DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Desc
`project_id`	A unique identifier for the proposed project. **Example:** `p0`
`project_title`	Title of the project. **Exa** • `Art Will Make You H` • `First Grad`
`project_grade_category`	Grade level of students for which the project is targeted. One of the fo enumerated v • `Grades P` • `Grade` • `Grade` • `Grades`
`project_subject_categories`	One or more (comma-separated) subject categories for the project fr following enumerated list of v • `Applied Lea` • `Care & H` • `Health & S` • `History & C` • `Literacy & Lan` • `Math & Sc` • `Music & The` • `Special` • `W` **Exar** • `Music & The` • `Literacy & Language, Math & Sc`

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [1]:

```
import sys
!{sys.executable} -m pip install gensim
```

```
Collecting gensim
  Using cached https://files.pythonhosted.org/packages/ef/65/c90886ac34d4b12
d3ae0bcc7aece1af57e1f30e7138aabbb3e3c027e705a/gensim-3.8.0-cp35-cp35m-manyli
nux1_x86_64.whl (https://files.pythonhosted.org/packages/ef/65/c90886ac34d4b
12d3ae0bcc7aece1af57e1f30e7138aabbb3e3c027e705a/gensim-3.8.0-cp35-cp35m-many
linux1_x86_64.whl)
Collecting six>=1.5.0 (from gensim)
  Using cached https://files.pythonhosted.org/packages/73/fb/00a976f728d0d1f
ecfe898238ce23f502a721c0ac0ecfedb80e0d88c64e9/six-1.12.0-py2.py3-none-any.wh
l (https://files.pythonhosted.org/packages/73/fb/00a976f728d0d1fecfe898238ce
23f502a721c0ac0ecfedb80e0d88c64e9/six-1.12.0-py2.py3-none-any.whl)
Collecting scipy>=0.18.1 (from gensim)
  Using cached https://files.pythonhosted.org/packages/7a/0e/3781e028d62a842
2244582abd8f084e6314297026760587c85607f687bf3/scipy-1.3.1-cp35-cp35m-manylin
ux1_x86_64.whl (https://files.pythonhosted.org/packages/7a/0e/3781e028d62a84
22244582abd8f084e6314297026760587c85607f687bf3/scipy-1.3.1-cp35-cp35m-manyli
nux1_x86_64.whl)
Collecting smart-open>=1.7.0 (from gensim)
Collecting numpy>=1.11.3 (from gensim)
  Using cached https://files.pythonhosted.org/packages/d4/64/7619774f0bd8ef3
64d46a5df8eb1bc78784cd787324b9624f6793e72f787/numpy-1.17.1-cp35-cp35m-manyli
nux1_x86_64.whl (https://files.pythonhosted.org/packages/d4/64/7619774f0bd8e
f364d46a5df8eb1bc78784cd787324b9624f6793e72f787/numpy-1.17.1-cp35-cp35m-many
linux1_x86_64.whl)
Collecting boto>=2.32 (from smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/23/10/c0b78c27298029e
4454a472a1919bde20cb182dab1662cec7f2ca1dcc523/boto-2.49.0-py2.py3-none-any.w
hl (https://files.pythonhosted.org/packages/23/10/c0b78c27298029e4454a472a19
19bde20cb182dab1662cec7f2ca1dcc523/boto-2.49.0-py2.py3-none-any.whl)
Collecting boto3 (from smart-open>=1.7.0->gensim)
  Downloading https://files.pythonhosted.org/packages/c2/1f/59aa653d8eb71060
fa776c773d84bfafebe49cee1b041cd5a8899c32b9d8/boto3-1.9.218-py2.py3-none-any.
whl (https://files.pythonhosted.org/packages/c2/1f/59aa653d8eb71060fa776c773
d84bfafebe49cee1b041cd5a8899c32b9d8/boto3-1.9.218-py2.py3-none-any.whl) (128
kB)
    100% |████████████████████████████████| 133kB 3.1MB/s ta 0:00:01
Collecting requests (from smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/51/bd/23c926cd341ea6b
7dd0b2a00aba99ae0f828be89d72b2190f27c11d4b7fb/requests-2.22.0-py2.py3-none-a
ny.whl (https://files.pythonhosted.org/packages/51/bd/23c926cd341ea6b7dd0b2a
00aba99ae0f828be89d72b2190f27c11d4b7fb/requests-2.22.0-py2.py3-none-any.whl)
Collecting botocore<1.13.0,>=1.12.218 (from boto3->smart-open>=1.7.0->gensi
m)
  Downloading https://files.pythonhosted.org/packages/46/aa/359ceab0a3c3fdc2
57bcffb09eee8335ecf9c673228255fa64ef228fcbfd/botocore-1.12.218-py2.py3-none-
any.whl (https://files.pythonhosted.org/packages/46/aa/359ceab0a3c3fdc257bcf
fb09eee8335ecf9c673228255fa64ef228fcbfd/botocore-1.12.218-py2.py3-none-any.w
hl) (5.7MB)
    100% |████████████████████████████████| 5.7MB 267kB/s eta 0:00:01
Collecting jmespath<1.0.0,>=0.7.1 (from boto3->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/83/94/7179c3832a6d45b
266ddb2aac329e101367fbdb11f425f13771d27f225bb/jmespath-0.9.4-py2.py3-none-an
y.whl (https://files.pythonhosted.org/packages/83/94/7179c3832a6d45b266ddb2a
ac329e101367fbdb11f425f13771d27f225bb/jmespath-0.9.4-py2.py3-none-any.whl)
Collecting s3transfer<0.3.0,>=0.2.0 (from boto3->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/16/8a/1fc3dba0c4923c2
```

```
a76e1ff0d52b305c44606da63f718d14d3231e21c51b0/s3transfer-0.2.1-py2.py3-none-
any.whl (https://files.pythonhosted.org/packages/16/8a/1fc3dba0c4923c2a76e1f
f0d52b305c44606da63f718d14d3231e21c51b0/s3transfer-0.2.1-py2.py3-none-any.wh
l)
Collecting certifi>=2017.4.17 (from requests->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/69/1b/b853c7a9d4f6a6d
00749e94eb6f3a041e342a885b87340b79c1ef73e3a78/certifi-2019.6.16-py2.py3-none
-any.whl (https://files.pythonhosted.org/packages/69/1b/b853c7a9d4f6a6d00749
e94eb6f3a041e342a885b87340b79c1ef73e3a78/certifi-2019.6.16-py2.py3-none-any.
whl)
Collecting urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 (from requests->smart-ope
n>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/e6/60/247f23a7121ae63
2d62811ba7f273d0e58972d75e58a94d329d51550a47d/urllib3-1.25.3-py2.py3-none-an
y.whl (https://files.pythonhosted.org/packages/e6/60/247f23a7121ae632d62811b
a7f273d0e58972d75e58a94d329d51550a47d/urllib3-1.25.3-py2.py3-none-any.whl)
Collecting idna<2.9,>=2.5 (from requests->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/14/2c/cd551d81dbe1520
0be1cf41cd03869a46fe7226e7450af7a6545bfc474c9/idna-2.8-py2.py3-none-any.whl
 (https://files.pythonhosted.org/packages/14/2c/cd551d81dbe15200be1cf41cd038
69a46fe7226e7450af7a6545bfc474c9/idna-2.8-py2.py3-none-any.whl)
Collecting chardet<3.1.0,>=3.0.2 (from requests->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/bc/a9/01ffebfb562e427
4b6487b4bb1ddec7ca55ec7510b22e4c51f14098443b8/chardet-3.0.4-py2.py3-none-an
y.whl (https://files.pythonhosted.org/packages/bc/a9/01ffebfb562e4274b6487b4
bb1ddec7ca55ec7510b22e4c51f14098443b8/chardet-3.0.4-py2.py3-none-any.whl)
Collecting python-dateutil<3.0.0,>=2.1; python_version >= "2.7" (from botoco
re<1.13.0,>=1.12.218->boto3->smart-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/41/17/c62faccbfbd163c
7f57f3844689e3a78bae1f403648a6afb1d0866d87fbb/python_dateutil-2.8.0-py2.py3-
none-any.whl (https://files.pythonhosted.org/packages/41/17/c62faccbfbd163c7
f57f3844689e3a78bae1f403648a6afb1d0866d87fbb/python_dateutil-2.8.0-py2.py3-n
one-any.whl)
Collecting docutils<0.16,>=0.10 (from botocore<1.13.0,>=1.12.218->boto3->sma
rt-open>=1.7.0->gensim)
  Using cached https://files.pythonhosted.org/packages/22/cd/a6aa959dca61991
8ccb55023b4cb151949c64d4d5d55b3f4ffd7eee0c6e8/docutils-0.15.2-py3-none-any.w
hl (https://files.pythonhosted.org/packages/22/cd/a6aa959dca619918ccb55023b4
cb151949c64d4d5d55b3f4ffd7eee0c6e8/docutils-0.15.2-py3-none-any.whl)
Installing collected packages: six, numpy, scipy, boto, urllib3, python-date
util, jmespath, docutils, botocore, s3transfer, boto3, certifi, idna, charde
t, requests, smart-open, gensim
Successfully installed boto-2.49.0 boto3-1.9.218 botocore-1.12.218 certifi-2
019.6.16 chardet-3.0.4 docutils-0.15.2 gensim-3.8.0 idna-2.8 jmespath-0.9.4
 numpy-1.17.1 python-dateutil-2.8.0 requests-2.22.0 s3transfer-0.2.1 scipy-
1.3.1 six-1.12.0 smart-open-1.8.4 urllib3-1.25.3
```

In [1]:

```
pip install xgboost
```

```
Collecting xgboost
  Using cached https://files.pythonhosted.org/packages/c1/24/5fe7237b2eca13e
e0cfb100bec8c23f4e69ce9df852a64b0493d49dae4e0/xgboost-0.90-py2.py3-none-many
linux1_x86_64.whl (https://files.pythonhosted.org/packages/c1/24/5fe7237b2ec
a13ee0cfb100bec8c23f4e69ce9df852a64b0493d49dae4e0/xgboost-0.90-py2.py3-none-
manylinux1_x86_64.whl)
Collecting numpy (from xgboost)
  Using cached https://files.pythonhosted.org/packages/d4/64/7619774f0bd8ef3
64d46a5df8eb1bc78784cd787324b9624f6793e72f787/numpy-1.17.1-cp35-cp35m-manyli
nux1_x86_64.whl (https://files.pythonhosted.org/packages/d4/64/7619774f0bd8e
f364d46a5df8eb1bc78784cd787324b9624f6793e72f787/numpy-1.17.1-cp35-cp35m-many
linux1_x86_64.whl)
Collecting scipy (from xgboost)
  Using cached https://files.pythonhosted.org/packages/7a/0e/3781e028d62a842
2244582abd8f084e6314297026760587c85607f687bf3/scipy-1.3.1-cp35-cp35m-manylin
ux1_x86_64.whl (https://files.pythonhosted.org/packages/7a/0e/3781e028d62a84
22244582abd8f084e6314297026760587c85607f687bf3/scipy-1.3.1-cp35-cp35m-manyli
nux1_x86_64.whl)
Installing collected packages: numpy, scipy, xgboost
Successfully installed numpy-1.17.1 scipy-1.3.1 xgboost-0.90
Note: you may need to restart the kernel to use updated packages.
```

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv')[:50000]
resource_data = pd.read_csv('resources.csv')
```

In [3]:

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

```
Number of data points in train data (50000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 's
chool_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

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

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

Out[4]:

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

In [5]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2 0 00:5
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2 0 01:0

In [6]:

```
project_grade_category = []

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

project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data["project_grade_category"] = project_grade_category
project_data.head(5)
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	00:
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	01:
29891	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs.	CA	01:
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms.	CA	02:
49228	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms.	IL	07:

1.2 preprocessing of `project_subject_categories`

In [7]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [8]:

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

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

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

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

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

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

Clean Titles (Text preprocessing)

In [9]:

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

In [10]:

```
# 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 [11]:

```
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%|██████████| 50000/50000 [00:01<00:00, 35842.74it/s]
```

In [12]:

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

In [13]:

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

Feature "Number of Words in Title"

In [14]:

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

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

Out[14]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	00:
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	01:
29891	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs.	CA	01:
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms.	CA	02:
49228	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms.	IL	07:

1.3 Text preprocessing

In [15]:

```
# 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 [16]:

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

Out[16]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2 (00:5
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2 (01:(

Clean Essays (Text preprocessing)

In [17]:

```
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%|██████████| 50000/50000 [00:32<00:00, 1549.19it/s]
```

In [18]:

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

In [19]:

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

Number of Words in Essay

In [20]:

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

project_data["essay_word_count"] = essay_word_count

project_data.head(5)
```

Out[20]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	00:
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	01:
29891	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs.	CA	01:
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms.	CA	02:
49228	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms.	IL	07:

Train test Split

In [21]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data, project_data['project_is_
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=
```

In [22]:

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

```
i recently read article giving students choice learn we already set goals no
t let choose sit give options sit i teach low income title 1 school every ye
ar i class range abilities yet age they learn differently different interest
s some adhd fast learners yet eager active learners want need able move arou
nd room yet place comfortable complete work we need classroom rug use class 
reading time students use learning times i also requested four kore kids wob
ble chairs four back jack padded portable chairs students still move whole g
roup lessons without disrupting class having areas provide little ones way w
iggle working benjamin franklin said tell i forget teach i may remember invo
lve i learn i want children involved learning choice sit learn giving option
s comfortable flexible seating
==================================================
at beginning every class start math application problem help students see re
levance topics math we always groups lot cooperative activities we also use 
lots technology class i love seeing students grow love math i diverse popula
tion students different races ses experiences my students love school starti
ng embrace hard work takes fifth grader my school 5th 6th grade school consi
dered school middle grades it located suburban area it diverse many years i 
inclusion setting many students disabilities it hard see board resources old
outdated a new document camera classroom allow students see board clearly in
structional times create classroom environment lots movement not necessary s
tudents cannot see board it frustrating teach lesson many students not see b
oard resources i old outdated oftentimes students tell wait moving takes for
ever write notes cannot see materials i want students enjoy coming class lea
rn math not feel frustrated cannot see board
==================================================
my students love coming school love learning i strive daily make classroom r
elaxed comfortable welcoming environment learners excel grow learning and ne
w rug make days even brighter my 2nd grade classroom filled 20 amazing young
learners these students fill heart everyday passion learning new things work
ing students engaged subject matter much fun we small elementary school mid 
missouri 80 percent free reduced lunch rate i wide range learners classroom 
students learn different ways so important provide learning environment meet
s students a beautiful new carpet focal point classroom the carpet full stud
ents day long it clean comfortable place students find comfort learning stud
ents sitting small groups laying reading book even dancing carpet brain brea
ks day a carpet elementary classroom heart learning takes place thank donati
ng considering donation project i want make 2nd grade classroom comfortable 
inviting starbucks cozy grandma living room this beautiful carpet perfect ad
dition classroom filled much excitement enthusiasm
==================================================
i teach title 1 school 73 students receive free reduced lunch our school pro
vides free breakfast students i special education certified teacher i teach 
kindergarten general education setting class consists 52 students special ne
eds the disabilities include autism spectrum disorder speech impaired langua
ge impaired other health impaired adhd developmentally delayed i also 42 stu
dents english language learners self motivated learners synonym students the
y love learn possess positive outlook attitude school almost everyday studen
```

```
ts would ask ms perez going learn today i could not ask better greeting stud
ents this project greatly impact students learning daily basis the wobble ch
airs provide assistance students difficulties focusing attending lessons dis
cussions despite fact students participate physical activities p e recess go
noodle dance videos sessions classroom students still energy stand wiggle se
ats lessons due special needs beyond students control lot distraction studen
t learning not really achieved full potential the lack appropriate stimulati
on hinders focus learn class students special needs able sit wobble chairs w
hole group small group lessons this enable little active bodies move sitting
still without disrupting students as result students improve focus increase
student attention learning content areas in addition visual timer help stude
nts actually see allotted time activities this benefit especially ell studen
ts students special needs whenever independent classwork work centers studen
ts refer self monitor progress completing assignments it encourage use time
wisely finish tasks time it also help students smoother transition one activ
ity another by donating project significantly help students special needs eq
ual opportunity learn peers behavior issues greatly minimized classroom mana
gement optimized help set students success i looking forward seeing students
become active listeners engaged learners always happy go school nannan
==================================================
```

In [23]:

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

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

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

In [24]:

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

```
i teach title 1 school 73 students receive free reduced lunch our school pro
vides free breakfast students i special education certified teacher i teach
kindergarten general education setting class consists 52 students special ne
eds the disabilities include autism spectrum disorder speech impaired langua
ge impaired other health impaired adhd developmentally delayed i also 42 stu
dents english language learners self motivated learners synonym students the
y love learn possess positive outlook attitude school almost everyday studen
ts would ask ms perez going learn today i could not ask better greeting stud
ents this project greatly impact students learning daily basis the wobble ch
airs provide assistance students difficulties focusing attending lessons dis
cussions despite fact students participate physical activities p e recess go
noodle dance videos sessions classroom students still energy stand wiggle se
ats lessons due special needs beyond students control lot distraction studen
t learning not really achieved full potential the lack appropriate stimulati
on hinders focus learn class students special needs able sit wobble chairs w
hole group small group lessons this enable little active bodies move sitting
still without disrupting students as result students improve focus increase
student attention learning content areas in addition visual timer help stude
nts actually see allotted time activities this benefit especially ell studen
ts students special needs whenever independent classwork work centers studen
ts refer self monitor progress completing assignments it encourage use time
wisely finish tasks time it also help students smoother transition one activ
ity another by donating project significantly help students special needs eq
ual opportunity learn peers behavior issues greatly minimized classroom mana
gement optimized help set students success i looking forward seeing students
become active listeners engaged learners always happy go school nannan
==================================================
```

In [25]:

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

```
i teach title 1 school 73 students receive free reduced lunch our school pro
vides free breakfast students i special education certified teacher i teach
kindergarten general education setting class consists 52 students special ne
eds the disabilities include autism spectrum disorder speech impaired langua
ge impaired other health impaired adhd developmentally delayed i also 42 stu
dents english language learners self motivated learners synonym students the
y love learn possess positive outlook attitude school almost everyday studen
ts would ask ms perez going learn today i could not ask better greeting stud
ents this project greatly impact students learning daily basis the wobble ch
airs provide assistance students difficulties focusing attending lessons dis
cussions despite fact students participate physical activities p e recess go
noodle dance videos sessions classroom students still energy stand wiggle se
ats lessons due special needs beyond students control lot distraction studen
t learning not really achieved full potential the lack appropriate stimulati
on hinders focus learn class students special needs able sit wobble chairs w
hole group small group lessons this enable little active bodies move sitting
still without disrupting students as result students improve focus increase
student attention learning content areas in addition visual timer help stude
nts actually see allotted time activities this benefit especially ell studen
ts students special needs whenever independent classwork work centers studen
ts refer self monitor progress completing assignments it encourage use time
wisely finish tasks time it also help students smoother transition one activ
ity another by donating project significantly help students special needs eq
ual opportunity learn peers behavior issues greatly minimized classroom mana
gement optimized help set students success i looking forward seeing students
become active listeners engaged learners always happy go school nannan
```

In [26]:

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

```
i teach title 1 school 73 students receive free reduced lunch our school pro
vides free breakfast students i special education certified teacher i teach
kindergarten general education setting class consists 52 students special ne
eds the disabilities include autism spectrum disorder speech impaired langua
ge impaired other health impaired adhd developmentally delayed i also 42 stu
dents english language learners self motivated learners synonym students the
y love learn possess positive outlook attitude school almost everyday studen
ts would ask ms perez going learn today i could not ask better greeting stud
ents this project greatly impact students learning daily basis the wobble ch
airs provide assistance students difficulties focusing attending lessons dis
cussions despite fact students participate physical activities p e recess go
noodle dance videos sessions classroom students still energy stand wiggle se
ats lessons due special needs beyond students control lot distraction studen
t learning not really achieved full potential the lack appropriate stimulati
on hinders focus learn class students special needs able sit wobble chairs w
hole group small group lessons this enable little active bodies move sitting
still without disrupting students as result students improve focus increase
student attention learning content areas in addition visual timer help stude
nts actually see allotted time activities this benefit especially ell studen
ts students special needs whenever independent classwork work centers studen
ts refer self monitor progress completing assignments it encourage use time
wisely finish tasks time it also help students smoother transition one activ
ity another by donating project significantly help students special needs eq
ual opportunity learn peers behavior issues greatly minimized classroom mana
gement optimized help set students success i looking forward seeing students
become active listeners engaged learners always happy go school nannan
```

In [27]:

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

Preprocessed Train data (Essay)

In [28]:

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

```
100%|██████████| 22445/22445 [00:10<00:00, 2091.06it/s]
```

In [29]:

```
# after preprocesing
preprocessed_essays_train[10000]
```

Out[29]:

```
'students struggling readers year moved new position intervention teacher th
ird fifth grade school students working trying best catch peers students two
grade levels academic grade although struggling not lost enthusiasm learning
always excited see come class pick working hard get reading math skills back
track everyone wants succeed no matter students use building fluency card ba
nk partner increase reading fluency students love time one another watch num
bers go use high interest intervention folder set working students small gro
up setting kit addresses several common core state standards students able r
eview practice new math skills common core practice cards wipe pockets excit
ed using nonfiction reading comprehension cards students students love read
things interested materials enable help students get back track nannan'
```

Preprocessed Test data (Essay)

In [30]:

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

```
100%|██████████| 16500/16500 [00:07<00:00, 2101.76it/s]
```

In [31]:

```
preprocessed_essays_test[0]
```

Out[31]:

```
'students come united states although lived neighborhood whole lives 97 stud
ents school receive free reduced lunch many overcome obstacles getting schoo
l day regardless continue see growth not academically also socially emotiona
lly family units second grade teacher really great chance inspire empower ac
hieve fullest potential well set path help succeed rest lives research shows
students multiple learning styles visual auditory kinesthetic etc many stude
nts unique learning styles like move learn wobble seats allow students abili
ty rock lean safe way get excess energy learn students use chairs centers bi
ggest movers shakers able get jitters move lessons ensure need movement not
impede learning nannan'
```

Preprocessed Cross Validation data (essay)

In [32]:

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

```
100%|██████████| 11055/11055 [00:05<00:00, 2082.25it/s]
```

In [33]:

```
preprocessed_essays_cv[0]
```

Out[33]:

```
'students classroom extremely hard workers love learning classroom values ch
allenges sees mistakes opportunities learn skills important students academi
c success community rich culture creativity short money school title 1 schoo
l 90 percent families qualifying free reduced meals majority families school
spanish speaking many languages overheard hallway conversations parents stud
ents materials put use immediately new books cracked open eager students can
not wait get lost story trade books central effectiveness reading workshop m
odel cornerstone engaging texts engaging reading class builds community pass
ion literacy read class sets together meaningful experience students develop
language skills time discuss social implications novels basic supplies penci
ls paper post notebooks make students practice writing classroom nannan'
```

1.4 Preprocessing of `project_title`

Preprocessing of Project Title for Train data

In [34]:

```
# similarly you can preprocess the titles also
preprocessed_titles_train = []

for titles in tqdm(X_train["clean_titles"]):
    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)
    preprocessed_titles_train.append(title.lower().strip())
```

```
100%|██████████| 22445/22445 [00:00<00:00, 36476.32it/s]
```

In [35]:

```
preprocessed_titles_train[0]
```

Out[35]:

```
'loving language literacy'
```

Preprocessing of Project Title for Test data

In [36]:

```
preprocessed_titles_test = []

for titles in tqdm(X_test["clean_titles"]):
    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)
    preprocessed_titles_test.append(title.lower().strip())
```

```
100%|██████████| 16500/16500 [00:00<00:00, 35904.29it/s]
```

In [37]:

```
preprocessed_titles_test[0]
```

Out[37]:

```
'ants pants move learn'
```

Preprocessing of Project Title for CV data

In [38]:

```
preprocessed_titles_cv = []

for titles in tqdm(X_cv["clean_titles"]):
    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)
    preprocessed_titles_cv.append(title.lower().strip())
```

```
100%|██████████| 11055/11055 [00:00<00:00, 35914.98it/s]
```

In [39]:

```
preprocessed_titles_cv[0]
```

Out[39]:

```
'books boosting language arts skills'
```

In [40]:

```
#Source:https://github.com/roothd17/Donor-Choose-ML/blob/master/Donor%20Choose%20RF%20and%2
def feaDic( alpha, feature, df ):

    count = X_train[ feature ].value_counts()

    # count :  CA     597         NY     306          TX     289        FL     231        NC     206

    featDict = dict()

    # denominator will contain the number of time that particular feature occured in whole

    for i, denominator in count.items():   # Here i = CA and deno = 597

        vec = []

        for j in range(1,3):  # itearte 2 times

            cls_cnt = X_train.loc[ ( X_train['project_is_approved'] == j ) & ( X_train[feat
            # cls_cnt will return a type(xtr) that will contain Only single features belong

            # cls_cnt.shape[0] will contain the number of time that particular feature occu

            vec.append( ( cls_cnt.shape[0] + alpha * 10 ) / ( denominator + 90 * alpha ) )

        # we are adding the feature to the dict as key and vec as value
        featDict[i] = vec
    return featDict

# when we caculate the probability of a feature belongs to any particular class, we apply L
# (numerator + 10 *alpha) / (denominator + 90 *alpha )



def feature( alpha, feature, df ):

    featureDict = feaDic( alpha, feature, df ) # Function Call

    count = X_train[feature].value_counts()

    # feat :it will contain the feature for each feature value in the data
    feat = []


    for index, row in df.iterrows():

        if row[feature] in dict( count ).keys():
            feat.append( featureDict[ row[feature] ] )
        else:
            feat.append([0.5, 0.05])

    return feat
```

1.5 Preparing data for models

In [41]:

```
project_data.columns
```

Out[41]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'project_grade_category', 'clean_categories', 'clean_subcategories',
       'clean_titles', 'title_word_count', 'clean_essays', 'essay_word_coun
t'],
      dtype='object')
```

we are going to consider

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

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

       - quantity : numerical (optinal)
       - teacher_number_of_previously_posted_projects : numerical
       - price : numerical
```

1.5.1 Vectorizing Categorical data

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

In [42]:

```
alpha = 1 # alpha is used for laplace smoothing

X_train_cc_ohe = np.array( feature( alpha, "clean_categories", X_train) )
X_test_cc_ohe = np.array( feature( alpha, "clean_categories", X_test) )
X_cv_cc_ohe = np.array( feature( alpha, "clean_categories", X_cv) )

print( X_train_cc_ohe.shape )
print( X_test_cc_ohe.shape )
print( X_cv_cc_ohe.shape )
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

In [43]:

```
alpha = 1 # alpha is used for laplace smoothing

X_train_csc_ohe = np.array( feature( alpha, "clean_subcategories", X_train) )
X_test_csc_ohe = np.array( feature( alpha, "clean_subcategories", X_test) )
X_cv_csc_ohe = np.array( feature( alpha, "clean_subcategories", X_cv) )

print( X_train_csc_ohe.shape )
print( X_test_csc_ohe.shape )
print( X_cv_csc_ohe.shape )
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

In [44]:

```
alpha = 1 # alpha is used for laplace smoothing

X_train_teacher_ohe = np.array( feature( alpha, "teacher_prefix", X_train) )
X_test_teacher_ohe = np.array( feature( alpha, "teacher_prefix", X_test) )
X_cv_teacher_ohe = np.array( feature( alpha, "teacher_prefix", X_cv) )

print( X_train_teacher_ohe.shape )
print( X_test_teacher_ohe.shape )
print( X_cv_teacher_ohe.shape )
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

In [45]:

```
alpha = 1 # alpha is used for laplace smoothing

X_train_state_ohe = np.array( feature( alpha, "school_state", X_train) )
X_test_state_ohe = np.array( feature( alpha, "school_state", X_test) )
X_cv_state_ohe = np.array( feature( alpha, "school_state", X_cv) )

print( X_train_state_ohe.shape )
print( X_test_state_ohe.shape )
print( X_cv_state_ohe.shape )
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

In [46]:

```
alpha = 1 # alpha is used for laplace smoothing

X_train_grade_ohe = np.array( feature( alpha, "project_grade_category", X_train) )
X_test_grade_ohe = np.array( feature( alpha, "project_grade_category", X_test) )
X_cv_grade_ohe = np.array( feature( alpha, "project_grade_category", X_cv) )

print( X_train_grade_ohe.shape )
print( X_test_grade_ohe.shape )
print( X_cv_grade_ohe.shape )
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

a) Bag of words Train Data (Essays)

In [47]:

```
# We are considering only the words which appeared in at least 10 documents(rows or project
vectorizer_bow_essay = CountVectorizer(min_df=10)

vectorizer_bow_essay.fit(preprocessed_essays_train)

text_bow_train = vectorizer_bow_essay.transform(preprocessed_essays_train)

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

```
Shape of matrix after one hot encoding  (22445, 8801)
```

b) Bag of words Test Data (Essays)

In [48]:

```
text_bow_test = vectorizer_bow_essay.transform(preprocessed_essays_test)
print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8801)
```

c) Bag of words CV Data (Essays)

In [49]:

```
text_bow_cv = vectorizer_bow_essay.transform(preprocessed_essays_cv)
print("Shape of matrix after one hot encoding ",text_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8801)
```

d) Bag of words train Data (Titles)

In [50]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
vectorizer_bow_title = CountVectorizer(min_df=10)

vectorizer_bow_title.fit(preprocessed_titles_train)

title_bow_train = vectorizer_bow_title.transform(preprocessed_titles_train)

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

```
Shape of matrix after one hot encoding  (22445, 1169)
```

e) Bag of words Test Data (Titles)

In [51]:

```
title_bow_test = vectorizer_bow_title.transform(preprocessed_titles_test)
print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1169)
```

f) Bag of words Data (Titles)

In [52]:

```
title_bow_cv = vectorizer_bow_title.transform(preprocessed_titles_cv)
print("Shape of matrix after one hot encoding ",title_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 1169)
```

1.5.2.2 TFIDF vectorizer

a) TFIDF vectorizer Train Data (Essays)

In [53]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
vectorizer_tfidf_essay.fit(preprocessed_essays_train)

text_tfidf_train = vectorizer_tfidf_essay.transform(preprocessed_essays_train)

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

```
Shape of matrix after one hot encoding  (22445, 8801)
```

b) TFIDF vectorizer Test Data (Essays)

In [54]:

```
text_tfidf_test = vectorizer_tfidf_essay.transform(preprocessed_essays_test)
print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8801)
```

c) TFIDF vectorizer CV Data (Essays)

In [55]:

```
text_tfidf_cv = vectorizer_tfidf_essay.transform(preprocessed_essays_cv)
print("Shape of matrix after one hot encoding ",text_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8801)
```

c) TFIDF vectorizer Train Data (Titles)

In [56]:

```
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

vectorizer_tfidf_titles.fit(preprocessed_titles_train)
title_tfidf_train = vectorizer_tfidf_titles.transform(preprocessed_titles_train)

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

```
Shape of matrix after one hot encoding  (22445, 1169)
```

d) TFIDF vectorizer Test Data (Titles)

In [57]:

```
title_tfidf_test = vectorizer_tfidf_titles.transform(preprocessed_titles_test)
print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1169)
```

e) TFIDF vectorizer CV Data (Titles)

In [58]:

```
title_tfidf_cv = vectorizer_tfidf_titles.transform(preprocessed_titles_cv)
print("Shape of matrix after one hot encoding ",title_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 1169)
```

C) 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')


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

print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

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

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


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

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

```
Loading Glove Model

---------------------------------------------------------------------------
FileNotFoundError                         Traceback (most recent call last)
<ipython-input-59-40504d584192> in <module>
     12     return model
     13 
---> 14 model = loadGloveModel('glove.42B.300d.txt')
     15 
     16 

<ipython-input-59-40504d584192> in loadGloveModel(gloveFile)
      2 def loadGloveModel(gloveFile):
      3     print ("Loading Glove Model")
----> 4     f = open(gloveFile,'r', encoding="utf8")
      5     model = {}
      6     for line in tqdm(f):

FileNotFoundError: [Errno 2] No such file or directory: 'glove.42B.300d.txt'
```

In [61]:

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

Train Essay

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_train = [];

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%|██████████| 22445/22445 [00:07<00:00, 2920.95it/s]

22445
300
```

Test Essay

In [63]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_test = [];

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%|██████████| 16500/16500 [00:05<00:00, 2836.91it/s]

16500
300
```

Cross validation Essay

In [64]:

```
avg_w2v_vectors_cv = [];

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%|██████████| 11055/11055 [00:03<00:00, 2805.02it/s]

11055
300
```

train Titles

In [65]:

```
avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm(X_train["clean_titles"]): # for each title
    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_train.append(vector)

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

```
100%|██████████| 22445/22445 [00:00<00:00, 44249.68it/s]

22445
300
```

Test Titles

In [66]:

```
avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm(X_test["clean_titles"]): # for each title
    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%|██████████| 16500/16500 [00:00<00:00, 44507.08it/s]

16500
300
```

CV Titles

In [67]:

```
avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm(X_cv["clean_titles"]): # for each title
    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%|██████████| 11055/11055 [00:00<00:00, 42956.59it/s]

11055
300
```

D) Using Pretrained Models: TFIDF weighted W2V

Train - Essays

In [68]:

```
# 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 [69]:

```
# 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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

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

```
100%|██████████| 22445/22445 [00:48<00:00, 465.84it/s]

22445
300
```

Test essays

In [70]:

```
# 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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)

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

```
100%|██████████| 16500/16500 [00:35<00:00, 467.47it/s]

16500
300
```

CV essays

In [71]:

```
# 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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_cv.append(vector)

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

```
100%|██████████| 11055/11055 [00:22<00:00, 480.81it/s]

11055
300
```

Train Titles

In [72]:

```
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 [73]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_train = [];

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 value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_train.append(vector)

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

```
100%|██████████| 22445/22445 [00:00<00:00, 22513.14it/s]

22445
300
```

Test Titles

In [74]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_test = [];

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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_test.append(vector)

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

```
100%|██████████| 16500/16500 [00:00<00:00, 23643.94it/s]

16500
300
```

CV Titles

In [75]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_cv = [];

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((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_cv.append(vector)

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

```
100%|██████████| 11055/11055 [00:00<00:00, 17632.77it/s]

11055
300
```

1.5.3 Vectorizing Numerical features

a) Price

In [76]:

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

In [77]:

```
# join two dataframes in python:
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')
```

In [78]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikitlearn.org/stable/modules/generated/sklearn.preproc
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import Normalizer
from sklearn import preprocessing
price_scalar = MinMaxScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standarddevi
#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_train = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
price_train
# Now standardize the data with above maen and variance.
price_test = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
price_test
# Now standardize the data with above maen and variance.
price_cv = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
price_cv
```

Out[78]:

```
array([[0.03844138],
       [0.01495348],
       [0.01239906],
       ...,
       [0.06474475],
       [0.0024144 ],
       [0.00206234]])
```

In [79]:

```
print("After vectorizations")
print(price_train.shape, y_train.shape)
print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
```

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

b) Quantity

In [80]:

```
price_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and standard
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0]
# Now standardize the data with above maen and variance.
quantity_train = price_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
quantity_train
# Now standardize the data with above maen and variance.
quantity_cv = price_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
quantity_cv
# Now standardize the data with above maen and variance.
quantity_test = price_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_test
```

Out[80]:

```
array([[0.00538213],
       [0.0204521 ],
       [0.18729817],
       ...,
       [0.00107643],
       [0.00215285],
       [0.00645856]])
```

In [81]:

```
print("After vectorizations")
print(quantity_train.reshape, y_train.shape)
print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
```

```
After vectorizations
<built-in method reshape of numpy.ndarray object at 0x7f211b357850> (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
```

c) Number of Projects previously proposed by Teacher

In [82]:

```
price_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0]
# Now standardize the data with above maen and variance.
prev_projects_train = price_scalar.transform(X_train['teacher_number_of_previously_posted_p
prev_projects_train
# Now standardize the data with above maen and variance.
prev_projects_cv = price_scalar.transform(X_cv['teacher_number_of_previously_posted_project
prev_projects_cv
# Now standardize the data with above maen and variance.
prev_projects_test = price_scalar.transform(X_test['teacher_number_of_previously_posted_pro
prev_projects_test
```

Out[82]:

```
array([[0.04672897],
       [0.24065421],
       [0.        ],
       ...,
       [0.        ],
       [0.0046729 ],
       [0.0046729 ]])
```

In [83]:

```
print("After vectorizations")
print(prev_projects_train.shape, y_train.shape)
print(prev_projects_cv.shape, y_cv.shape)
print(prev_projects_test.shape, y_test.shape)
```

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

Assignment 9: RF and GBDT

Response Coding: Example

The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

1. **Apply both Random Forrest and GBDT on these feature sets**

    - Set 1: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-

numerical-features/): use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
- Set 3: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
- Set 4: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)**

   - Consider the following range for hyperparameters **n_estimators** = [10, 50, 100, 150, 200, 300, 500, 1000], **max_depth** = [2, 3, 4, 5, 6, 7, 8, 9, 10]
   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - find the best hyper paramter using k-fold cross validation/simple cross validation data
   - use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

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

     with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

or

   - 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

     seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
   - You can choose either of the plotting techniques: 3d plot or heat map
   - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
   - Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points

4. **Conclusion**

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

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. (https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

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

In [82]:

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

X_tr = hstack((X_train_cc_ohe, X_train_csc_ohe,X_train_state_ohe, X_train_grade_ohe,X_trair
X_te = hstack((X_test_cc_ohe, X_test_csc_ohe,X_test_state_ohe, X_test_grade_ohe,X_test_teac
X_cr = hstack((X_cv_cc_ohe, X_cv_csc_ohe,X_cv_state_ohe, X_cv_grade_ohe,X_cv_teacher_ohe, p
```

In [83]:

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

```
Final Data matrix
(22445, 9920) (22445,)
(11055, 9920) (11055,)
(16500, 9920) (16500,)
============================================================================
========================
```

In [84]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # 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 = 4900
    # 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
```

A) Gridsearch-cv

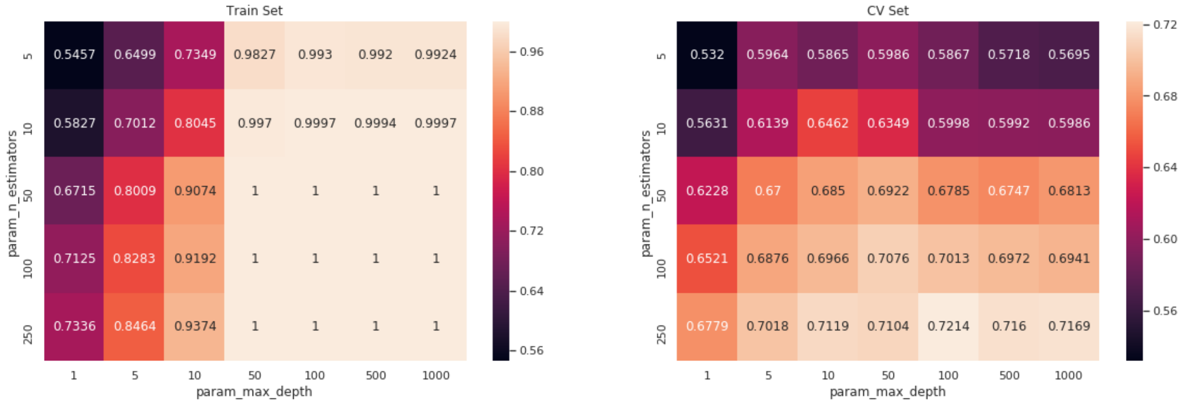
In [85]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
rfc1 = RandomForestClassifier(class_weight = 'balanced')

parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50, 100,
for i in tqdm(parameters):

    clf1 = GridSearchCV(rfc1, parameters, cv= 2, scoring='roc_auc',n_jobs=-1,return_train_s
    clf1.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [06:18<00:00, 189.50s/it]
```

In [86]:

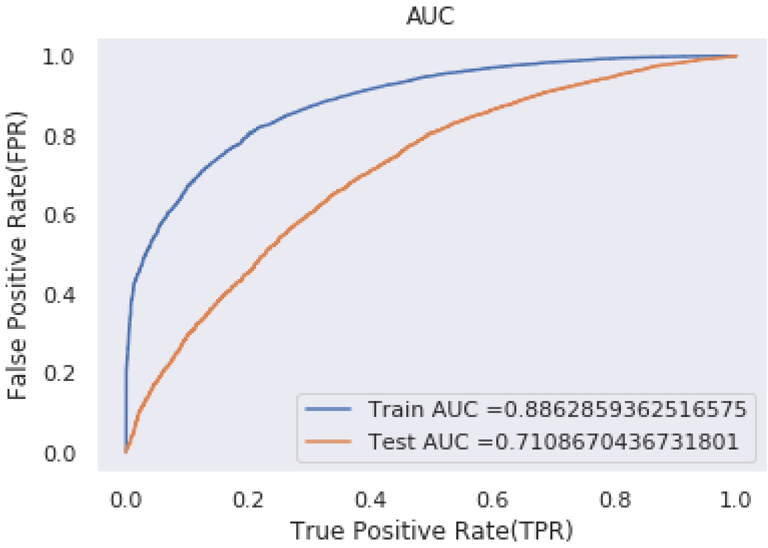
```
import seaborn as sns; sns.set()


max_scores1 = pd.DataFrame(clf1.cv_results_).groupby(['param_n_estimators', 'param_max_dept


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



B) Train model using the best hyper-parameter value

In [87]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = RandomForestClassifier(max_depth = 10, n_estimators =250,class_weight = 'balanced')
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



D) Confusion Matrix

In [85]:

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

Train Data

In [89]:

```
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) 0.24999997915341 for threshold 0.477
[[ 1732  1731]
 [  962 18020]]
```

In [90]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thre
```

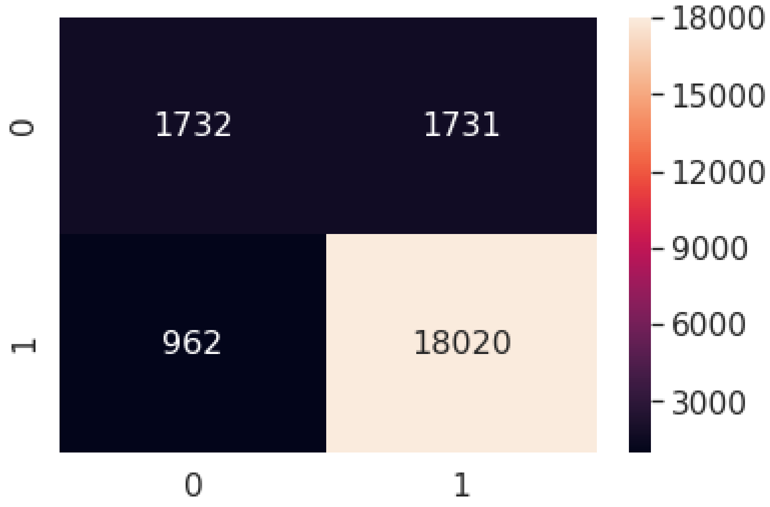
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.477
```

In [91]:

```
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[91]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb65baec1d0>
```



Test Data

In [92]:

```
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) 0.24999984572938835 for threshold 0.485
[[  897  1649]
 [ 1551 12403]]
```

In [93]:

```
conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_threshc
```

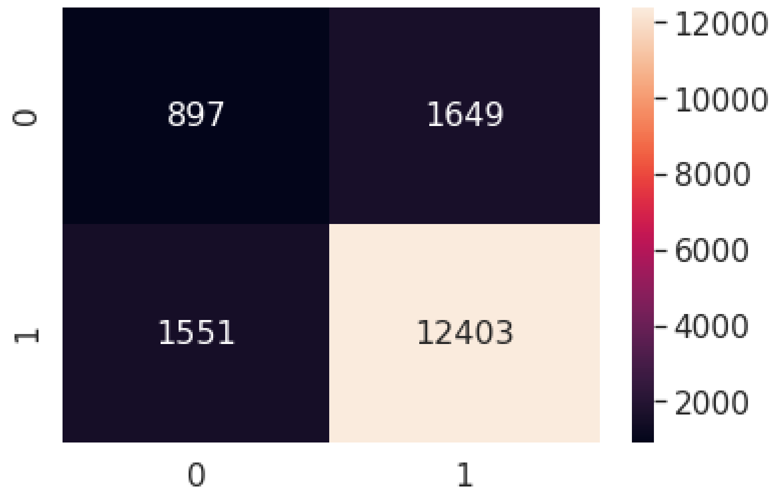
```
the maximum value of tpr*(1-fpr) 0.24999984572938835 for threshold 0.485
```

In [94]:

```
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[94]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb65ae35550>
```



XG boost

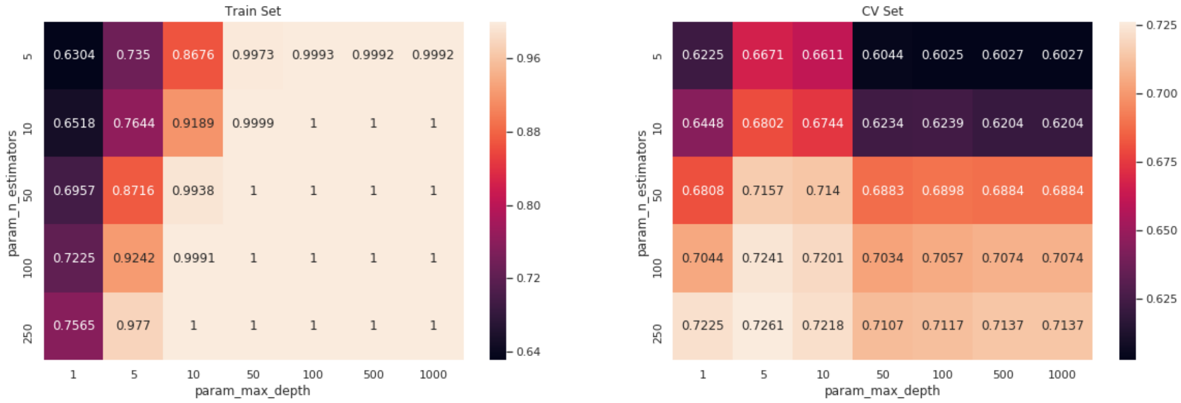
In [97]:

```
#https://xgboost.readthedocs.io/en/latest/python/python_api.html#module-xgboost.sklearnfrom

from xgboost import XGBClassifier

rgb1 = XGBClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50, 100,
for i in tqdm(parameters) :
    clf1_xgb = GridSearchCV(rgb1, parameters, cv=2,n_jobs=-1, scoring='roc_auc',return_trai
    clf1_xgb.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [27:35<00:00, 827.30s/it]
```

In [98]:

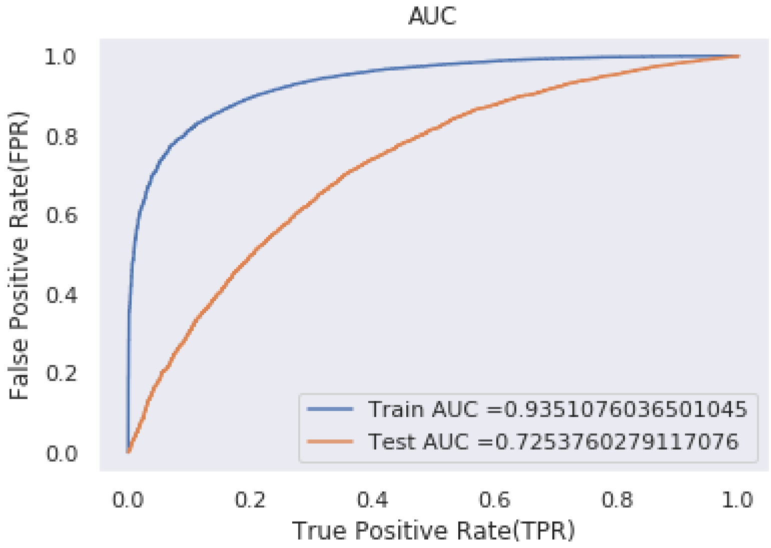
```
import seaborn as sns; sns.set()


max_scores2 = pd.DataFrame(clf1_xgb.cv_results_).groupby(['param_n_estimators', 'param_max_


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores2.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores2.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train model using the best hyper-parameter value

In [99]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = XGBClassifier(max_depth = 5, n_estimators = 250,class_weight = 'balanced')
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion Matrix (Train data)

In [100]:

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

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.648
[[ 1732  1731]
 [  454 18528]]
```

In [101]:

```
conf_matr_df_train_xgb1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_t
```

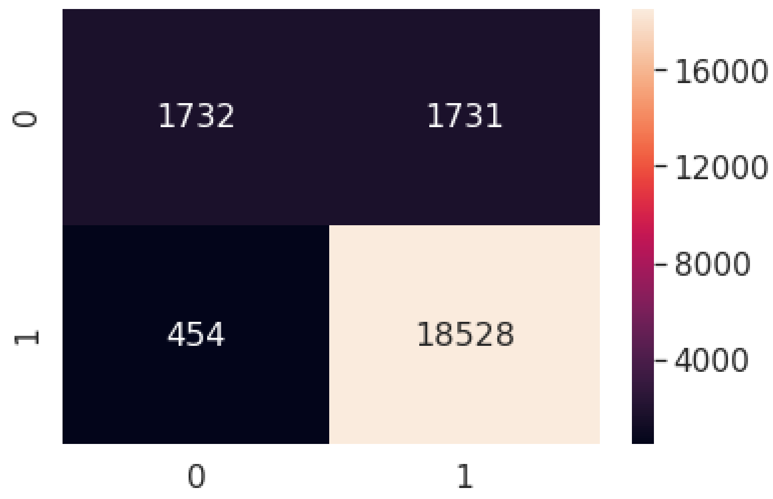
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.648
```

In [102]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_xgb1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[102]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb65bb117b8>
```



Test data

In [103]:

```
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) 0.24999984572938835 for threshold 0.682
[[  691  1855]
 [  947 13007]]
```

In [104]:

```
conf_matr_df_test_xgb1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thre
```

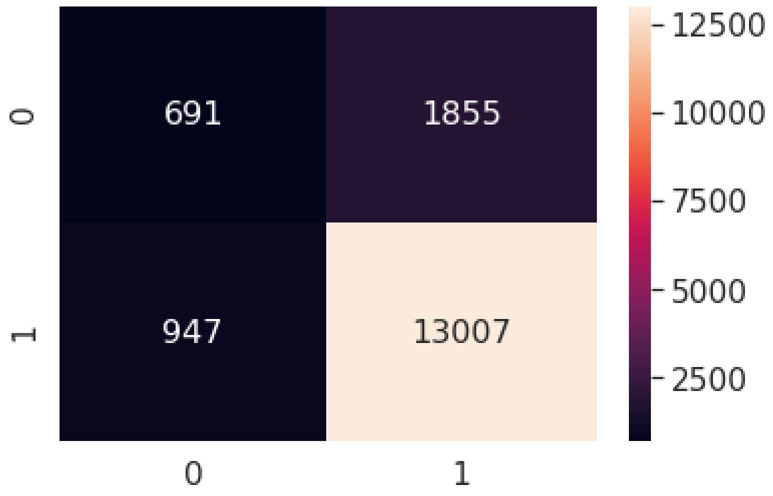
```
the maximum value of tpr*(1-fpr) 0.24999984572938835 for threshold 0.682
```

In [105]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_xgb1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[105]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659f64a90>
```



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

In [106]:

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

X_tr2 = hstack((X_train_cc_ohe, X_train_csc_ohe,X_train_state_ohe, X_train_grade_ohe,X_trai
X_te2 = hstack((X_test_cc_ohe, X_test_csc_ohe,X_test_state_ohe, X_test_grade_ohe,X_test_tea
X_cr2 = hstack((X_cv_cc_ohe, X_cv_csc_ohe,X_cv_state_ohe, X_cv_grade_ohe,X_cv_teacher_ohe,
```

In [107]:

```
print("Final Data matrix")
print(X_tr2.shape, y_train.shape)
print(X_cr2.shape, y_cv.shape)
print(X_te2.shape, y_test.shape)
```

```
Final Data matrix
(22445, 9920) (22445,)
(11055, 9920) (11055,)
(16500, 9920) (16500,)
```

GridSearch CV

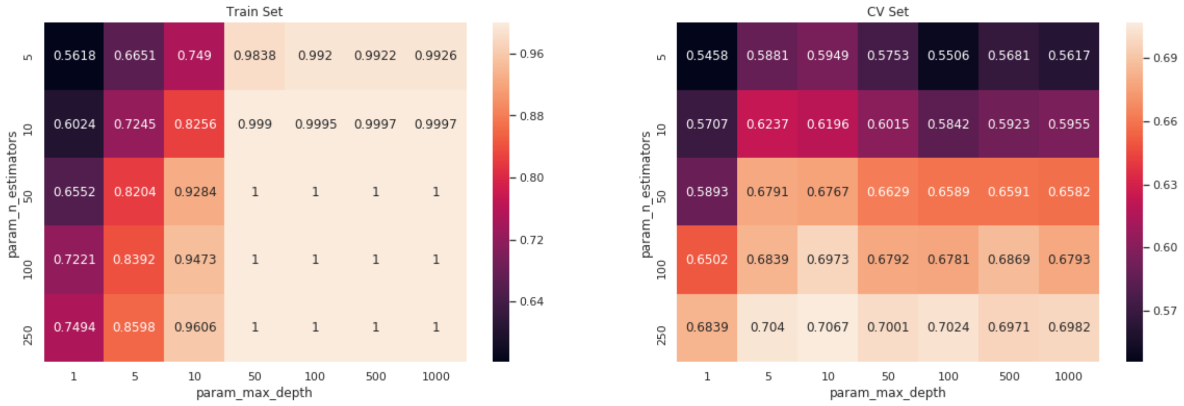
In [108]:

```
rfc2 = RandomForestClassifier(class_weight = 'balanced')

parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50, 100,
for i in tqdm(parameters):
    clf2 = GridSearchCV(rfc2, parameters, cv= 2, scoring='roc_auc',n_jobs=-1,return_train_s
    clf2.fit(X_tr2, y_train)
```

```
100%|██████████| 2/2 [03:39<00:00, 110.71s/it]
```

In [109]:

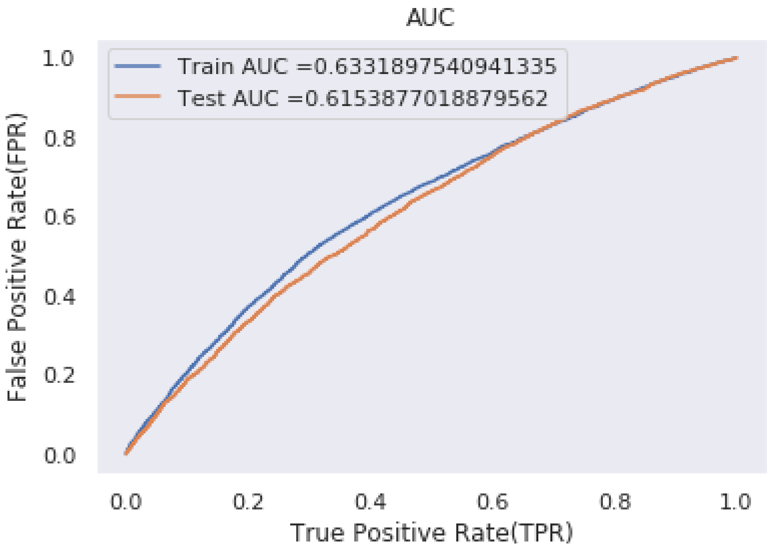
```
import seaborn as sns; sns.set()


max_scores3 = pd.DataFrame(clf2.cv_results_).groupby(['param_n_estimators', 'param_max_dept


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores3.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores3.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train model using the best hyper-parameter value

In [110]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = RandomForestClassifier(max_depth = 10, n_estimators = 250,class_weight = 'balanced'
model.fit(X_tr2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion Matrix -Train data

In [111]:

```
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) 0.24999997915341 for threshold 0.5
[[ 1732  1731]
 [ 5936 13046]]
```

In [112]:

```
conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thre
```

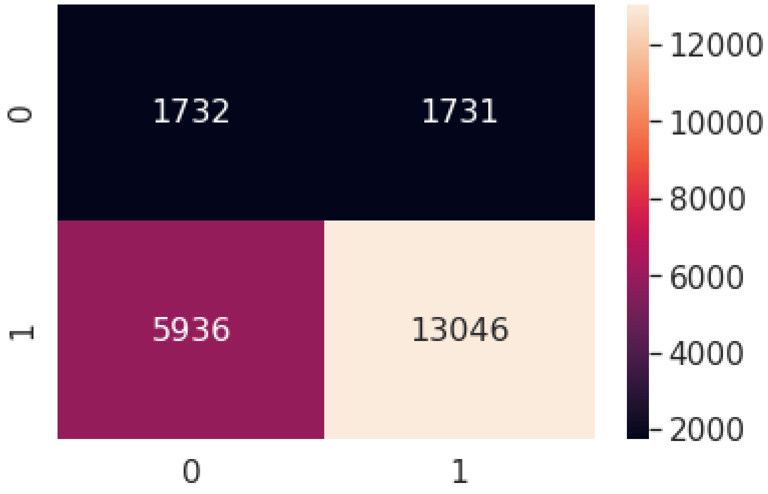
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.5
```

In [113]:

```
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[113]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659f3d8d0>
```



Test Data

In [114]:

```
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) 0.25 for threshold 0.505
[[1540 1006]
 [6153 7801]]
```

In [115]:

```
conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresho
```

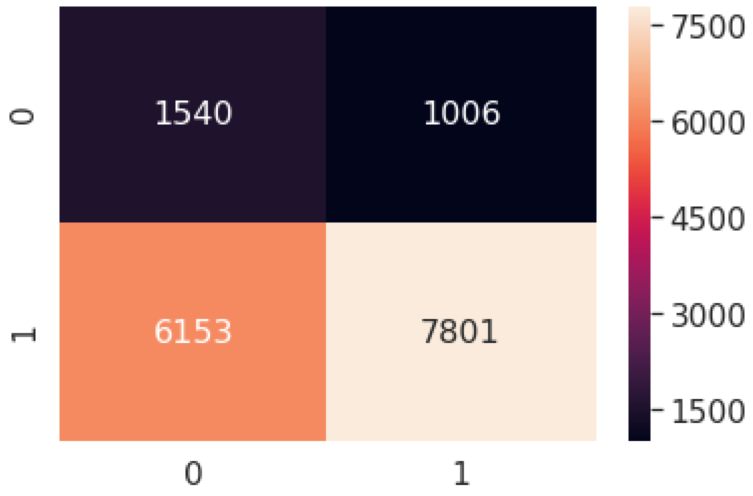
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.505
```

In [116]:

```
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[116]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659fac710>
```



XG Boost

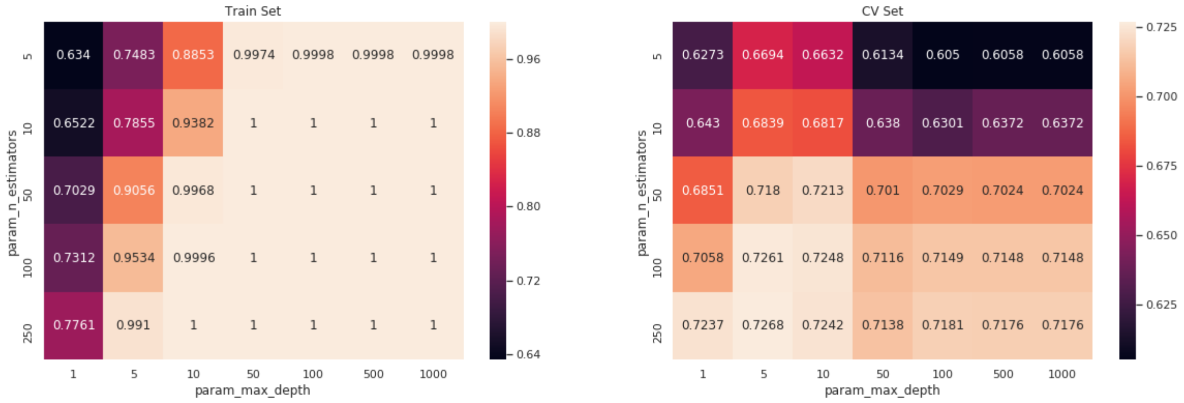
In [117]:

```
#https://xgboost.readthedocs.io/en/latest/python/python_api.html#module-xgboost.sklearnfrom

from xgboost import XGBClassifier

rgb2 = XGBClassifier(class_weight = 'balanced')

for i in tqdm(parameters) :
    parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50,

    clf2_xgb = GridSearchCV(rgb2, parameters, cv=2, scoring='roc_auc',n_jobs=-1,return_trai
    clf2_xgb.fit(X_tr2, y_train)
```

```
100%|██████████| 2/2 [45:52<00:00, 1373.11s/it]
```

In [118]:

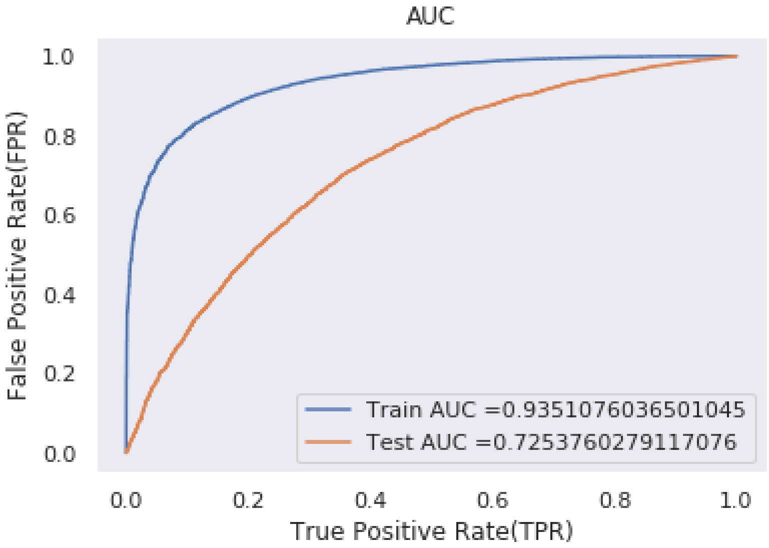
```
import seaborn as sns; sns.set()


max_scores4 = pd.DataFrame(clf2_xgb.cv_results_).groupby(['param_n_estimators', 'param_max_


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores4.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores4.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train model using the best hyper-parameter value

In [119]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = XGBClassifier(max_depth =5, n_estimators = 250,class_weight = 'balanced')
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion Matrix(Train Data)

In [120]:

```
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) 0.24999997915341 for threshold 0.648
[[ 1732  1731]
 [  454 18528]]
```

In [121]:

```
conf_matr_df_train_xgb2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_t
```

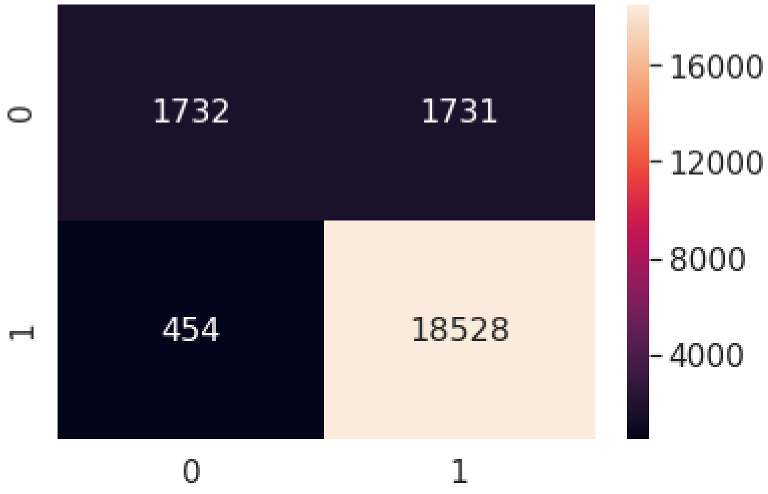
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.648
```

In [122]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_xgb2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[122]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb65a9c9cf8>
```



Test data

In [123]:

```
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) 0.24999984572938835 for threshold 0.682
[[  691  1855]
 [  947 13007]]
```

In [124]:

```
conf_matr_df_test_xgb2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thre
```

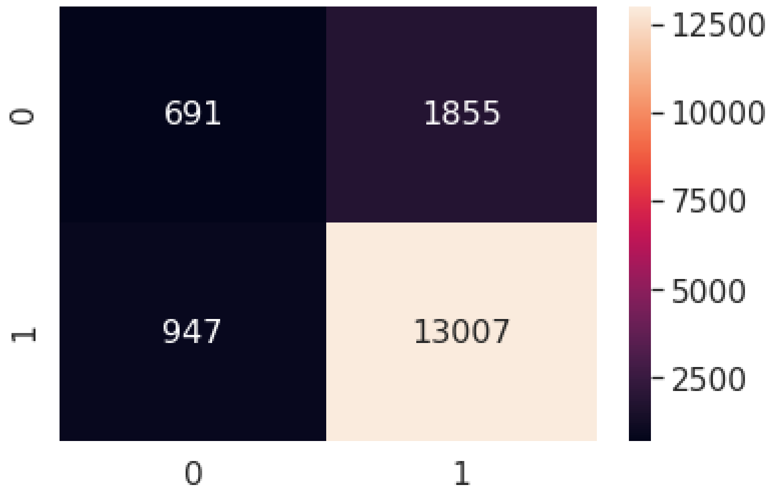
```
the maximum value of tpr*(1-fpr) 0.24999984572938835 for threshold 0.682
```

In [125]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_xgb2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[125]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659c59ba8>
```



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

In [126]:

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


X_tr = np.hstack((X_train_cc_ohe, X_train_csc_ohe,X_train_state_ohe, X_train_grade_ohe,X_tr
X_te = np.hstack((X_test_cc_ohe, X_test_csc_ohe,X_test_state_ohe, X_test_grade_ohe,X_test_t
X_cr = np.hstack((X_cv_cc_ohe, X_cv_csc_ohe,X_cv_state_ohe, X_cv_grade_ohe,X_cv_teacher_ohe
```

In [127]:

```
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
(22445, 613) (22445,)
(11055, 613) (11055,)
(16500, 613) (16500,)
```

Gridsearch CV

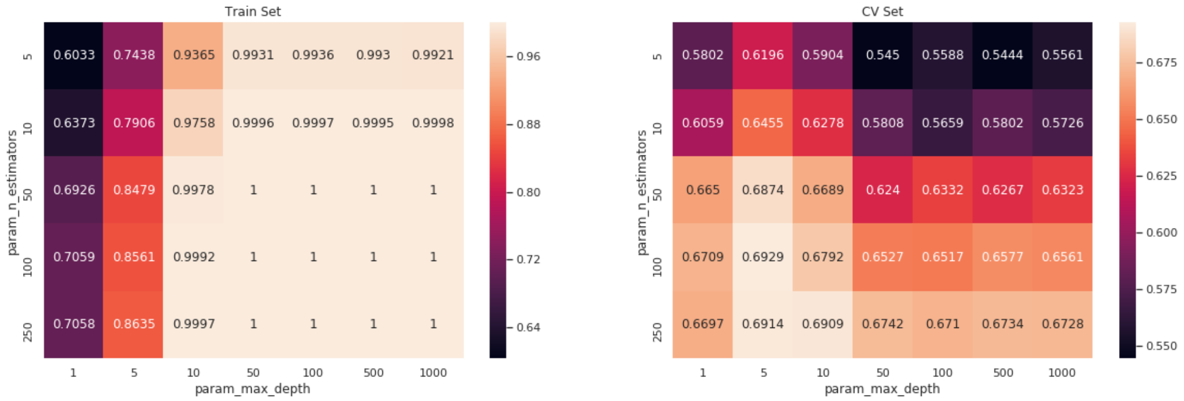
In [128]:

```
rfc3 = RandomForestClassifier(class_weight = 'balanced')
for i in tqdm(parameters) :
    parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50,

    clf3 = GridSearchCV(rfc3, parameters, cv= 2, scoring='roc_auc',n_jobs=-1,return_train_s
    clf3.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [08:59<00:00, 276.78s/it]
```

In [129]:

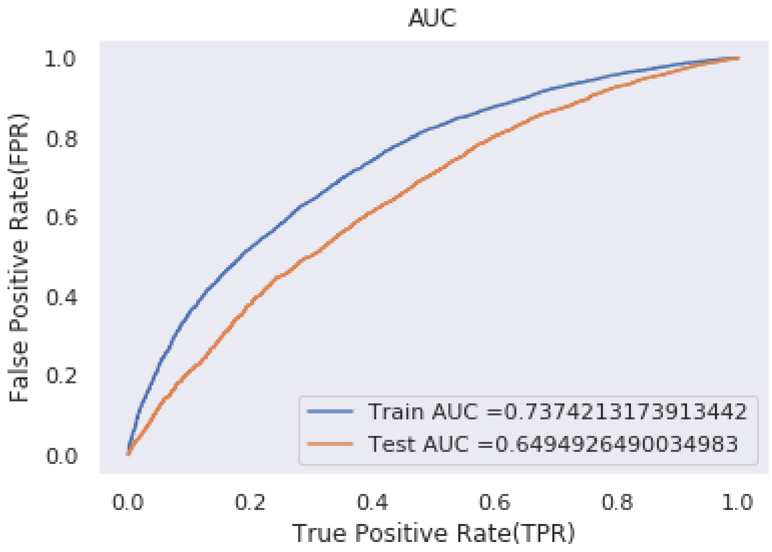
```
import seaborn as sns; sns.set()


max_scores5 = pd.DataFrame(clf3.cv_results_).groupby(['param_n_estimators', 'param_max_dept


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores5.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores5.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



B) Train the model using the best hyper parameter value

In [130]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = RandomForestClassifier(max_depth = 5, min_samples_split = 100,class_weight = 'balar
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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

Train data

In [131]:

```
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) 0.24999997915341 for threshold 0.473
[[ 1732  1731]
 [ 3361 15621]]
```

In [132]:

```
conf_matr_df_train_5 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thre
```

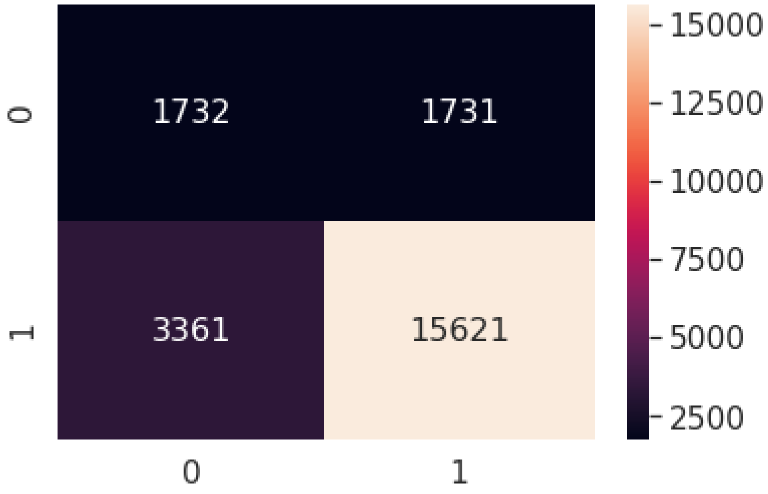
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.473
```

In [133]:

```
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[133]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659c35c50>
```



Test data

In [134]:

```
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) 0.25 for threshold 0.5
[[1357 1189]
 [4487 9467]]
```

In [135]:

```
conf_matr_df_test_6 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresho
```

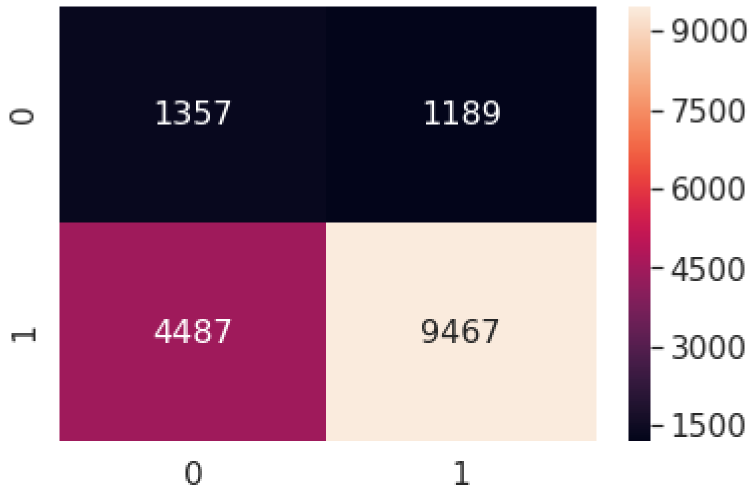
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.5
```

In [136]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_6, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[136]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659fe7630>
```



XGBoost

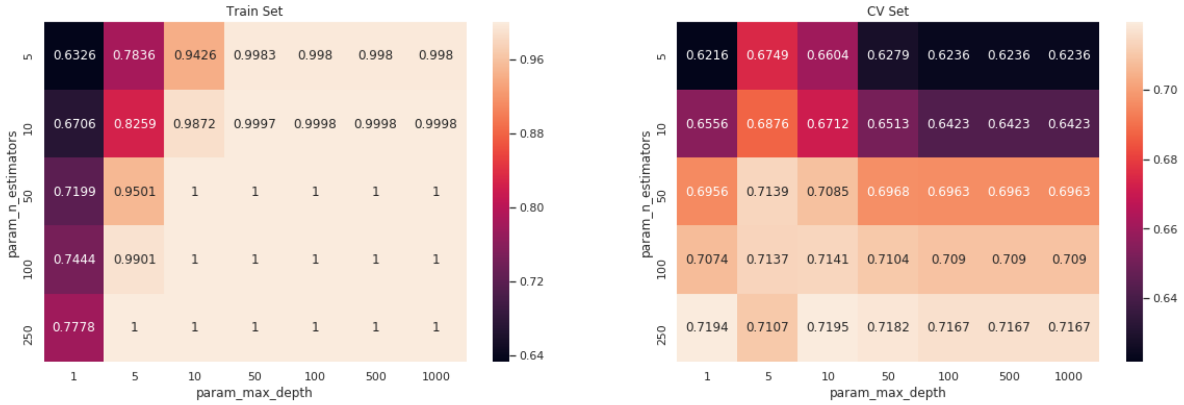
In [137]:

```
from xgboost import XGBClassifier

rgb3 = XGBClassifier(class_weight = 'balanced')

for i in tqdm(parameters) :
    parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50,

    clf3_xgb = GridSearchCV(rgb3, parameters, cv=2, scoring='roc_auc',n_jobs=-1,return_trai
    clf3_xgb.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [1:25:58<00:00, 2578.62s/it]
```

In [138]:

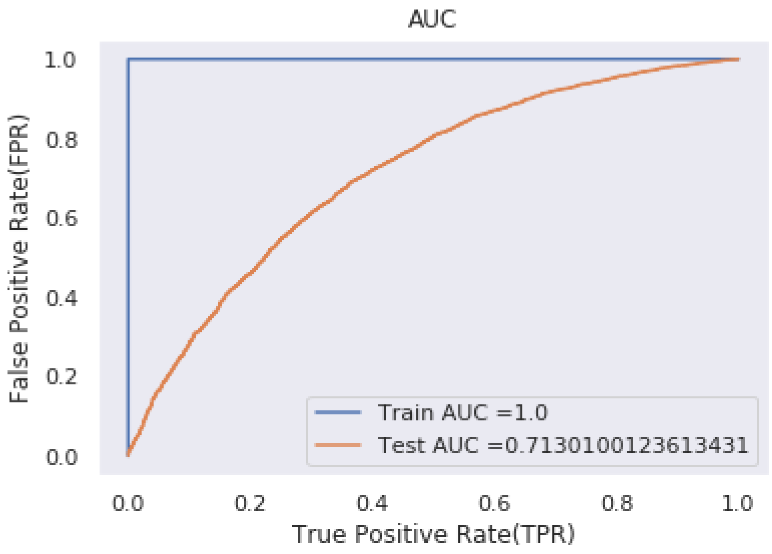
```
import seaborn as sns; sns.set()


max_scores6 = pd.DataFrame(clf3_xgb.cv_results_).groupby(['param_n_estimators', 'param_max_


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores6.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores6.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train the model using the best hyper parameter value

In [139]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = XGBClassifier(max_depth = 10, n_estimators = 250,class_weight = 'balanced')
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion matrix(test data)

In [140]:

```
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) 0.23689064270787533 for threshold 0.024
[[ 2128  1335]
 [    0 18982]]
```

In [141]:

```
conf_matr_df_train_xgb3 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_t
```

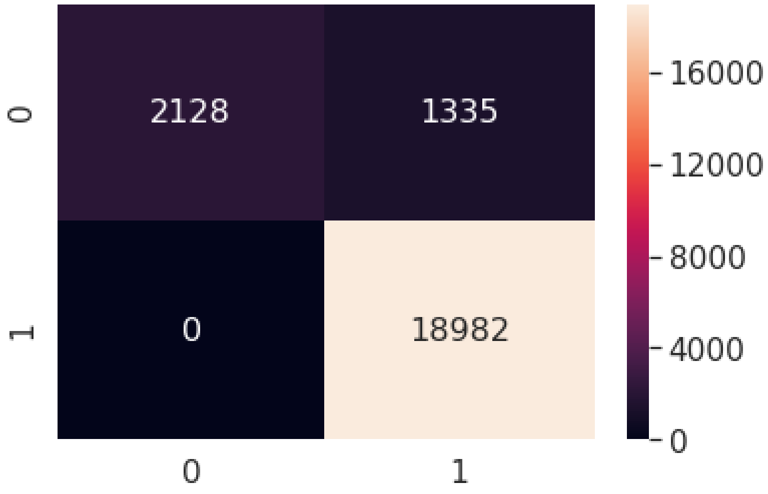
```
the maximum value of tpr*(1-fpr) 0.23689064270787533 for threshold 0.024
```

In [142]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_xgb3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[142]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659e0a668>
```



Train data

In [143]:

```
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) 0.25 for threshold 0.996
[[ 2299   247]
 [10152  3802]]
```

In [144]:

```
conf_matr_df_test_xgb3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thre
```

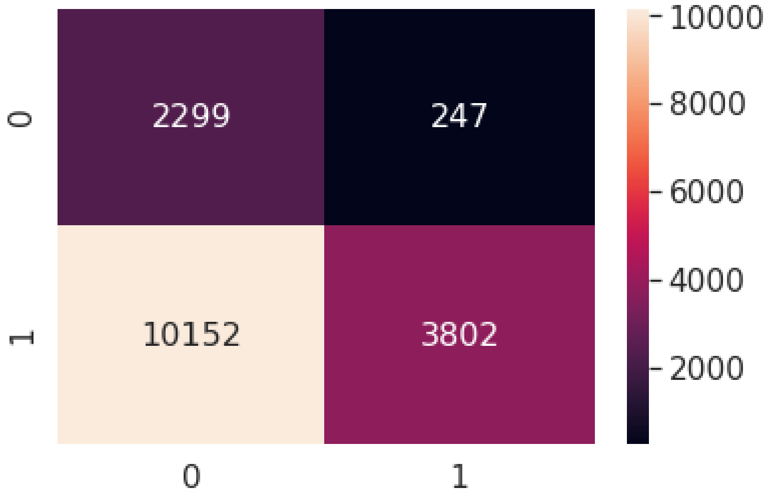
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.996
```

In [145]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_xgb3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[145]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb6606022e8>
```



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

In [87]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
import numpy as np
X_tr = np.hstack((X_train_cc_ohe, X_train_csc_ohe,X_train_state_ohe, X_train_grade_ohe,X_tr
X_te = np.hstack((X_test_cc_ohe, X_test_csc_ohe,X_test_state_ohe, X_test_grade_ohe,X_test_t
X_cr = np.hstack((X_cv_cc_ohe, X_cv_csc_ohe,X_cv_state_ohe, X_cv_grade_ohe,X_cv_teacher_ohe
```

In [88]:

```
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
(22445, 613) (22445,)
(11055, 613) (11055,)
(16500, 613) (16500,)
```

GridSearchCV

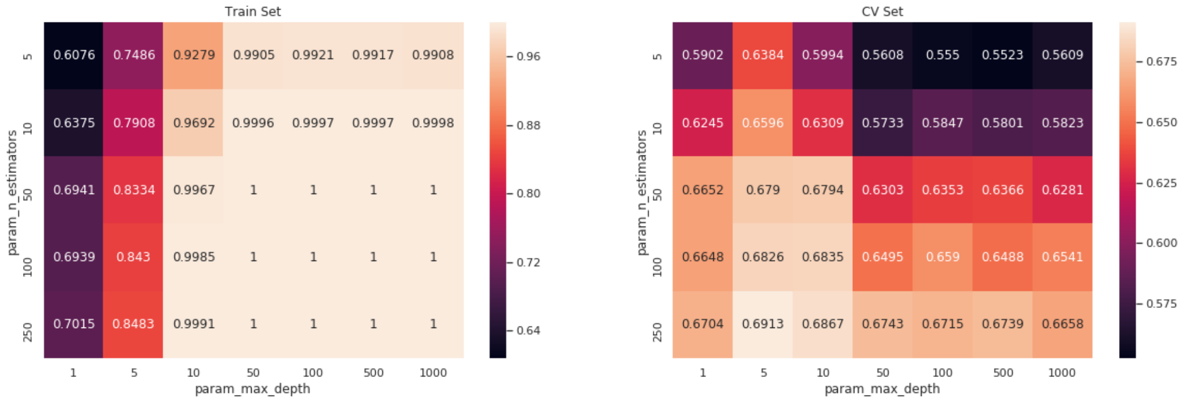
In [149]:

```
rfc4 = RandomForestClassifier(class_weight = 'balanced')
for i in tqdm(parameters) :
    parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50,
    clf4 = GridSearchCV(rfc4, parameters, cv= 2, scoring='roc_auc',n_jobs=-1,return_train_s
    clf4.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [09:28<00:00, 284.44s/it]
```

In [150]:

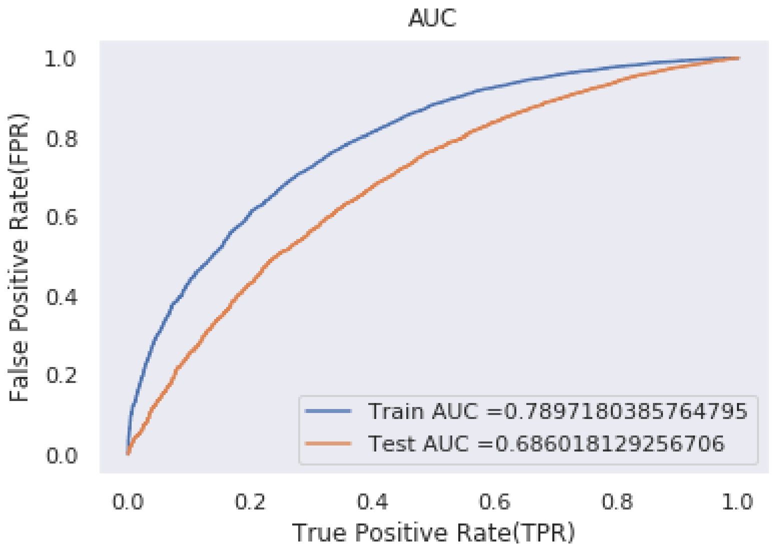
```
import seaborn as sns; sns.set()


max_scores7 = pd.DataFrame(clf4.cv_results_).groupby(['param_n_estimators', 'param_max_dept


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores7.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores7.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train the model using the best hyper parameter value

In [151]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = RandomForestClassifier(max_depth = 5, n_estimators = 250,class_weight = 'balanced')
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion Matrix

In [152]:

```
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) 0.24999997915341 for threshold 0.467
[[ 1732  1731]
 [ 2243 16739]]
```

In [153]:

```
conf_matr_df_train_7 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thre
```

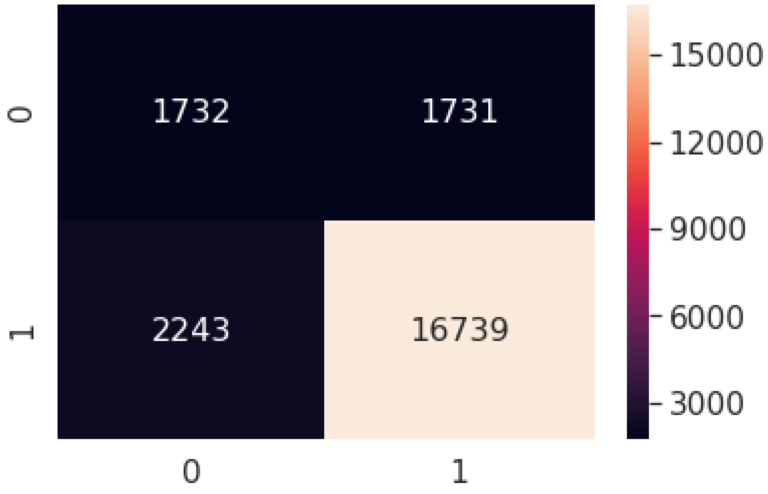
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.467
```

In [154]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_7, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[154]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb659c08780>
```



In [155]:

```
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) 0.25 for threshold 0.49
[[ 1317  1229]
 [ 3421 10533]]
```

In [156]:

```
conf_matr_df_test_8 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresho
```

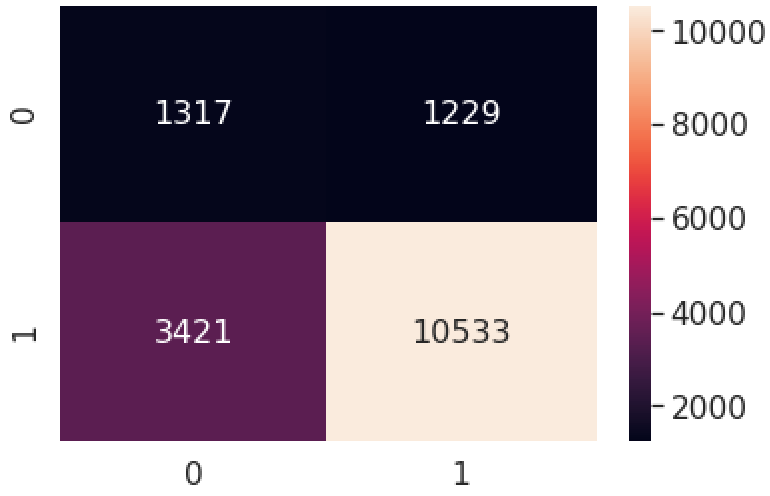
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.49
```

In [157]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_8, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[157]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb65a0502b0>
```



XGBoost

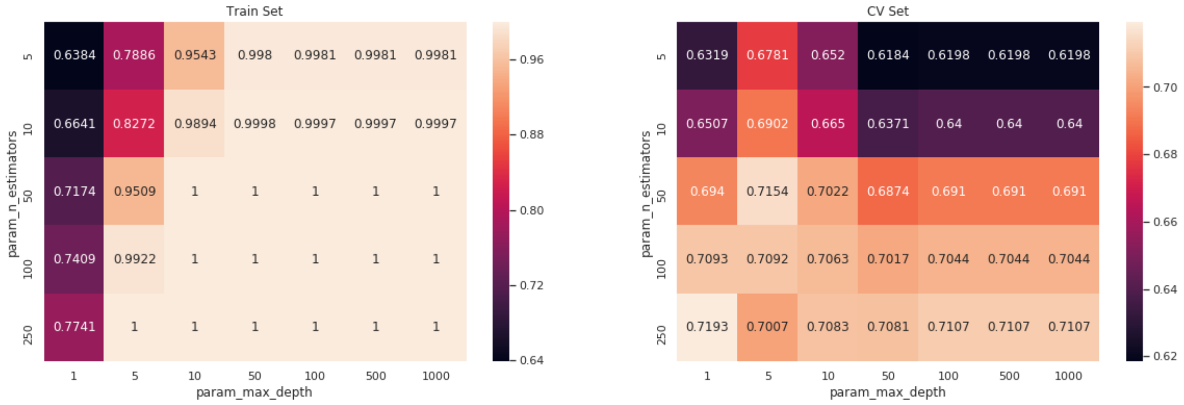
In [89]:

```
from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier

rgb4 = XGBClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'n_estimators': [5, 10, 50, 100,
for i in tqdm(parameters) :


    clf4_xgb = GridSearchCV(rgb4, parameters, cv=2, scoring='roc_auc',n_jobs=-1,return_trai
    clf4_xgb.fit(X_tr, y_train)
```

```
100%|██████████| 2/2 [1:02:01<00:00, 1864.74s/it]
```

In [90]:

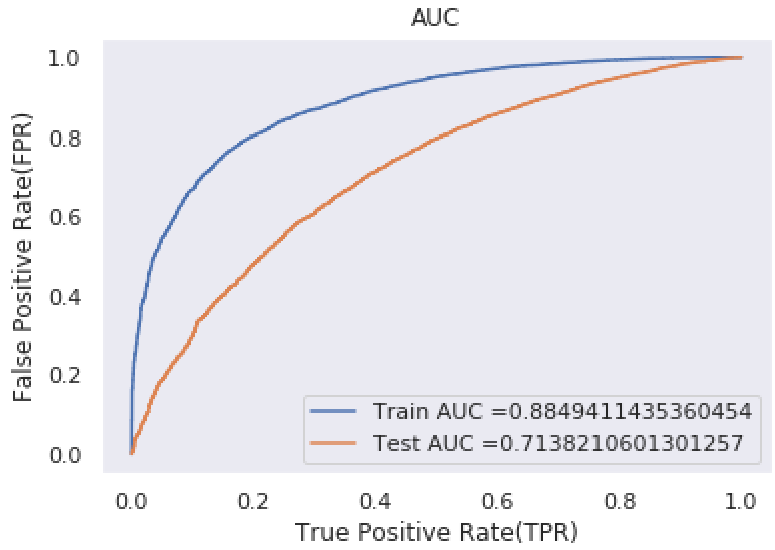
```
import seaborn as sns; sns.set()


max_scores8 = pd.DataFrame(clf4_xgb.cv_results_).groupby(['param_n_estimators', 'param_max_


fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores8.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores8.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train Model using best Hyperparameter Value

In [95]:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.m
from sklearn.metrics import roc_curve, auc
model = XGBClassifier(max_depth = 5, n_estimators = 50,class_weight = 'balanced')
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# 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()
```



Confusion Matrix

In [96]:

```
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) 0.24999997915341 for threshold 0.716
[[ 1732  1731]
 [  926 18056]]
```

In [97]:

```
conf_matr_df_train_xgb4 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_t
```

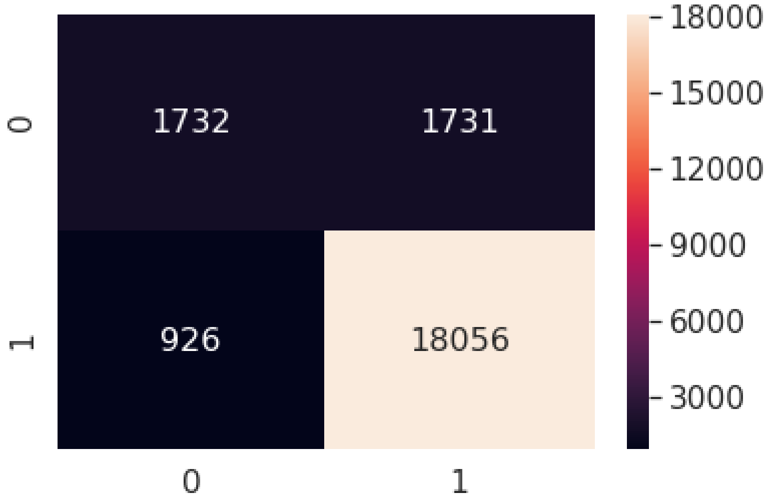
```
the maximum value of tpr*(1-fpr) 0.24999997915341 for threshold 0.716
```

In [98]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_xgb4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[98]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f211922ed68>
```



In [99]:

```
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) 0.25 for threshold 0.765
[[ 1011  1535]
 [ 1946 12008]]
```

In [100]:

```
conf_matr_df_test_xgb4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thre
```

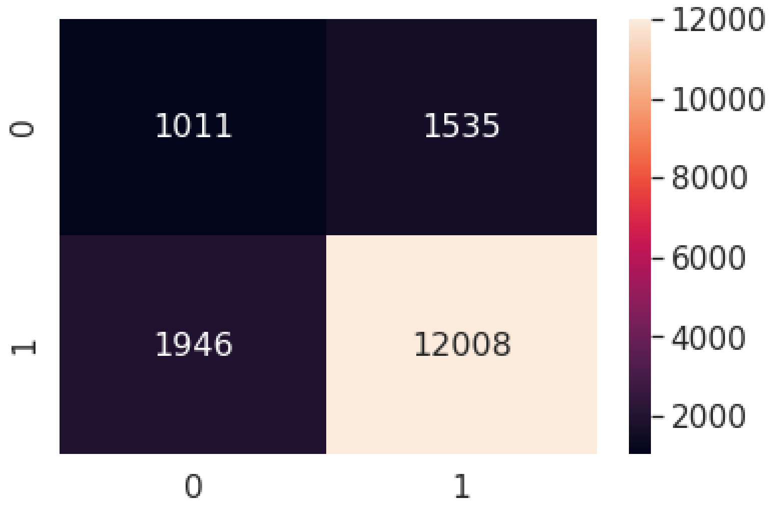
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.765
```

In [101]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_xgb4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[101]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f21192c8e48>
```



In [103]:

```
from prettytable import PrettyTable

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

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Depth:Hyper Parameter","Estimators:Hyper Parameter

x.add_row(["BOW", "Random forest",10,250 ,0.71])
x.add_row(["BOW", "XGBoost", 5,250, 0.725])
x.add_row(["TFIDF", "Random forest", 10,250, 0.615])
x.add_row(["TFIDF", "XGBoost", 5,250, 0.725])
x.add_row(["AVG W2V", "Random forest", 5,250, 0.649])
x.add_row(["AVG W2V", "XGBoost", 10,250, 0.713])
x.add_row(["TFIDF W2V", "Random forest", 5,250, 0.686])
x.add_row(["TFIDF W2V", "XGBoost", 5,250, 0.71])



print(x)
```

```
+------------+---------------+-----------------------+----------------------
------+-------+
| Vectorizer |     Model     | Depth:Hyper Parameter | Estimators:Hyper Para
meter |  AUC  |
+------------+---------------+-----------------------+----------------------
------+-------+
|    BOW     | Random forest |           10          |            250
|  0.71 |
|    BOW     |    XGBoost    |           5           |            250
| 0.725 |
|   TFIDF    | Random forest |           10          |            250
| 0.615 |
|   TFIDF    |    XGBoost    |           5           |            250
| 0.725 |
|  AVG W2V   | Random forest |           5           |            250
| 0.649 |
|  AVG W2V   |    XGBoost    |           10          |            250
| 0.713 |
| TFIDF W2V  | Random forest |           5           |            250
| 0.686 |
| TFIDF W2V  |    XGBoost    |           5           |            250
|  0.71 |
+------------+---------------+-----------------------+----------------------
------+-------+
```