DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

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

importing necessary packages that might be used here :

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
from sklearn.metrics import accuracy_score
```

1.1 Reading Data

Reading first 50000 datapts using parameter nrows

In [2]:

```
project_data = pd.read_csv('train_data.csv',nrows=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' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

```
# 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[4]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	L

In [5]:

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

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

Out[5]:

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

removing space in project grade category

preprocessing of project_grade_category

In [6]:

```
#preprocess project grade category
print(project_data['project_grade_category'].values[0])
print("="*50)
print(project_data['project_grade_category'].values[150])
print("="*50)
print(project_data['project_grade_category'].values[1000])
print("="*50)
print(project_data['project_grade_category'].values[20000])
print("="*50)


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

```
Grades PreK-2
==================================================
Grades 3-5
==================================================
Grades PreK-2
==================================================
Grades PreK-2
==================================================
```

Out[6]:

```
Grades PreK-2    20316
Grades 3-5       16968
Grades 6-8        7750
Grades 9-12       4966
Name: project_grade_category, dtype: int64
```

In [7]:

```
preprocessed_project_grade_categories= []

for grade_cat in tqdm(project_data["project_grade_category"]):

    grade_cat = grade_cat.replace('-', '_')  #Replacing(-) with(_)
    grade_cat = grade_cat.replace('Grades', '') #Removing grades as it is redundant

    grad_cat = ' '.join(f for f in grade_cat.split())
    preprocessed_project_grade_categories.append(grad_cat.strip())
```

```
100%|████████████████████████████████| 50000/50000 [00:00<00:00, 100532.54it/s]
```

In [8]:

```
print(preprocessed_project_grade_categories[1])
print("="*50)
print(preprocessed_project_grade_categories[50])
print("="*50)
print(preprocessed_project_grade_categories[500])
print("="*50)
print(preprocessed_project_grade_categories[5000])
print("="*50)
print(preprocessed_project_grade_categories[10001])
print("="*50)
```

```
3_5
==================================================
3_5
==================================================
PreK_2
==================================================
3_5
==================================================
PreK_2
==================================================
```

1.2 preprocessing of `project_subject_categories`

In [9]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [10]:

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

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

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

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

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

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

1.4 preprocessing teacher prefix

In [11]:

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

In [12]:

```
def replace_cate(lst):           # Removing (.) in Mrs.
    return lst.replace('.','')


project_data['teacher_prefix']= project_data['teacher_prefix'].astype(str).apply(replace_cate)
```

In [13]:

```
preprocessed_teacher_prefix = []

for teach_prefix in tqdm(project_data["teacher_prefix"]):

    preprocessed_teacher_prefix.append(teach_prefix.strip())
```

```
100%|████████████████████████████████| 50000/50000 [00:00<00:00, 268626.63it/s]
```

In [14]:

```
print(preprocessed_teacher_prefix[1])
print("="*50)
print(preprocessed_teacher_prefix[50])
print("="*50)
project_data.teacher_prefix.value_counts()
```

```
Mrs
==================================================
Mrs
==================================================
```

Out[14]:

```
Mrs        26140
Ms         17936
Mr          4859
Teacher     1061
Dr             2
null           2
Name: teacher_prefix, dtype: int64
```

Adding a new feature Number of words in title

In [15]:

```
title_word_count = []
```

In [16]:

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

In [17]:

```
project_data["title_word_count"] = title_word_count
```

In [18]:

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

Out[18]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs	GA	2016-04-27 00:53:00	Grades PreK-2	Flex Seating Flex Lear
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs	WA	2016-04-27 01:05:25	Grades 3-5	Going D The A I Think
29891	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs	CA	2016-04-27 01:10:09	Grades 3-5	Brea Box to Ig Engagem
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms	CA	2016-04-27 02:04:15	Grades PreK-2	iPa Lear
						2016-		A flex classr

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_
49228	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms	IL	04-27 07:19:44	Grades PreK-2	classr for flex mi

1.5 Combining all 4 project essays to one big essay

In [19]:

```
# 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)
```

1.6 Adding a new feature Number of words in essay

In [20]:

```
essay_word_count=[]
```

In [21]:

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

In [22]:

```
project_data["essay_word_count"] = essay_word_count
```

In [23]:

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

Out[23]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_ti
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs	GA	2016-04-27 00:53:00	Grades PreK-2	Flexi Seating Flexi Learn
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs	WA	2016-04-27 01:05:25	Grades 3-5	Going De The Ar In Thinki

1.7 Train test split

Splitting of dataset is happening first to avoid the problem of data leakage

In [24]:

```
# train test split using sklearn.model selection
from sklearn.model_selection import train_test_split

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

```
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train,
random_state=0)
```

In [25]:

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

1.8 Text preprocessing

In [26]:

```
# printing some random reviews

print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[500])
print("="*50)
print(X_train['essay'].values[1000])
print("="*50)
print(X_train['essay'].values[10000])
print("="*50)
print(X_train['essay'].values[20000])
print("="*50)
```

```
Northeast Hamilton is more than a school, it's a family! Our family has been through some tough ti
mes the last several years. Our enrollment dwindled and our unique pre-k to 12th grade school beca
me just an elementary school. But our students are resilient, and our staff is dedicated! We are b
ecoming stronger as we redefine our image. Our goal is to help the students at NEH develop an inno
vative mindset ready to take ownership for their learning and change the world!Students today need
the time an space to be innovative. They deserve to have the tools to help them tinker and pursue
their passions. Author George Courous wrote in his book, The Innovator's Mindset, \"In a world whe
re new challenges constantly arise, students must be taught to think critically about what they ar
e facing. They must learn to collaborate with others to develop solutions for problems.\" I want t
o create a Magical Makerspace where all of the students in our school can wonder, explore, design,
create, and develop critical thinking skills. It will be a space where they can work together and
learn to be collaborative problem solvers. My dream is that this Magical MakerSpace is a place for
all students to uncover their talents and fall in love with learning!nannan
==================================================
My students need a variety of interesting fiction books to read and discuss in their reading book
clubs!\r\n\r\nGrade 3 is a huge year for students as readers! During this school year students are
expected not just to read text, but to analyze, infer, make predictions using text evidence, set g
oals as a reader and have conversations with their peers about the text. Students are expected to
read for an hour each day and that means a lot of reading!\r\n\r\nOur class loves reading books to
gether and discussing our favorite parts and interesting passages. My students are a diverse group
of third graders who come from a wide range of cultural, linguistic, and socioeconomic
backgrounds. They get so excited to get new books and share their thinking with their
peers.\r\n\r\n\r\n\r\nMy Project\r\n\r\nThis year will be an important year for our grade 3
readers! The more they read, the better readers they will be!\r\n\r\nWe want to ensure they have q
uality fiction books at their fingertips.\r\n\r\nThey will be reading the same great books as the
other students in their group and will be able to share their opinions, find interesting passages,
look for evidence in the text, identify with the characters and much more!\r\n\r\nThe goal is that
students develop a love of reading! We want to inspire students and make our book clubs a dynamic
part of our reading workshop.\r\n\r\nnannan
==================================================
My classroom community is wonderfully diverse, filled with excitement and brimming with curiosity.
Transitional Kindergarten students tend to be this way. Their experiences are varied (some coming
from years of preschool and others just stepping into a formal setting).  Their enthusiasm is cont
agious (how could you not smile seeing the love of learning on their faces) and they heads are fil
led with questions they desperately want answered.  My job is use the components of STEAM
(science, technology, engineering, art and mathematics) to facilitate expanding their knowledge, c
reate experiences that are exciting and memorable and foster creativity and imagination.Why do we
want Osmos? Osmo's groundbreaking system fosters social intelligence and creative thinking by open
ing up the iPad to the endless possibilities of physical play.  By using Osmo, I will be able to
expand and engage my students in mathematics, language arts, fine motor strengthening and coding.
Osmo does this by allowing students to use developmentally appropriate hands-on manipulatives to e
ngage and directly interact with the games on the ipad screens.  One of the best features is that
these games can be accessed by any level of student ability and keeps students motivated and chall
enged. These games will be played collaboratively, independently and in small groups allowing for
growth in both academics, as well as social and emotional development.nannan
==================================================
We begin our school day gathering on the carpet.  The carpet area in  our classroom is where we bu
ild a sense of community.  \r\nIt is a gathering spot in the  room where students share stories, r
esolve conflicts, review lessons, sing, dance and read.My prekindergarten students are very
curious and enthusiastic students! They enter my classroom each day excited and eager to
learn.\r\nThey are constantly asking questions, making discoveries, and trying to make sense of th
e world around them. My students attend a Title I school in a large urban district. All of the stu
dents at the school qualify for the Federal Free Lunch Program. The students are predominately Lat
ino and the majority of them are English Language Learners. Despite their disadvantaged
background, my students are enthusiastic children who enter my classroom every day ready to
learn.By having our own classroom vacuum, we will be able to maintain a healthy environment.  The
carpet is a high traffic area.  It is used throughout the day by 34 energetic preschoolers.  It is
not uncommon to see students' crumbs form lunch, dirt tracks from outdoor play time, and small pie
ces\r\nof art supplies on the carpet. It is difficult to sweep these items away with a broom.  A v
acuum would be awesome! With easy access to a vacuum, I will be able to vacuum the carpet as neede
d to help maintain a clean and safe environment.It is important for all children to have a clean a
nd inviting classroom environment.  The carpet area is a vital space in our preschool classroom.
By having a vacuum, I will be able to use it to keep the carpet area clean. It will help maintain
a positive learning environment for all students.
==================================================
As a teacher in a low income, poverty stricken neighborhood my students face many challenges both
in and out of the classroom. Despite the odds against them, my students are motivated individuals
with a passion for learning. Simply put, they just want to learn.  As a passionate teacher it is m
y top priority to see that they have access to educational resources, technology, and books! I wan
t my students to know that they have people on their side that care about their education.My 5th g
rade are great with video and computer games but it is one thing to know how to use these
technologies. It’s another, however, to understand the logic behind them. When learning to
program, kids understand the digital world they inhabit. Coding is the  “magic” of technology so t
hey can truly understand the logic and science that controls this technology. \r\nProgramming give
s children the ability to create technologies that impact those around them. These Dash and Dot ro
bots will enable my students to learn how to code and when kids learn to code, it will empower the
m to learn many other things and will open up many new opportunities for learning, the world is no
w in their hands. I saw a TED talk about coding and Scientist Mitch Resnick uses this beautiful an
alogy about coding, \"It's useful to make an analogy to reading and writing, when you learn to rea
d and write it opens up opportunities for you to learn so many other things, when you learn to
read you can then read to learn, which is the same thing with coding, if you learn to code you can
code to learn.\" \r\nI want to provide my students with these Dash and Dot robots so they can keep
up with the demands of the 21st century by learning this digital literacy.nannan
==================================================
```

In [27]:

```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 [28]:

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

```
As a teacher in a low income, poverty stricken neighborhood my students face many challenges both
in and out of the classroom. Despite the odds against them, my students are motivated individuals
with a passion for learning. Simply put, they just want to learn.  As a passionate teacher it is m
y top priority to see that they have access to educational resources, technology, and books! I wan
t my students to know that they have people on their side that care about their education.My 5th g
rade are great with video and computer games but it is one thing to know how to use these
technologies. It’s another, however, to understand the logic behind them. When learning to
program, kids understand the digital world they inhabit. Coding is the  “magic” of technology so t
hey can truly understand the logic and science that controls this technology. \r\nProgramming give
hey can truly understand the logic and science that controls this technology. \r\nProgramming give
s children the ability to create technologies that impact those around them. These Dash and Dot ro
bots will enable my students to learn how to code and when kids learn to code, it will empower the
m to learn many other things and will open up many new opportunities for learning, the world is no
w in their hands. I saw a TED talk about coding and Scientist Mitch Resnick uses this beautiful an
alogy about coding, \"It is useful to make an analogy to reading and writing, when you learn to re
ad and write it opens up opportunities for you to learn so many other things, when you learn to
read you can then read to learn, which is the same thing with coding, if you learn to code you can
code to learn.\" \r\nI want to provide my students with these Dash and Dot robots so they can keep
up with the demands of the 21st century by learning this digital literacy.nannan
==================================================
```

In [29]:

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

```
As a teacher in a low income, poverty stricken neighborhood my students face many challenges both
in and out of the classroom. Despite the odds against them, my students are motivated individuals
with a passion for learning. Simply put, they just want to learn.  As a passionate teacher it is m
y top priority to see that they have access to educational resources, technology, and books! I wan
t my students to know that they have people on their side that care about their education.My 5th g
rade are great with video and computer games but it is one thing to know how to use these
technologies. It’s another, however, to understand the logic behind them. When learning to
program, kids understand the digital world they inhabit. Coding is the  “magic” of technology so t
hey can truly understand the logic and science that controls this technology.   Programming gives
children the ability to create technologies that impact those around them. These Dash and Dot robo
ts will enable my students to learn how to code and when kids learn to code, it will empower them
to learn many other things and will open up many new opportunities for learning, the world is now
in their hands. I saw a TED talk about coding and Scientist Mitch Resnick uses this beautiful anal
ogy about coding,  It is useful to make an analogy to reading and writing, when you learn to read
and write it opens up opportunities for you to learn so many other things, when you learn to read
you can then read to learn, which is the same thing with coding, if you learn to code you can code
to learn.    I want to provide my students with these Dash and Dot robots so they can keep up with
the demands of the 21st century by learning this digital literacy.nannan
```

In [30]:

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

```
As a teacher in a low income poverty stricken neighborhood my students face many challenges both i
n and out of the classroom Despite the odds against them my students are motivated individuals wit
h a passion for learning Simply put they just want to learn As a passionate teacher it is my top p
riority to see that they have access to educational resources technology and books I want my stude
nts to know that they have people on their side that care about their education My 5th grade are g
reat with video and computer games but it is one thing to know how to use these technologies It s
another however to understand the logic behind them When learning to program kids understand the d
igital world they inhabit Coding is the magic of technology so they can truly understand the logic
and science that controls this technology Programming gives children the ability to create
technologies that impact those around them These Dash and Dot robots will enable my students to le
arn how to code and when kids learn to code it will empower them to learn many other things and wi
ll open up many new opportunities for learning the world is now in their hands I saw a TED talk ab
out coding and Scientist Mitch Resnick uses this beautiful analogy about coding It is useful to ma
ke an analogy to reading and writing when you learn to read and write it opens up opportunities
for you to learn so many other things when you learn to read you can then read to learn which is t
he same thing with coding if you learn to code you can code to learn I want to provide my students
with these Dash and Dot robots so they can keep up with the demands of the 21st century by learnin
g this digital literacy nannan
```

In [31]:

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

1.8.1 Preprocessesd training data - Text

In [32]:

```
# Combining all the above

from tqdm import tqdm
preprocessed_essays_train = []
# tqdm is for printing the status bar
for sentence in tqdm(X_train['essay'].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_train.append(sent.lower().strip())
```

```
100%|████████████████████████████████████| 22445/22445 [01:07<00:00, 333.52it/s]
```

In [33]:

```
# after preprocesing
preprocessed_essays_train[2000]
```

Out[33]:

```
'school located low socio economic area students always hard working eager learn backgrounds like
celebrate academic success encourage future opportunities leave memories learning fun teachers not
wait celebrate student achievements 5th grade graduation worked hard year made great progress able
give copy dr seuss book oh places go small token see future plan use 50 copies oh places go dr seu
ss graduation gift kids pass student book teachers school teachers write encouraging notes
memories students know idea not new many parents kids however many parents struggle not able affor
d books help able give experience kids may even take books move middle school high school done pro
ject past kids always end bringing books school next day share notes letters also plan keep projec
t secret great surprise kids open book nannan'
```

1.8.2 preprocessed test data

In [34]:

```
preprocessed_essays_test = []
# tqdm is for printing the status bar
for sentence in tqdm(X_test['essay'].values):
    sent = decontracted(sentence)
    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 [00:51<00:00, 317.31it/s]
```

In [35]:

```
# after preprocesing test data
preprocessed_essays_test[1000]
```

Out[35]:

```
'teach 2 way spanish dual immersion school wonderful class brilliant exploring minds take us
endless opportunities everyday students minds challenged english spanish enjoy languages songs
role play academics social interactions school culturally diverse share embrace cultures
traditions school community friendships build students become excited working playing two
languages goal guide students high academic achievement subject areas languages also support appre
ciation understanding cultures developing positive attitudes among students families communities s
tudents need easel painting supplies create explore daily bases make learning fun students learnin
g two languages everyday would wonderful express learning art subjects connected art want give stu
dents opportunity write sentences second language draw picture connecting writing give meaning wan
t students share creations want practice language artwork materials make difference students displ
ayed work gives joy pride nannan'
```

1.8.3 Preprocessed cross validation data

In [36]:

```
preprocessed_essays_cv = []
# tqdm is for printing the status bar
for sentence in tqdm(X_cv['essay'].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 [00:33<00:00, 331.85it/s]
```

In [37]:

```
# after preprocesing
preprocessed_essays_cv[2000]
```

Out[37]:

```
'teach computer science title school louisiana 100 percent students receive free breakfast lunch m
any students receive backpack food weekend despite many hardships students love anything
technology resources limited students living poverty also limited access technology school home no
t sufficient access technology deprives students necessary skills need succeed today workforce int
roducing coding robotics young learners challenge would like use cubelets robotics introduce presc
hool kindergarten first graders robotics kit contains 6 cubelets snapped together make endless var
iety robots no programming no wires anyone build robots drive around tabletop respond light
objects surprisingly lifelike behavior instead programming behavior snap cubelets together watch b
ehavior emerge like flock birds swarm bees cubelet tiny computer inside robot right put cubelets t
ogether actually making robot several smaller robots cubelet communicates neighbors know two block
s next talking charger included preschool stem kits not sold cubelets nannan'
```

1.9 preprocessing of project title

In [38]:

```
# printing some randomproject titles.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
```

```
Flexible Seating for Flexible Learning
==================================================
Elmo for Math Instruction
==================================================
Comfy Carpet for Creative Learning
==================================================
Wiggle, Waggle, Wobble: Hocus Focus!
==================================================
```

1.9.1 Preprocessing of Project Title(Train)

In [39]:

```
preprocessed_titles_train = []

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

```
100%|██████████████████████████████████| 22445/22445 [00:03<00:00, 6829.80it/s]
```

In [40]:

```
preprocessed_titles_train[1000]
```

Out[40]:

```
'technology hands play engaged learning for all'
```

1.9.2 Preprocessing of Project Title(Test)

In [41]:

```
preprocessed_titles_test = []

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

```
100%|██████████████████████████████████| 16500/16500 [00:02<00:00, 6327.01it/s]
```

In [ ]:

```
preprocessed_titles_test[1000]
```

```
preprocessed_titles_test[1000]
```

1.9.3 Preprocessing of Project Title(Cv)

In [42]:

```
preprocessed_titles_cv = []

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

```
100%|████████████████████████████████████████| 11055/11055 [00:01<00:00, 6650.91it/s]
```

In [43]:

```
preprocessed_titles_cv[600]
```

Out[43]:

```
'robotics programming middle schoolers'
```

1.10 Preparing data for models

In [44]:

```
project_data.columns
```

Out[44]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count', 'essay',
       'essay_word_count'],
      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 (optional)

- 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/

one hot vector for clean categories of Projects (train,test,cv)

In [45]:

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

from sklearn.feature_extraction.text import CountVectorizer

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

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

print(vectorizer.get_feature_names())

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

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix of Train data after one hot encoding  (22445, 9)
Shape of matrix of Test data after one hot encoding  (16500, 9)
Shape of matrix of CV data after one hot encoding  (11055, 9)
```

one hot vector for clean subcategories (train ,test,cv)

In [46]:

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

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

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


print(vectorizer.get_feature_names())

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

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix of Train data after one hot encoding  (22445, 30)
Shape of matrix of Test data after one hot encoding  (16500, 30)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 30)
```

One hot vector for school states(train,test,cv)

In [47]:

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

In [48]:

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

In [49]:

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

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

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

print(vectorizer.get_feature_names())

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

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'SD', 'NE', 'AK', 'DE', 'WV', 'ME', 'NM', 'HI', 'DC', 'KS', 'I
D', 'IA', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'NV', 'MD', 'TN', 'CT', 'AL', 'UT', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'MA', 'LA', 'WA', 'MO', 'IN', 'OH', 'PA', 'MI', 'GA', 'SC', 'IL', 'NC', 'FL', 'TX', 'NY
', 'CA']
Shape of matrix of Train data after one hot encoding  (22445, 51)
Shape of matrix of Test data after one hot encoding  (16500, 51)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 51)
```

abbreviations chart

one hot vector for Project grade category (train,test,cv)

In [50]:

```
my_counter = Counter()
for project_grade in preprocessed_project_grade_categories:
    my_counter.update(project_grade.split())
```

In [51]:

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

In [52]:

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

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

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

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",project_grade_categories_one_hot_train.shape)
```

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

```
['9_12', '6_8', '3_5', 'PreK_2']
Shape of matrix of Train data after one hot encoding  (22445, 4)
Shape of matrix of Test data after one hot encoding  (16500, 4)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 4)
```

One hot vector for teacher prefix(train,test,cv)

In [54]:

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

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

print("After vectorizations")
print("Shape of matrix of Train data after one hot
encoding",teacher_prefix_categories_one_hot_train.shape, y_train.shape)
print("Shape of matrix of cv data after one hot encoding",teacher_prefix_categories_one_hot_cv.sha
pe, y_cv.shape)
print("Shape of matrix of Test data after one hot encoding",teacher_prefix_categories_one_hot_test
.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
Shape of matrix of Train data after one hot encoding (22445, 5) (22445,)
Shape of matrix of cv data after one hot encoding (11055, 5) (11055,)
Shape of matrix of Test data after one hot encoding (16500, 5) (16500,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
===================================================================================================
```

1.11 Vectorizing Text data

(A) Bag of words

BOW (train essays)

In [55]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10,max_features=5000)  #selecting top 5000 features
vectorizer.fit(preprocessed_essays_train)

text_bow_train = vectorizer.transform(preprocessed_essays_train)

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

```
Shape of matrix after one hot encoding  (22445, 5000)
```

Bow (test data essays)

In [56]:

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

```
Shape of matrix after one hot encoding  (16500, 5000)
```

BOW Cv data essays

In [57]:

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

```
Shape of matrix after one hot encoding  (11055, 5000)
```

BOW train titles

In [58]:

```
vectorizer.fit(preprocessed_titles_train)
title_bow_train = vectorizer.transform(preprocessed_titles_train)
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1241)
```

BOW test titles

In [59]:

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

```
Shape of matrix after one hot encoding  (16500, 1241)
```

BOW cv titles

In [60]:

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

```
Shape of matrix after one hot encoding  (11055, 1241)
```

B) TFIDF vectorizer

tfidf train essays

In [62]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer(min_df=10,max_features=5000) #Considering top 5000 features
vectorizer.fit(preprocessed_essays_train)

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

```
Shape of matrix after one hot encoding  (22445, 5000)
```

tfidf test essays

In [63]:

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

```
Shape of matrix after one hot encoding  (16500, 5000)
```

tfidf cv essays

In [64]:

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

```
Shape of matrix after one hot encoding  (11055, 5000)
```

tfidf train titles

In [65]:

```
vectorizer = TfidfVectorizer(min_df=10)

vectorizer.fit(preprocessed_titles_train)
title_tfidf_train = vectorizer.transform(preprocessed_titles_train)
print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1241)
```

tfidf test titles

In [66]:

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

```
Shape of matrix after one hot encoding  (16500, 1241)
```

tfidf cv titles

In [67]:

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

```
Shape of matrix after one hot encoding  (11055, 1241)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [ ]:

```
''''# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039

 #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_train_essays = []

for i in preprocessed_essays_train :
    words_train_essays.extend(i.split(' '))

## Find the total number of words in the Train data of Essays.

print("all the words in the corpus", len(words_train_essays))


## Find the unique words in this set of words

words_train_essay = set(words_train_essays)
print("the unique words in the corpus", len(words_train_essay))

## Find the words present in both Glove Vectors as well as our corpus.

inter_words = set(model.keys()).intersection(words_train_essay)

print("The number of words that are present in both glove vectors and our corpus are {} which \
is nearly {}% ".format(len(inter_words),
np.round((float(len(inter_words))/len(words_train_essay))*100)))
```

In [ ]:

```
'''#words_corpus_train_essay = {}

words_glove = set(model.keys())

for i in words_train_essay:
    if i in words_glove:
        words_corpus_train_essay[i] = model[i]

print("word 2 vec length", len(words_corpus_train_essay))
```

In [ ]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
'''
import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_corpus_train_essay, f)
```

In [68]:

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

train essays

In [69]:

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

avg_w2v_vectors_train = [];

for sentence in tqdm(preprocessed_essays_train): # 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 [00:29<00:00, 760.25it/s]
```

```
22445
300
```

test essays

In [70]:

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

avg_w2v_vectors_test = [];

for sentence in tqdm(preprocessed_essays_test): # 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 [00:22<00:00, 717.76it/s]
```

```
16500
300
```

cv essays

In [71]:

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

avg_w2v_vectors_cv = [];

for sentence in tqdm(preprocessed_essays_cv): # 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 [00:15<00:00, 718.65it/s]
```

```
11055
300
```

train titles

```
In [72]:
```

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_train): # 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 [00:01<00:00, 13224.47it/s]
```

```
22445
300
```

test titles

```
In [73]:
```

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_test): # 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 [00:01<00:00, 13526.02it/s]
```

```
16500
300
```

cv titles

```
In [74]:
```

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_cv): # 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:
```

```
    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, 13826.20it/s]
```

```
11055
300
```

D) using Pretrained Models: TFIDF weighted W2V

train essays

In [75]:

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

In [76]:

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

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

```
100%|████████████████████████████████████| 22445/22445 [03:31<00:00, 106.30it/s]
```

```
22445
300
```

test essays

In [77]:

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

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

```
100%|████████████████████████████████████| 16500/16500 [02:39<00:00, 103.39it/s]
```

```
16500
300
```

Cv essays

In [78]:

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

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

```
100%|████████████████████████████████████| 11055/11055 [01:43<00:00, 107.11it/s]
```

```
11055
300
```

train titles

In [79]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_train)
# 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 [80]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_train = [];

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

print(len(tfidf_w2v_vectors_titles_train))
```

```
100%|███████████████████████████████████| 22445/22445 [00:03<00:00, 6802.86it/s]
```

```
22445
```

test titles

In [81]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_test = [];

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

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

```
100%|███████████████████████████████████| 16500/16500 [00:02<00:00, 5755.07it/s]
```

```
16500
300
```

cv titles

In [82]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_cv = [];

for sentence in tqdm(preprocessed_titles_cv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
```

```
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_cv.append(vector)

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

```
100%|██████████████████████████████████████████| 11055/11055 [00:01<00:00, 6887.25it/s]
```

```
11055
300
```

1.12 Vectorizing Numerical features

Various numerical feautures are :

1.Price

2.Quantity

3.Number of Projects previously proposed by Teacher

4.Title word Count (introduced by us)

5.Essay word Count (introduced by us)

1) Price

In [83]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in
-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(4)
```

Out[83]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21
2	p000003	298.97	4
3	p000004	1113.69	98

In [84]:

```
# 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 [85]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()

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

normalizer.fit(X_train['price'].values.reshape(-1,1))
```

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

print("After vectorizations")
print(price_train.shape, y_train.shape)
print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
print("="*100)
```

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

2) Quantity

In [86]:

```
normalizer = Normalizer()

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

normalizer.fit(X_train['quantity'].values.reshape(-1,1))

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

print("After vectorizations")
print(quantity_train.shape, y_train.shape)
print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
print("="*100)
```

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

3) Number of Projects previously proposed by Teacher

In [87]:

```
normalizer = Normalizer()

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

normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_posted_projects']
.values.reshape(-1,1))
prev_projects_cv =
normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].v
alues.reshape(-1,1))
```

```
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)
print("="*100)
```

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

4) Title word count

In [88]:

```
normalizer = Normalizer()

normalizer.fit(X_train['title_word_count'].values.reshape(-1,1))

title_word_count_train = normalizer.transform(X_train['title_word_count'].values.reshape(-1,1))
title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape(-1,1))

print("After vectorizations")
print(title_word_count_train.shape, y_train.shape)
print(title_word_count_cv.shape, y_cv.shape)
print(title_word_count_test.shape, y_test.shape)
print("="*100)
```

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

5) essay word count

In [89]:

```
normalizer = Normalizer()

normalizer.fit(X_train['essay_word_count'].values.reshape(-1,1))

essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.reshape(-1,1))
essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape(-1,1))

print("After vectorizations")
print(essay_word_count_train.shape, y_train.shape)
print(essay_word_count_cv.shape, y_cv.shape)
print(essay_word_count_test.shape, y_test.shape)
```

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

Assignment 3: Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**

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

- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning to find best K**

   - Find the best hyper parameter which results in the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation (or) simple cross validation data
   - Use gridsearch-cv or randomsearch-cv or 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, as shown in the figure
   - Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

4. **[Task-2]**

   - Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features

     -
       ```
       from sklearn.datasets import load_digits
       from sklearn.feature_selection import SelectKBest, chi2
       X, y = load_digits(return_X_y=True)
       X.shape
       X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
       X_new.shape
       ========
       output:
       (1797, 64)
       (1797, 20)
       ```

   - Repeat the steps 2 and 3 on the data matrix after feature selection

5. **Conclusion**

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

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-leakag, 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.

K Nearest Neighbor

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

In [90]:

```
# Code snippet taken from here: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, title_bow_train, text_bow_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
```

```
title_word_count_test, essay_word_count_test, title_bow_test, text_bow_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, title_bow_cv, text_bow_cv)).tocsr()
```

In [91]:

```
print("Final Data matrix")    #Printing shape of all 3 matrices
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, 6345) (22445,)
(11055, 6345) (11055,)
(16500, 6345) (16500,)
====================================================================================================
```

A) Find the best hyper parameter which results in the maximum AUC value

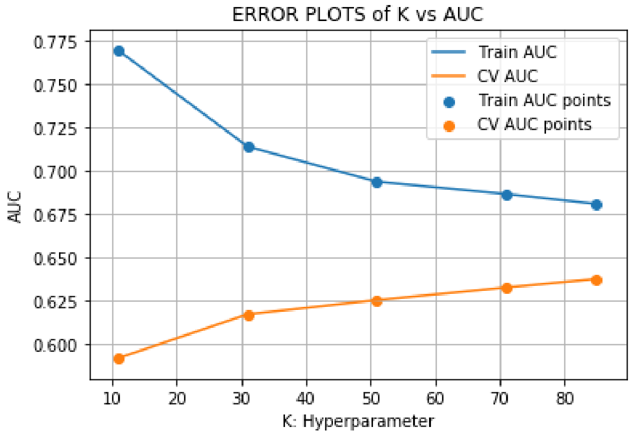
In [92]:

```
def batch_predict(clf, data):
    # In case of roc_auc_score(y_true, y_score) the y_score should be probability estimates of the
positive class
    # not the predicted outputs for the positive class

    #Predicting outputs in batches

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

    return y_data_pred
```

In [93]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

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

K = [ 11, 31, 51, 71,85]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cr)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    a.append(y_train_pred)
    b.append(y_cv_pred)

plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("K: Hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS of K vs AUC")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 5/5 [19:24<00:00, 220.93s/it]
```



The hyperparameter K from the given graph can be inferred to be 85

B) Gridsearch cv

- In the gridlayout each values are applied to find right hyperparameter
- Whereas in random search method any random value is tried to find right hyperparameter,certainly quicker
- But doesnt gaurantee optimal solution

In [94]:

```
# Code snippet taken from https://scikit-
learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV

neigh = KNeighborsClassifier()

parameters = {'n_neighbors':[11,31,51, 71, 85]}

#return_train_score needs to be set True

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

clf.fit(X_tr, y_train)
```

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

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

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

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


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
```

```
Fitting 2 folds for each of 5 candidates, totalling 10 fits
```

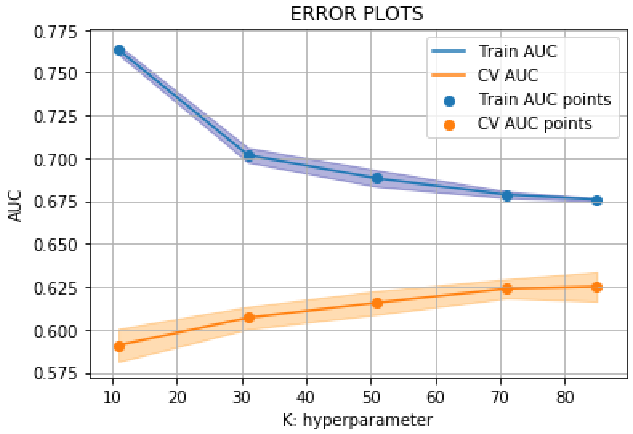
```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  44.1s
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:  1.4min remaining:    0.0s
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  41.5s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  41.1s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  40.9s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  41.4s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  41.9s
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total=  41.4s
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total=  43.8s
[CV] n_neighbors=85 ..................................................
[CV] ................................... n_neighbors=85, total=  43.0s
[CV] n_neighbors=85 ..................................................
[CV] ................................... n_neighbors=85, total=  47.5s
```

```
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed: 14.1min finished
```



In [95]:

```
best_k_set1 = 85   #Using plot we can deduce that it is roughly best k (Not much improvement after
k=80)
print("The best k found for set 1 is ",best_k_set1)
```

```
The best k found for set 1 is  85
```

In [96]:

```
from IPython.display import HTML
import pandas as pd
import numpy as np

def create_download_link(title = "Download the file", filename = "data.csv"):
    html = '<a href={filename}>{title}</a>'
    html = html.format(title=title,filename=filename)
    return HTML(html)

# create a link to download the dataframe which was saved with .to_csv method
#create_download_link(filename='submission.csv')
```

In [97]:

```
with open('knn1.pkl', 'wb') as f:
    pickle.dump(clf, f)
create_download_link(filename='knn1.pkl')        #creating a file for set1 to avoid training model
again n again
```

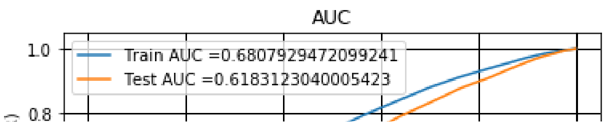
Out[97]:

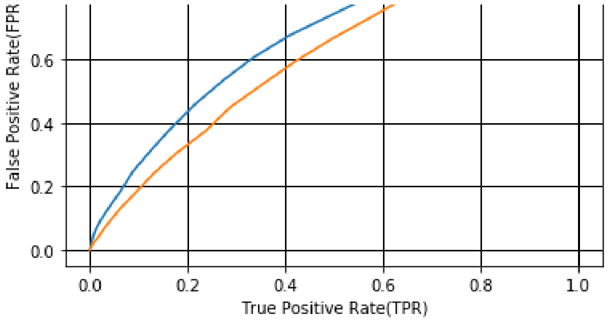
Download the file

C) Training model using the best hyperparameter found by our analysis

In [98]:

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


neigh = KNeighborsClassifier(n_neighbors=best_k_set1)
neigh.fit(X_tr, y_train)

#  In case of roc_auc_score(y_true, y_score) y_score should be probability estimates of the positi
ve class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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(color='black', linestyle='-', linewidth=1)
plt.show()
```





We observe that set1/Model1 gives Test AUC of 0.618 while train AUC of 0.680

D) Plotting Confusion Matrix

In [99]:

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

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

    # (tpr*(1-fpr)) if we need to maximize this value tpr should be high but fpr should be low

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

Train data

In [100]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")# Printing size of confusion matrix for train data
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) 0.24986989643163918 for threshold 0.776
[[ 1771  1692]
 [ 5027 13955]]
```

In [101]:

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

```
the maximum value of tpr*(1-fpr) 0.24986989643163918 for threshold 0.776
```

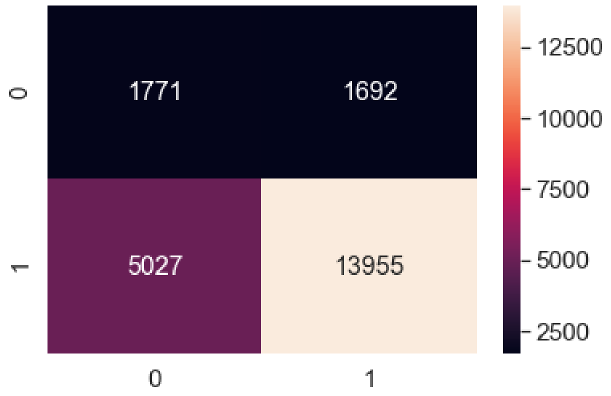
In [102]:

```
sns.set(font_scale=1.4)#for label size,using annot=true numbers are displayed in corrosponding
cells
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g') #fmt='g' implies genera
l format
# Reference taken from here : https://fmt.dev/latest/syntax.html
```

Out[102]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1487721c20>
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x1487721a20>
```



summary of confusion matrix for train data for set1

- set1 predicted positive class 15,667 times(1692 + 13955) ,of which it was correct 13955 times
- it predicted negative class 6778 times(1771 + 5027),out of which it was correct 1771 times,It failed to predict false negative cases

test data

In [103]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24997778503192472 for threshold 0.788
[[1285 1261]
 [4683 9271]]
```

In [104]:

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

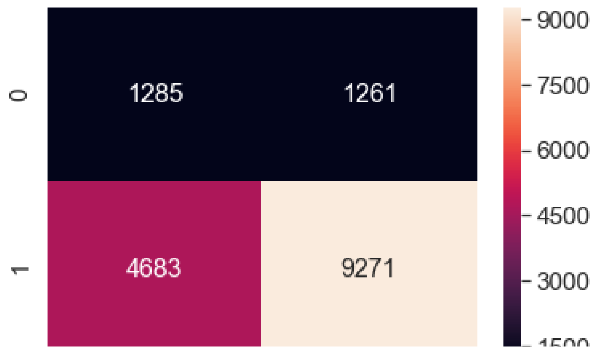
```
the maximum value of tpr*(1-fpr) 0.24997778503192472 for threshold 0.788
```

In [105]:

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

Out[105]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14966f54a8>
```



Summary for test data for set 1

- set2 predicted positive class for 10532 datapoints(1261 + 9271) ,out of which it was correct 9271 times.
- It predicted negative class for 5968 datapoints(1285 +4683) ,out of which only 1285 were correct.
- Again a large number of false negatives.

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

In [106]:

```
# Reference taken from here how to merge two sparse matrices using csr(): 
https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, 
school_state_categories_one_hot_train, project_grade_categories_one_hot_train, 
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, text_tfidf_train, title_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, 
school_state_categories_one_hot_test, project_grade_categories_one_hot_test, 
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test, 
title_word_count_test, essay_word_count_test, text_tfidf_test, title_tfidf_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, 
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv, 
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv, 
essay_word_count_cv, text_tfidf_cv, title_tfidf_cv)).tocsr()
```

In [107]:

```
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, 6345) (22445,)
(11055, 6345) (11055,)
(16500, 6345) (16500,)
====================================================================================================
```

A)Finding the best hyperparameter which has maximum AUC value

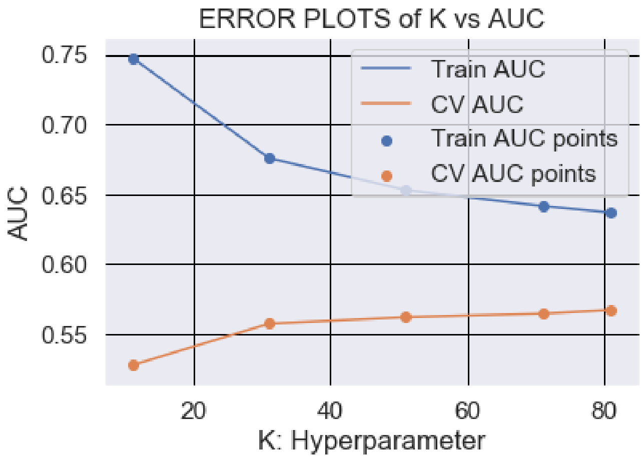
In [108]:

```
train_auc = []
cv_auc = []
K = [11,31,51,71,81]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cr)

    # In roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
100%|██████████████████████████████████████████████| 5/5 [23:13<00:00, 277.27s/it]
```

In [109]:

```
# references taken for gridlines
https://matplotlib.org/3.1.0/api/_as_gen/matplotlib.pyplot.grid.html

plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("K: Hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS of K vs AUC")
plt.grid(color='black', linestyle='-', linewidth=1)
```



B) Using Gridsearch-cv

In [110]:

```
neigh = KNeighborsClassifier()
parameters = {'n_neighbors':[ 11, 31, 51, 71, 81]}
clf = GridSearchCV(neigh, parameters, cv=2, scoring='roc_auc',return_train_score=True,verbose=2)
clf.fit(X_tr, y_train)

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

```
Fitting 2 folds for each of 5 candidates, totalling 10 fits
```

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

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  43.7s
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:  1.4min remaining:    0.0s
```

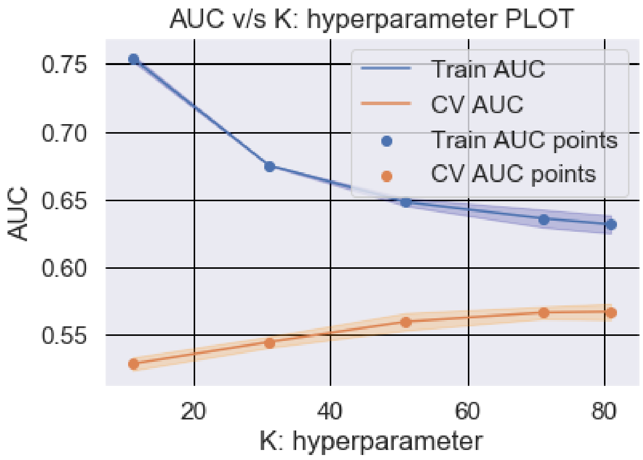
```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  42.0s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  41.4s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  41.4s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  41.9s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  41.8s
[CV] n_neighbors=71
```

```
[CV] n_neighbors=71 ....................................................
[CV] .................................... n_neighbors=71, total=  42.1s
[CV] n_neighbors=71 ....................................................
[CV] .................................... n_neighbors=71, total=  42.4s
[CV] n_neighbors=81 ....................................................
[CV] .................................... n_neighbors=81, total=  41.8s
[CV] n_neighbors=81 ....................................................
[CV] .................................... n_neighbors=81, total=  43.5s
```

```
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed: 14.0min finished
```

In [111]:

```
plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,
color='darkorange')

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


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter PLOT")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```



In [112]:

```
with open('knn2.pkl', 'wb') as f:
    pickle.dump(clf, f)
create_download_link(filename='knn2.pkl')
```

Out[112]:

Download the file

In [113]:

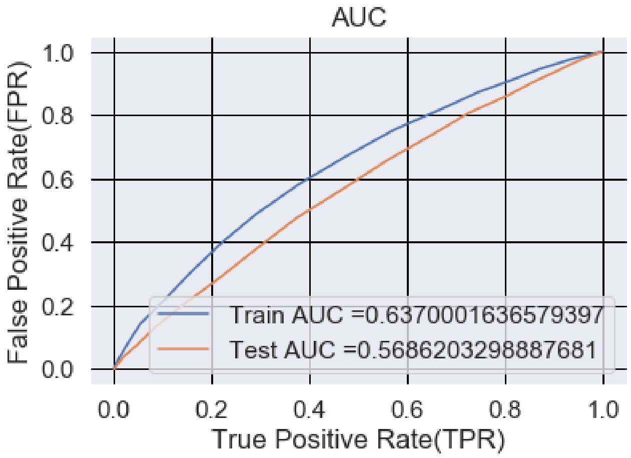
```
best_k_set2 = 81 #from plot we conclude
print("The best k found for set 2 is ",best_k_set2)
```

```
The best k found for set 2 is  81
```

C) Training model using best hyperparameter found in our analysis for set 2

In [114]:

```
neigh = KNeighborsClassifier(n_neighbors=best_k_set2)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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(color='black', linestyle='-', linewidth=1)
plt.show()
```



We observe that for set 2 we obtain a train AUC of 0.64 and test AUC of 0.576

D) Plotting confusion matrix

Train data

In [115]:

```
print("="*100)
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) 0.24947297735751794 for threshold 0.84
[[ 1811  1652]
 [ 6229 12753]]
```

In [116]:

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

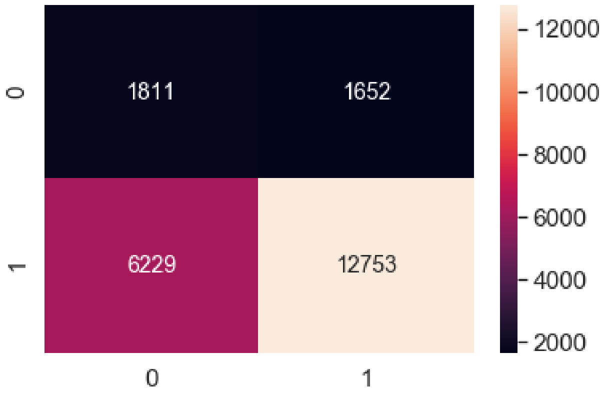
```
the maximum value of tpr*(1-fpr) 0.24947297735751794 for threshold 0.84
```

In [117]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 14}, fmt='g')
```

Out[117]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x149669f198>
```



Summary for confusion matrix for set 2 train data

- We observe that set2 makes a positive prediction for training data 14249 times(12753 + 1652),it is correct 12,753 times,roughly 88% times
- It makes a negative prediction 8040 times (1811 + 6229) ,it is correct only small number of times roughly 22% times
- Again has alot of false negatives

Test data

In [118]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24917789191060447 for threshold 0.852
[[1346 1200]
 [6008 7946]]
```

In [119]:

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

```
the maximum value of tpr*(1-fpr) 0.24917789191060447 for threshold 0.852
```

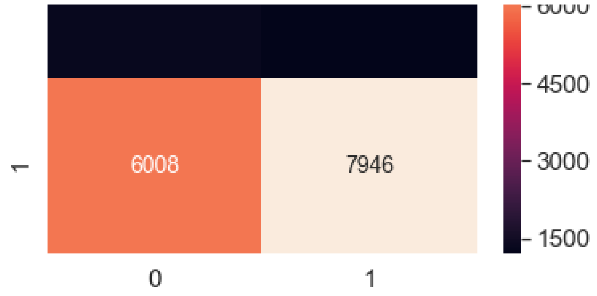
In [120]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 14}, fmt='g')
```

Out[120]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14978c3978>
```

1346
1200
0
7500
6000



Summary of confusion matrix for set 2 test data

- set2 makes predicts positive class 9146 times, out of which it is correct 7946 times,roughly 89% times
- it predicts negative class 7354 times (1346 + 6008) ,out of which it is correct 1346 times,roughly 18.5% times

Set 3 : categorical, numerical features + project_title(AVG W2V) + preprocessed_essay (AVG W2V

In [121]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, avg_w2v_vectors_train,
avg_w2v_vectors_titles_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, avg_w2v_vectors_test, avg_w2v_vectors_titles_test)).
tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, avg_w2v_vectors_cv, avg_w2v_vectors_titles_cv)).tocsr()
```

In [122]:

```
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)
```

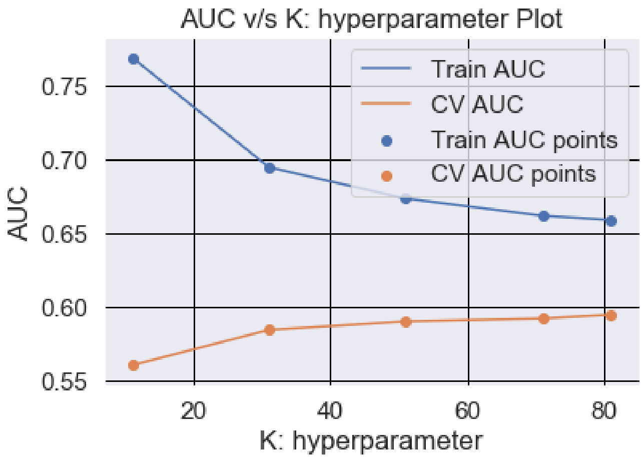
```
Final Data matrix
(22445, 704) (22445,)
(11055, 704) (11055,)
(16500, 704) (16500,)
====================================================================================================
```

A) Finding the best hyperparameter k which gives the maximum AUC

In [123]:

```
train_auc = []
cv_auc = []

K = [ 11,31, 51,71,81]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cr)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
100%|████████████████████████████████████████| 5/5 [3:34:14<00:00, 2721.74s/it]
```



B) Gridsearch -cv

In [124]:

```
# code snippet taken from here https://scikit-
learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html

neigh = KNeighborsClassifier()
parameters = {'n_neighbors':[ 11, 31, 51, 71, 81]}
clf = GridSearchCV(neigh, parameters, cv=2, scoring='roc_auc',return_train_score=True,verbose=2)
clf.fit(X_tr, y_train)

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

plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
# this code snippet taken from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,
color='darkorange')

plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot - using GridSearchcv")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
Fitting 2 folds for each of 5 candidates, totalling 10 fits
```

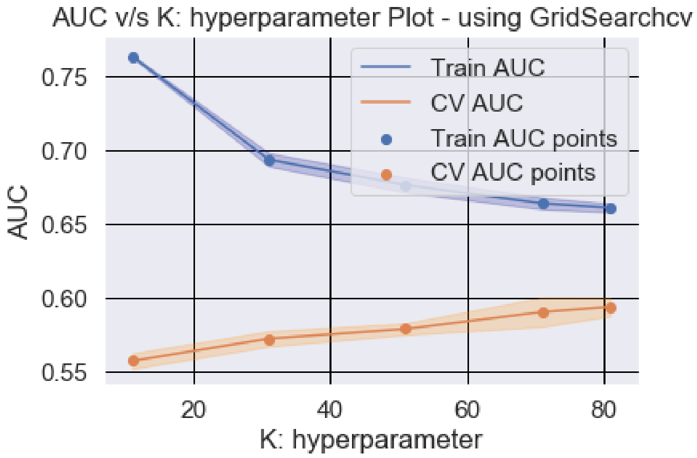
```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total= 9.0min
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed: 17.8min remaining:    0.0s
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total= 8.9min
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total= 9.6min
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total= 9.6min
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total= 9.2min
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total= 9.6min
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total= 8.7min
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total= 9.2min
[CV] n_neighbors=81 ..................................................
[CV] ................................... n_neighbors=81, total= 8.6min
[CV] n_neighbors=81 ..................................................
[CV] ................................... n_neighbors=81, total= 9.1min
```

```
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed: 183.1min finished
```



In [125]:

```
with open('knn3.pkl', 'wb') as f:
    pickle.dump(clf, f)
create_download_link(filename='knn3.pkl')
```

Out[125]:

Download the file

In [126]:

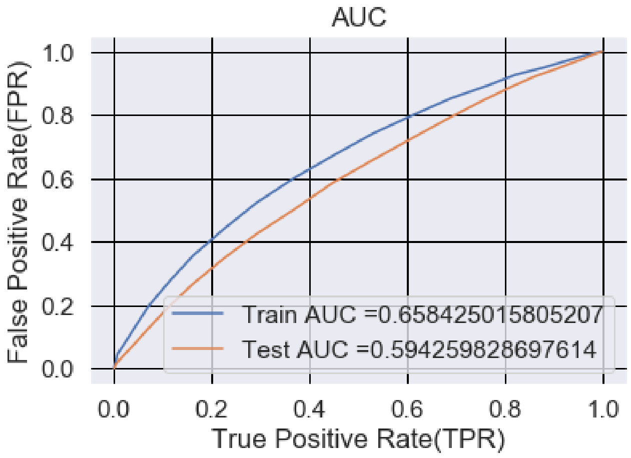
```
best_k_set3 = 81
print("The best k found for set 3 is ",best_k_set3)
```

```
The best k found for set 3 is  81
```

C) train the model using the best hyperparameter we found in our analysis

In [127]:

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

neigh = KNeighborsClassifier(n_neighbors=best_k_set3)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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(color='black', linestyle='-', linewidth=1)
plt.show()
```



D) Plotting confusion Matrix

Train data

In [128]:

```
print("="*100)
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) 0.24901835492220095 for threshold 0.827
[[ 1623  1840]
 [ 4896 14086]]
```

In [129]:

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

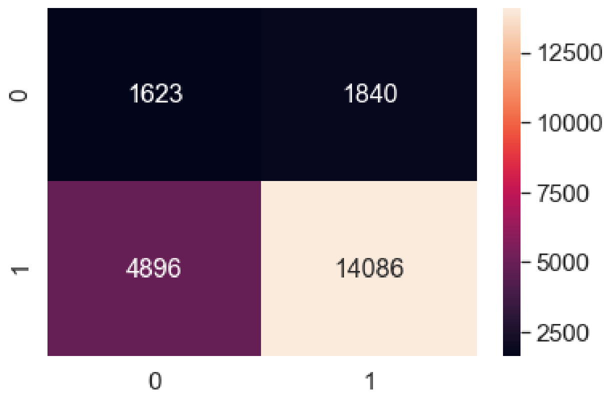
```
the maximum value of tpr*(1-fpr) 0.24901835492220095 for threshold 0.827
```

In [130]:

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

Out[130]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14978d3c50>
```



Summary of model 3 for train data

- Set 3 predicts positive class label in 21926 cases(1840 + 14086),out of which it is right 88% times
- It predicts negative label in 6519 cases (1623 + 4896),out of which it is right 25% times

test data

In [131]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24903719711279465 for threshold 0.84
[[1194 1352]
 [4761 9193]]
```

In [132]:

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

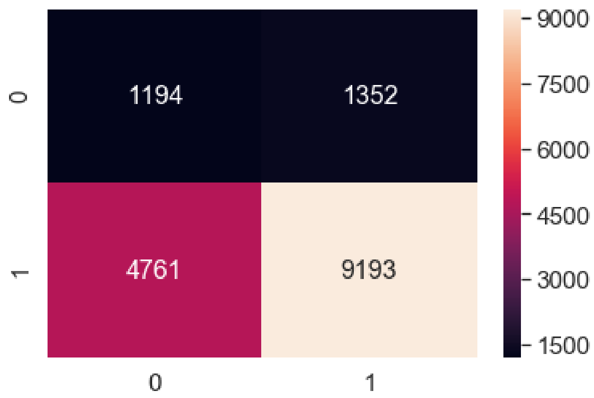
```
the maximum value of tpr*(1-fpr) 0.24903719711279465 for threshold 0.84
```

In [133]:

```
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[133]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x148772ad68>
```



Summary of the heat map of test data

- According to confusion matrix,model predicts positive class 10645 times(9193 + 1352),out of which it is right in 87% cases
- Model Predicts negative class 5955 times (1194 + 4761),out of which it is correct 20% times,false negatives are alot in mumber(4761)

Set 4 : categorical, numerical features + project_title(TFIDF W2V) + preprocessed_essay (TFIDF W2V)

In [134]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, tfidf_w2v_vectors_train, tfidf_w2v_vectors_titles_train)).
tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, tfidf_w2v_vectors_test,
tfidf_w2v_vectors_titles_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, tfidf_w2v_vectors_cv, tfidf_w2v_vectors_titles_cv)).tocsr()
```

In [135]:

```
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, 704) (22445,)
(11055, 704) (11055,)
(16500, 704) (16500,)
====================================================================================================
```

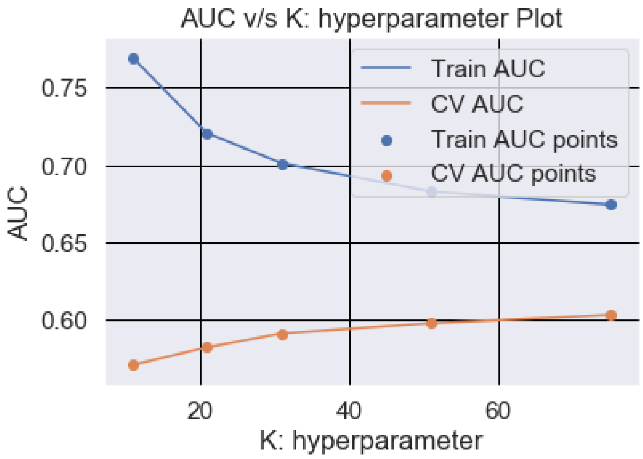
A) finding the best hyperparameter which gives the maximum AUC

In [136]:

```
train_auc = []
cv_auc = []
```

```
K = [11,21, 31, 51,75]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cr)
    #In case of roc_auc_score(y_true, y_score) y_score should be prob estimatate
    #of positive labelled class and not the predicted output
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
100%|████████████████████████████████████████| 5/5 [5:55:33<00:00, 4212.59s/it]
```



B) Gridsearch -cv

In [137]:

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

neigh = KNeighborsClassifier()
parameters = {'n_neighbors':[11,21,31,51,75]}
clf = GridSearchCV(neigh, parameters, cv=2, scoring='roc_auc',return_train_score=True,verbose=2)
clf.fit(X_tr, y_train)

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

plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,
color='darkorange')
```

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


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot - using GridSearchcv")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
Fitting 2 folds for each of 5 candidates, totalling 10 fits
```

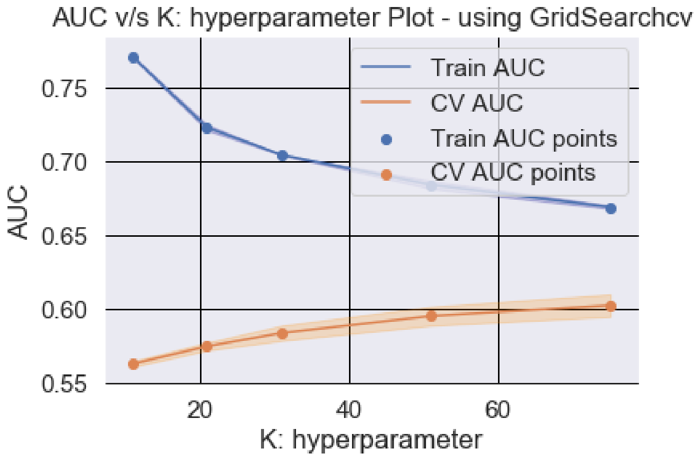
```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=11.5min
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed: 22.7min remaining:    0.0s
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=10.7min
[CV] n_neighbors=21 ..................................................
[CV] ................................... n_neighbors=21, total=11.2min
[CV] n_neighbors=21 ..................................................
[CV] ................................... n_neighbors=21, total=11.5min
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=11.0min
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=11.2min
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total= 9.1min
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total= 9.2min
[CV] n_neighbors=75 ..................................................
[CV] ................................... n_neighbors=75, total= 8.9min
[CV] n_neighbors=75 ..................................................
[CV] ................................... n_neighbors=75, total= 8.9min
```

```
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed: 205.5min finished
```



In [138]:

```
with open('knn4.pkl', 'wb') as f:
    pickle.dump(clf, f)
create_download_link(filename='knn4.pkl')
```

Out[138]:

Download the file

In [139]:

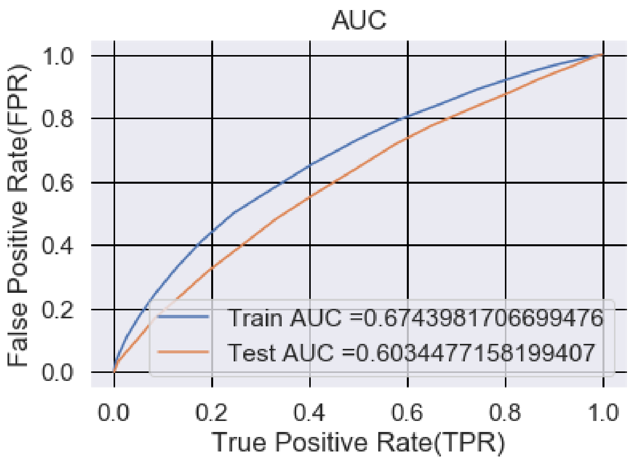
```
best_k_set4 = 75
print("The best k found for set 4 is" ,best_k_set4)
```

```
The best k found for set 4 is 75
```

Training model using best hyperparameter value we got in our analysis

In [140]:

```
#  code snippet taken from https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

neigh = KNeighborsClassifier(n_neighbors=best_k_set4)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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(color='black', linestyle='-', linewidth=1)
plt.show()
```



Plotting the confusion matrix

train data

In [141]:

```
print("="*100)
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) 0.24999397533548212 for threshold 0.827
[[ 1740  1723]
 [ 5108 128741]]
 [ 5108 13874]]
```

In [142]:

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

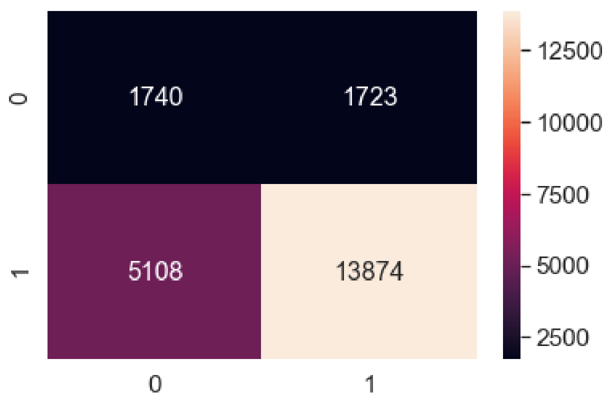
```
the maximum value of tpr*(1-fpr) 0.24999397533548212 for threshold 0.827
```

In [143]:

```
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[143]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1498e37a58>
```



summary about train data

13874 are true positives while 5108 are false negatives

test data

In [144]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24997392826663395 for threshold 0.84
[[1286 1260]
 [5028 8926]]
```

In [145]:

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

```
the maximum value of tpr*(1-fpr) 0.24997392826663395 for threshold 0.84
```

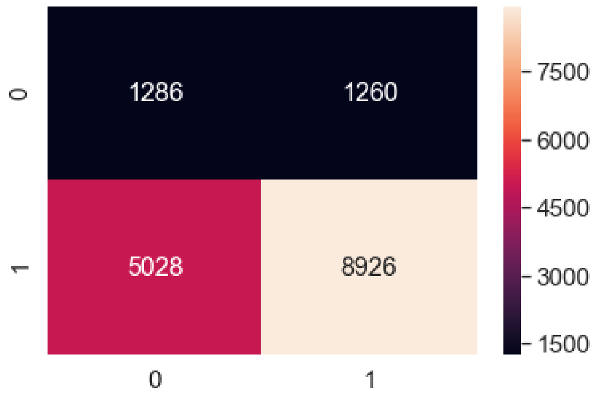
In [146]:

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

Out[146]:

Out[146]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14977bd2b0>
```



Summary

- 8926 are true positives while 5028 are false negatives

2.5 Feature selection with `SelectKBest`

In [156]:

```
X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, text_tfidf_train, title_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, text_tfidf_test, title_tfidf_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, text_tfidf_cv, title_tfidf_cv)).tocsr()
```

In [157]:

```
from sklearn.feature_selection import SelectKBest, chi2

sel=SelectKBest(chi2,k=2000).fit(X_tr,y_train)      # modifications done here
X_tr_new1=sel.transform(X_tr)
X_te_new1=sel.transform(X_te)
X_cr_new1=sel.transform(X_cr)
```

In [159]:

```
print("Final Data matrix")
print(X_tr_new1.shape, y_train.shape)
print(X_cr_new1.shape, y_cv.shape)
print(X_te_new1.shape, y_test.shape)
print("="*100)
```

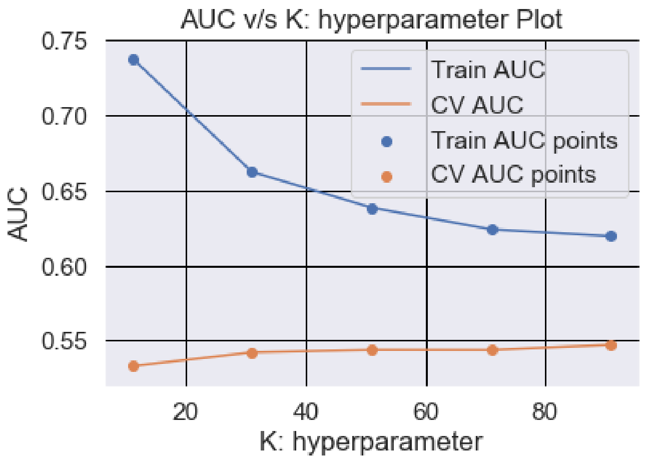
```
Final Data matrix
(22445, 2000) (22445,)
(11055, 2000) (11055,)
(16500, 2000) (16500,)
====================================================================================================
```

A) Finding best hyperparameter using best 2000 features on set2

In [161]:

```
train_auc = []
cv_auc = []

K = [11, 31,51 ,71,91]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_new, y_train)

    y_train_pred = batch_predict(neigh, X_tr_new1)
    y_cv_pred = batch_predict(neigh, X_cr_new1)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))







plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
  0%|                                                     | 0/5 [00:00<?, ?it/s]
 20%|█████████                                   | 1/5 [02:57<11:50, 177.55s/it]
 40%|█████████████████                           | 2/5 [05:56<08:53, 177.94s/it]
 60%|██████████████████████████                  | 3/5 [08:54<05:55, 177.84s/it]
 80%|███████████████████████████████████         | 4/5 [11:50<02:57, 177.41s/it]
100%|████████████████████████████████████████████| 5/5 [14:48<00:00, 177.56s/it]
```



B) gridsearch -cv

In [162]:

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

neigh = KNeighborsClassifier()
```

```
parameters = {'n_neighbors':[ 11, 31, 51, 71, 91]}

#return_train_score has default value has False,need to change it to True.
# verbose=2 to display progress and see messages while processing.

clf = GridSearchCV(neigh, parameters, cv=2, scoring='roc_auc',return_train_score=True,verbose=2)
clf.fit(X_tr_new1, y_train)

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

plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code snippet is taken from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,
color='darkorange')

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


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot - GridsearchCV")
plt.grid(color='black', linestyle='-', linewidth=1)
plt.show()
```

```
Fitting 2 folds for each of 5 candidates, totalling 10 fits
```

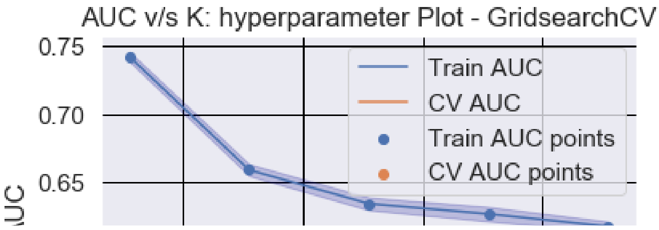
```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

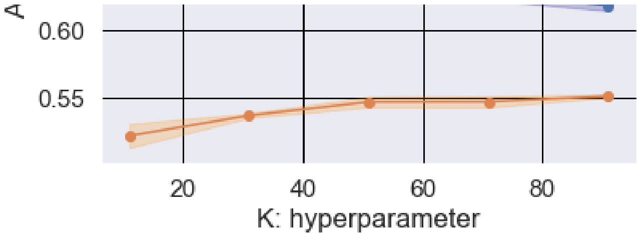
```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  27.7s
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   55.5s remaining:    0.0s
```

```
[CV] n_neighbors=11 ..................................................
[CV] ................................... n_neighbors=11, total=  27.4s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  26.5s
[CV] n_neighbors=31 ..................................................
[CV] ................................... n_neighbors=31, total=  27.7s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  28.5s
[CV] n_neighbors=51 ..................................................
[CV] ................................... n_neighbors=51, total=  27.7s
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total=  27.9s
[CV] n_neighbors=71 ..................................................
[CV] ................................... n_neighbors=71, total=  27.9s
[CV] n_neighbors=91 ..................................................
[CV] ................................... n_neighbors=91, total=  28.8s
[CV] n_neighbors=91 ..................................................
[CV] ................................... n_neighbors=91, total=  27.2s
```

```
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:  9.3min finished
```





In [163]:

```
with open('knn5.pkl', 'wb') as f:
    pickle.dump(clf, f)
create_download_link(filename='knn5.pkl')
```

Out[163]:

Download the file

In [164]:

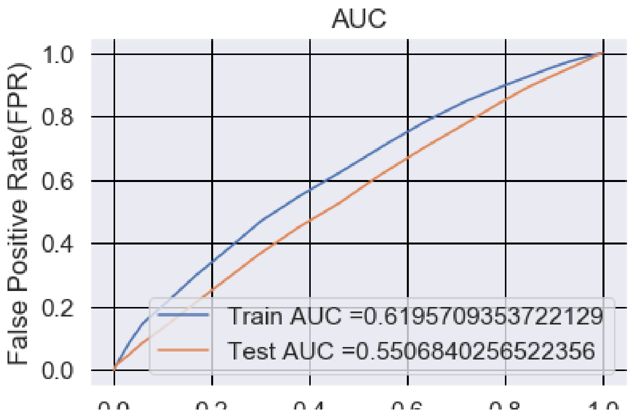
```
best_k_set5 =91
#best k found using grid search cv when using 2000 features on set2 using tfidf
print("The best k found using 2000 features on set2 is ",best_k_set5)
```

```
The best k found using 2000 features on set2 is  91
```

C) training model using best hyperparameter we found in our analysis

In [165]:

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

neigh = KNeighborsClassifier(n_neighbors=best_k_set5)
neigh.fit(X_tr_new1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr_new1)
y_test_pred = batch_predict(neigh, X_te_new1)

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(color='black', linestyle='-', linewidth=1)
plt.show()
```



D) plotting Confusion Matrix

train data

In [166]:

```
print("="*100)
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) 0.24912392205409958 for threshold 0.835
[[ 1834  1629]
 [ 7013 11969]]
```

In [167]:

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

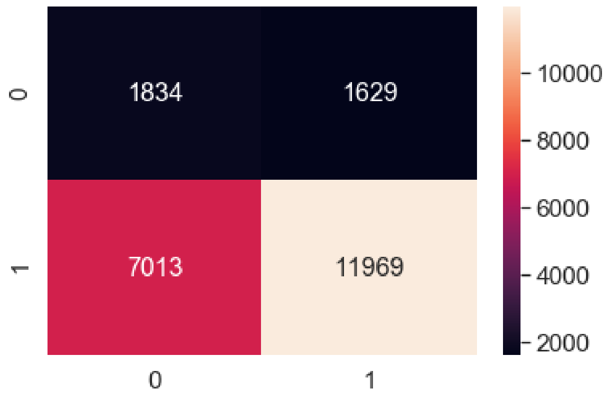
```
the maximum value of tpr*(1-fpr) 0.24912392205409958 for threshold 0.835
```

In [168]:

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

Out[168]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14977c3c88>
```



Summary for train data

- It predicts positive class 13598 times,out of which it is correct in 11969 cases,about 87% times
- It predicts negative class in 8847 times ,with large fraction as false negatives

test data

In [169]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2486657134799809 for threshold 0.846
[[1366 1180]
 [6579 7375]]
```

In [170]:

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

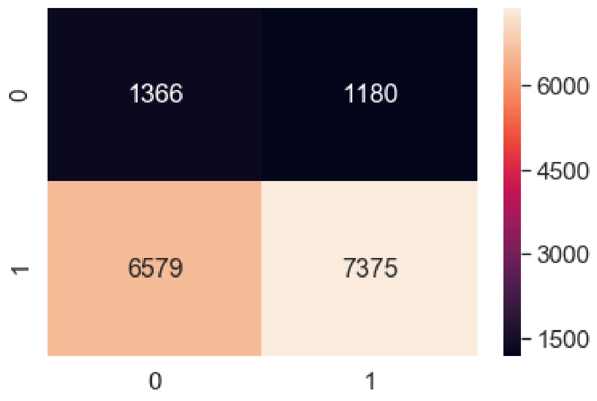
```
the maximum value of tpr*(1-fpr) 0.2486657134799809 for threshold 0.846
```

In [171]:

```
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[171]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14966b9908>
```



Sumary about model 5 test data confusion matrix

- It predicts positive classes about 7375 + 1180 times ,of which it is correct 7375 times

3. Conclusions

In [174]:

```
#Compare all your models using Prettytable library


from prettytable import PrettyTable



x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyper Parameter", "AUC"]

x.add_row(["BOW", "Brute",91 , 0.618])
x.add_row(["TFIDF", "Brute", 81, 0.566])
x.add_row(["AVG W2V", "Brute", 81, 0.594])
x.add_row(["TFIDF W2V", "Brute", 75, 0.603])
x.add_row(["TFIDF", "Top 2000", 91, 0.550])

print(x)
```

```
+------------+----------+-----------------+-------+
| Vectorizer |  Model   | Hyper Parameter |  AUC  |
| Vectorizer |  Model   | Hyper Parameter |  AUC  |
+------------+----------+-----------------+-------+
|    BOW     |  Brute   |        91       | 0.618 |
|   TFIDF    |  Brute   |        81       | 0.566 |
|  AVG W2V   |  Brute   |        81       | 0.594 |
| TFIDF W2V  |  Brute   |        75       | 0.603 |
|   TFIDF    | Top 2000 |        91       |  0.55 |
+------------+----------+-----------------+-------+
```

Summary about all models

1. As per analysis using K=91 with vectorizer as BOW has highest AUC followed by TFIDF W2V (K=75) with Auc of 0.603
2. Using tfidf with only 2000 features gives us least AUC among all models so going by such small features does not solve our problem

difference between fit(),transform(),fit_transform()

- To center the data (make it have zero mean and unit standard error), you subtract the mean and then divide the result by the standard deviation.
- fit() just calculates the parameters (e.g. mu and sigma in case of StandardScaler) and saves them as an internal objects state. Afterwards, you can call its transform() method to apply the transformation to a particular set of examples
  - for egs fit() function happens only on training data while transform () involves changing the values by keeping mu and sigma in calculation x'= ((x-mu)/sigma))
  - Using fix_transform(), we join these two steps and is used for the initial fitting of parameters on the training set x, but it also returns a transformed x′. Internally, it just calls first fit() and then transform() on the same data.

- generally fit_transform() should be applied on train data,and not on cv and test data,once fit has been done then we can use transform () on cv and test data

In [ ]: