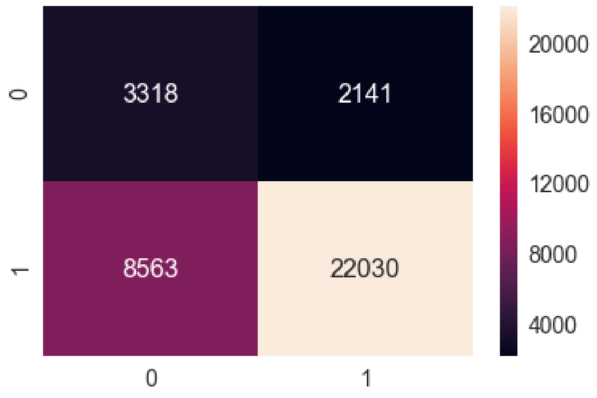
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.828
```

In [127]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[127]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3acc35f8>
```



Set 4 : Categorical, Numerical features + Project_title(TFIDF W2V) + Preprocessed_essay (TFIDF W2V)

Preprocessed_essay (TFIDF W2V)

In [128]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_standardized_train, quantity_standardized_train, pp
t_standardized_train, twc_standardized_train, ewc_standardized_train, tfidf_w2v_vectors_train, tfi
df_w2v_vectors_titles_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_standardized_test, quantity_standardized_test,
ppt_standardized_test, twc_standardized_test, ewc_standardized_test, tfidf_w2v_vectors_test,
tfidf_w2v_vectors_titles_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv,price_standardized_cv, quantity_standardized_cv,
ppt_standardized_cv, twc_standardized_cv, ewc_standardized_cv, tfidf_w2v_vectors_cv, tfidf_w2v_vect
ors_titles_cv)).tocsr()
```

In [129]:

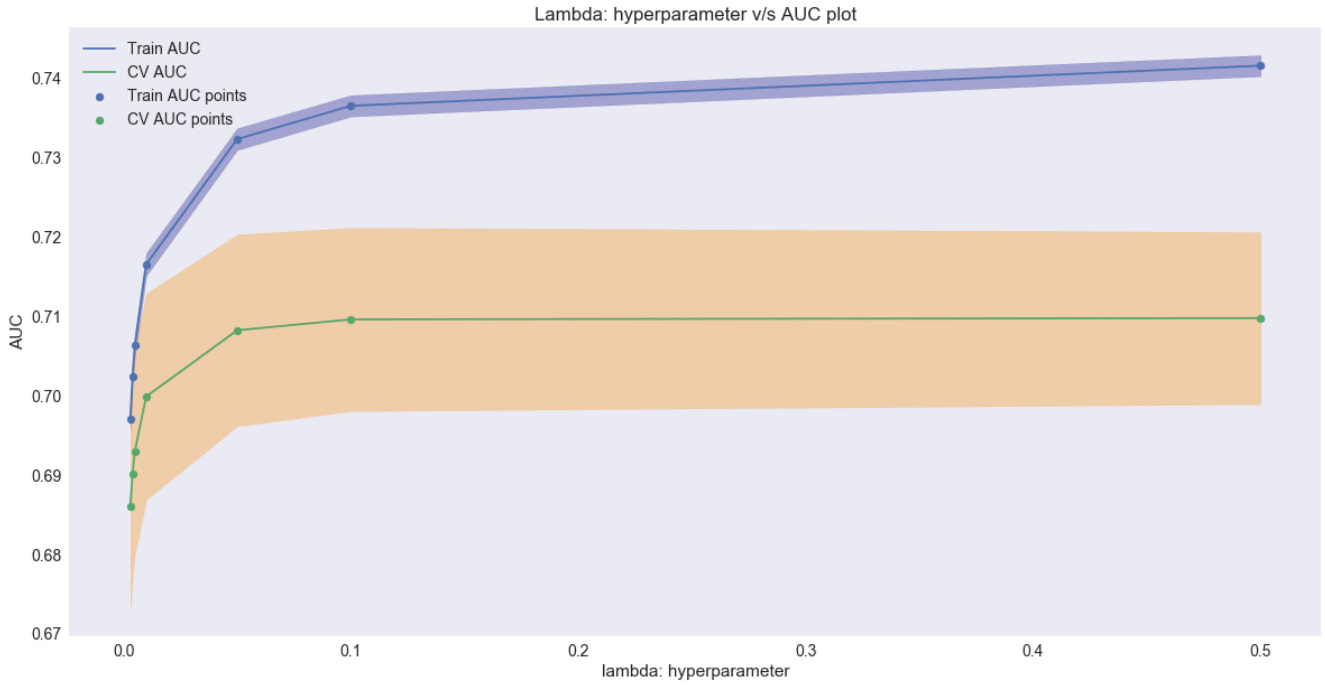
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49041, 705) (49041,)
(24155, 705) (24155,)
(36052, 705) (36052,)
```

A) GridSearchCV (10 Folds CV)

In [130]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

parameters = {'C':[0.003, 0.004, 0.005, 0.01,0.05, 0.1, 0.5]}

clf = GridSearchCV(lr, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr, y_train)

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

plt.figure(figsize=(20,10))

plt.plot(parameters['C'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['C'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='dar
korange')

plt.scatter(parameters['C'], train_auc, label='Train AUC points')
plt.scatter(parameters['C'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("Lambda: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



In [131]:

```
print([0.003, 0.004, 0.005, 0.01,0.05, 0.1, 0.5])
print(cv_auc)
```

```
[0.003, 0.004, 0.005, 0.01, 0.05, 0.1, 0.5]
[0.68606606 0.69018058 0.69300341 0.69990841 0.70824909 0.70962442
 0.70979167]
```

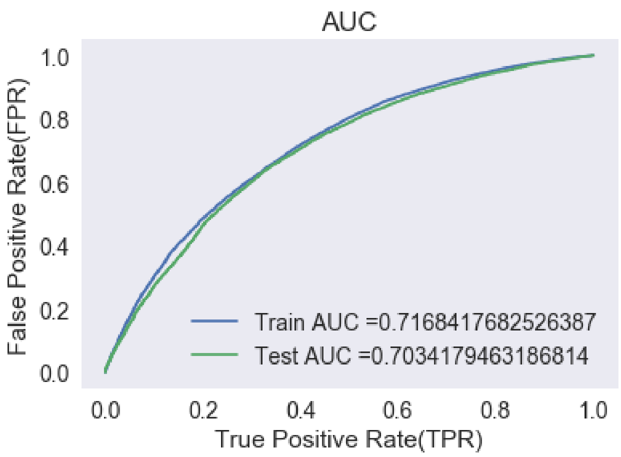
In [132]:

```
best_lambda_4=0.01
```

B) Train the model using the best hyper parameter value

In [133]:

```
model = LogisticRegression(C = best_lambda_4)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, 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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C) Confusion Matrix

Training Data

In [134]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.801
[[ 3713  3713]
 [ 8183 33432]]
```

In [135]:

```
conf_matr_df_train_4 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

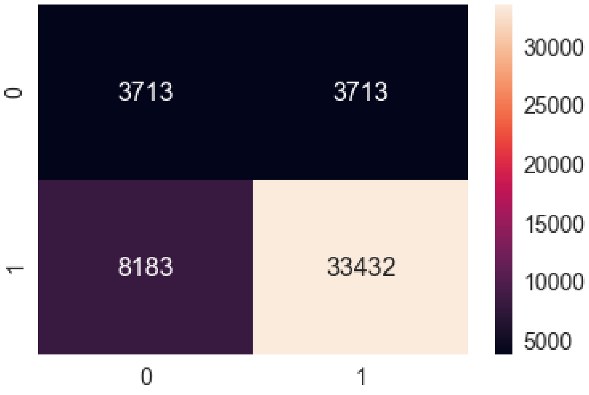
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.801
```

In [136]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[136]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f1c43f208>
```



Test Data

In [137]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.835
[[ 3459  2000]
 [ 9936 20657]]
```

In [138]:

```
conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

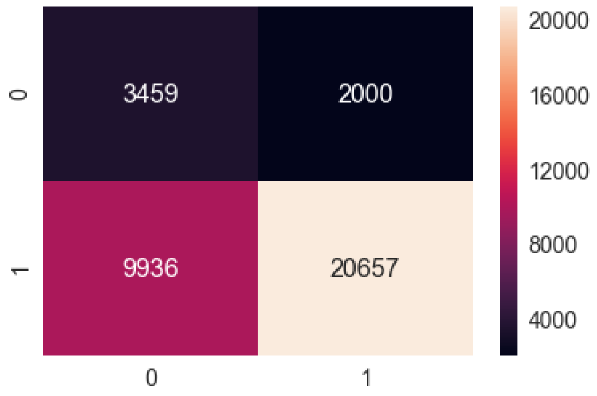
```
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.835
```

In [139]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[139]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3f3e5e48>
```



Set 5 : Categorical features, Numerical features & Essay Sentiments

In [140]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_standardized_train, quantity_standardized_train, pp
t_standardized_train, twc_standardized_train, ewc_standardized_train, pos_standardized_train,neg_s
tandardized_train,neu_standardized_train,com_standardized_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_standardized_test, quantity_standardized_test,
ppt_standardized_test, twc_standardized_test, ewc_standardized_test,
pos_standardized_test,neg_standardized_test,neu_standardized_test,com_standardized_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv,price_standardized_cv, quantity_standardized_cv,
ppt_standardized_cv, twc_standardized_cv, ewc_standardized_cv,  pos_standardized_cv,neg_standardize
d_cv,neu_standardized_cv,com_standardized_cv)).tocsr()
```

In [141]:

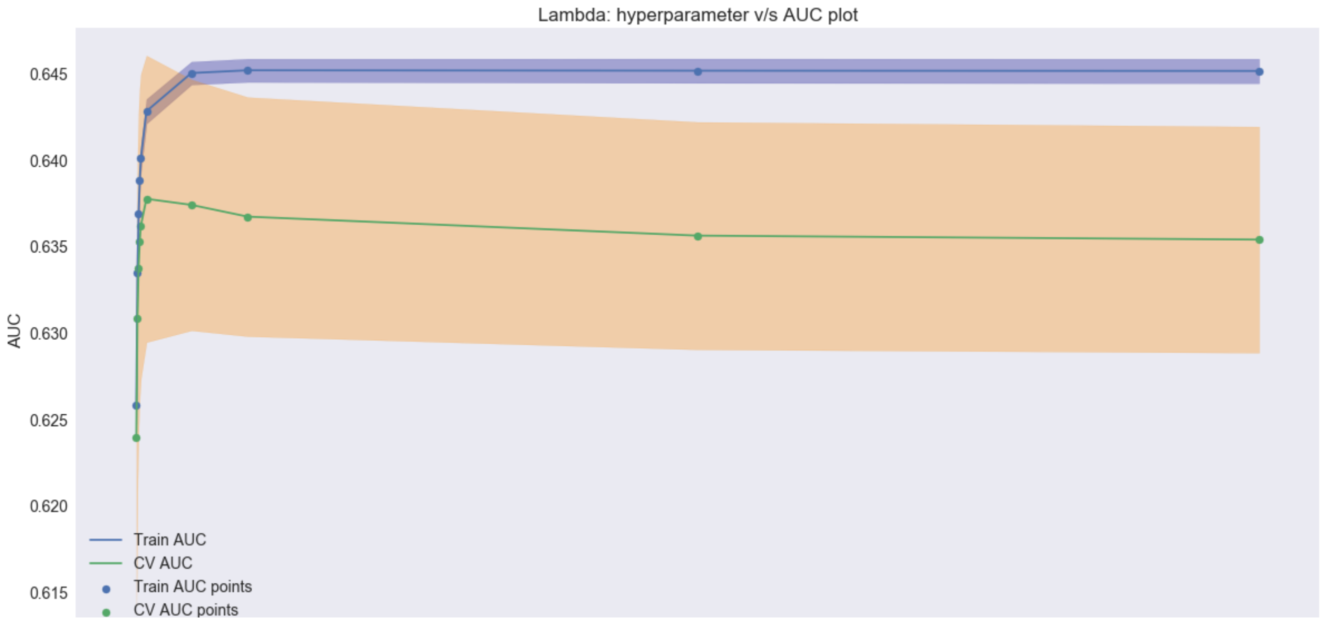
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

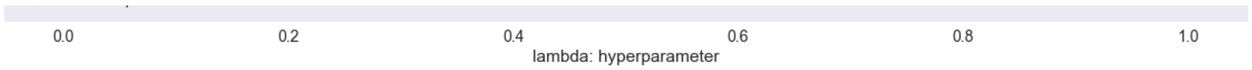
```
Final Data matrix
(49041, 109) (49041,)
(24155, 109) (24155,)
(36052, 109) (36052,)
```

A) GridSearchCV (10 Folds CV)

In [142]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

parameters = {'C':[0.001,0.002,0.003, 0.004, 0.005,0.01, 0.05, 0.1, 0.5,1]}

clf = GridSearchCV(lr, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr, y_train)

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

plt.figure(figsize=(20,10))

plt.plot(parameters['C'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['C'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['C'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='dar
korange')

plt.scatter(parameters['C'], train_auc, label='Train AUC points')
plt.scatter(parameters['C'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("Lambda: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```





In [143]:

```
print([0.001,0.002,0.003, 0.004, 0.005,0.01, 0.05, 0.1, 0.5,1])
print(cv_auc)
```

```
[0.001, 0.002, 0.003, 0.004, 0.005, 0.01, 0.05, 0.1, 0.5, 1]
[0.62393541 0.63085108 0.63374733 0.63528418 0.63619144 0.63777248
 0.63742072 0.63674194 0.63564346 0.6354134 ]
```

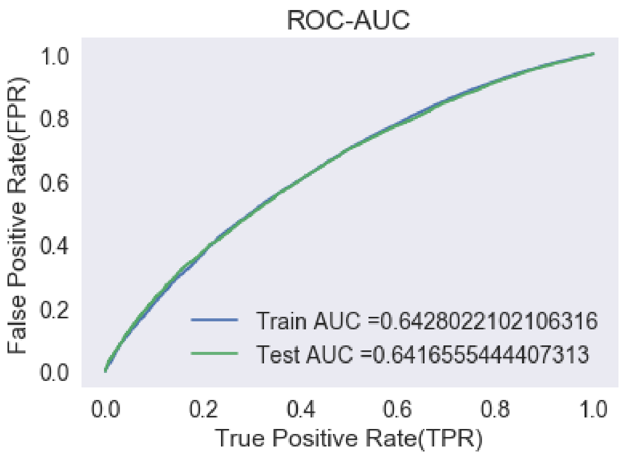
In [144]:

```
best_lambda_n=0.01
```

B) Train the model using the best hyper parameter value

In [145]:

```
model = LogisticRegression(C = best_lambda_n)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, 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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC-AUC")
plt.grid()
plt.show()
```



C) Confusion Matrix

Training Data

In [146]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.827
[[ 3713  3713]
 [12423 29192]]
```

In [147]:

```
conf_matr_df_train_5 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

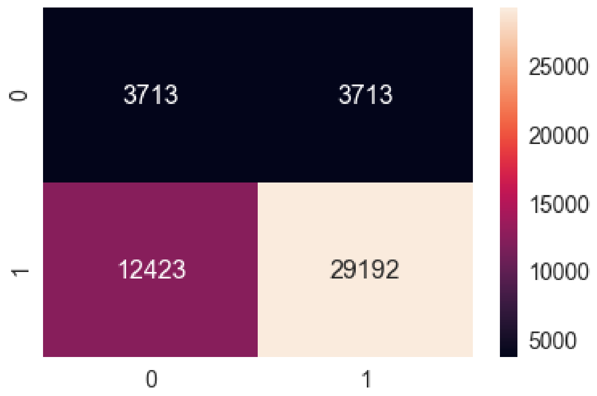
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.827
```

In [148]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_5, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[148]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f49aa2cc0>
```



Test Data

In [149]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.849
[[ 3533  1926]
 [13547 17046]]
```

In [150]:

```
conf_matr_df_test_5 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

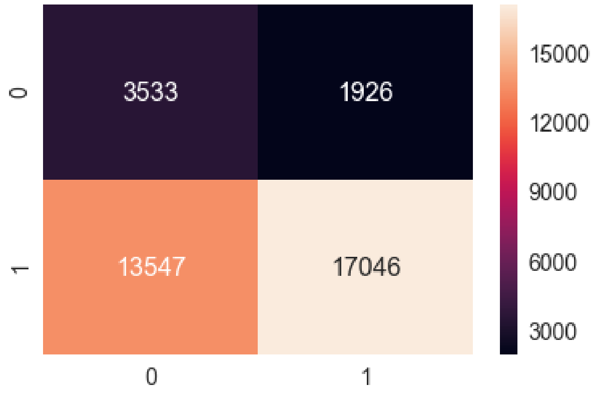
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.849
```

In [151]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_5, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[151]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x9f3c2e5160>
```



PRETTY TABLE

In [154]:

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

from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()
x.field_names = ["Vectorizer Used", "Model", "Lambda", "AUC-Score"]

x.add_row(["BOW", "Logistic Regression", 0.005, 0.67])
x.add_row(["TFIDF", "Logistic Regression", 0.1, 0.66])
x.add_row(["AVG W2V", "Logistic Regression", 1.0, 0.7])
x.add_row(["TFIDF W2V", "Logistic Regression", 0.01, 0.57])
x.add_row(["WITHOUT TEXT", "Logistic Regression", 0.01, 0.57])


print(x)
```

```
+-----------------+---------------------+--------+-----------+
| Vectorizer Used |        Model        | Lambda | AUC-Score |
+-----------------+---------------------+--------+-----------+
|       BOW       | Logistic Regression | 0.005  |    0.67   |
|      TFIDF      | Logistic Regression |  0.1   |    0.66   |
|     AVG W2V     | Logistic Regression |  1.0   |    0.7    |
|    TFIDF W2V    | Logistic Regression |  0.01  |    0.57   |
|   WITHOUT TEXT  | Logistic Regression |  0.01  |    0.57   |
+-----------------+---------------------+--------+-----------+
```

Conclusion :

- Best Lambda is found out using 10 Fold CV.
- Lambda=0 -->OVERFIT and Lanbda=Large-->UNDERFIT.. So, choosing right Lambda is a challenge.
- Text in the Essays and Titles play a vital role.
- Implemented a new feature using Sentiment Analysis (Vader) and used it as Numerical Feature.