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.

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

Out[4]:

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

id description quantity price

In [5]:

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


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


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


project_data.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	

In [6]:

```
project_grade_category = []

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

In [7]:

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

Out[7]:

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

In [8]:

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

In [9]:

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

In [10]:

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

Out[10]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_subject_categories	proje
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Math & Science	App

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_subject_categories	proje
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Special Needs	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Literacy & Language	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Applied Learning	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Literacy & Language	

1.2 preprocessing of `project_subject_categories`

In [11]:

```
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 [12]:

```
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 Clean Titles (Text preprocessing)

In [13]:

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

In [14]:

```
# 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 [15]:

```
clean_titles = []

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

```
100%|██████████| 109248/109248 [00:04<00:00, 25573.25it/s]
```

In [16]:

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

In [17]:

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

1.5 Introducing new feature "Number of Words in Title"

In [18]:

```
title_word_count = []
```

In [19]:

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

In [20]:

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

In [21]:

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

Out[21]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	I have been fortunate enough to use the Fairy ...	My students come from a variety of backgrounds...
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Imagine being 8-9 years old. You're in your th...	Most of my students have autism, anxiety anot...
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Having a class of 24 students comes with diver...	I have a class of twenty-four kindergarten stu...

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2
473	100660	p234804	cbc0e38f522143b86d372f8b4d4cff3	Mrs.	GA	2016-04-27 00:53:00	I recently read an article about giving studen...	I teach at a low-income (Title 1) school. Ever...
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	My students crave challenge, they eat obstacle...	We are an urban, public k-5 elementary school....

1.6 Combine 4 Project essays into 1 Essay

In [22]:

```
# 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)
```

1.7 Clean Essays (Text preprocessing)

In [23]:

```
clean_essay = []

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

```
100%|██████████| 109248/109248 [01:03<00:00, 1732.54it/s]
```

In [24]:

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

In [25]:

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

1.8 Introducing new feature "Number of Words in Essay"

In [26]:

```
essay_word_count = []
```

In [27]:

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

In [28]:

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

In [29]:

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

Out[29]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	I have been fortunate enough to use the Fairy ...	My students come from a variety of backgrounds...
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Imagine being 8-9 years old. You're in your th...	Most of my students have autism, anxiety anot...
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Having a class of 24 students comes with diver...	I have a class of twenty-four kindergarten stu...
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	I recently read an article about giving studen...	I teach at a low-income (Title 1) school. Ever...
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	My students crave challenge, they eat obstacle...	We are an urban, public k-5 elementary school...

1.9 Calculate Sentiment Scores for the essays

In [30]:

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

In [31]:

```
analyser = SentimentIntensityAnalyzer()
```

In [32]:

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

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

```
100%|██████████| 109248/109248 [20:28<00:00, 88.95it/s]
```

In [33]:

```
project_data["pos"] = pos
```

In [34]:

```
project_data["neg"] = neg
```

In [35]:

```
project_data["neu"] = neu
```

In [36]:

```
project_data["compound"] = compound
```

In [37]:

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

Out[37]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	I have been fortunate enough to use the Fairy ...	My students come from a variety of backgrounds...
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Imagine being 8-9 years old. You're in your th...	Most of my students have autism, anxiety anot...
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Having a class of 24 students comes with diver...	I have a class of twenty-four kindergarten stu...
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	I recently read an article about giving studen...	I teach at a low-income (Title 1) school. Ever...
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	My students crave challenge, they eat obstacle...	We are an urban, public k-5 elementary school....

5 rows × 24 columns

1.10 Test - Train Split

In [38]:

```
# train test split

from sklearn.model_selection import train_test_split

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

Preparing data for models

In [39]:

```
project_data.columns
```

Out[39]:

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

we are going to consider

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

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

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

2.1 Vectorizing Text data

A) Bag of Words (BOW) with min_df=10

Bag of words - Train Data - Essays

In [40]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).

vectorizer_bow_essay = CountVectorizer(min_df=10)

vectorizer_bow_essay.fit(X_train["clean_essays"])

text_bow_train = vectorizer_bow_essay.transform(X_train["clean_essays"])

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

```
('Shape of matrix after one hot encoding ', (73196, 14214))
```

Bag of words - Test Data - Essays

In [41]:

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

```
('Shape of matrix after one hot encoding ', (36052, 14214))
```

Bag of words - Train Data - Titles

In [42]:

```
vectorizer_bow_title = CountVectorizer(min_df=10)

vectorizer_bow_title.fit(X_train["clean_titles"])

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

```
('Shape of matrix after one hot encoding ', (73196, 2646))
```

Bag of words - Test Data - Titles

In [43]:

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

```
('Shape of matrix after one hot encoding ', (36052, 2646))
```

B) TFIDF vectorizer with min_df=10

TFIDF - Train Data - Essays

In [44]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
vectorizer_tfidf_essay.fit(X_train["clean_essays"])

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

```
('Shape of matrix after one hot encoding ', (73196, 14214))
```

TFIDF - Test Data - Essays

In [45]:

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

```
('Shape of matrix after one hot encoding ', (36052, 14214))
```

TFIDF - Train Data - Titles

In [46]:

```
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

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

```
('Shape of matrix after one hot encoding ', (73196, 2646))
```

TFIDF - Test Data - Titles

In [47]:

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

```
('Shape of matrix after one hot encoding ', (36052, 2646))
```

C) Using Pretrained Models : AVG W2V

In [48]:

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

def loadGloveModel(gloveFile):
```

```
def loadGloveModel(gloveFile):

    print ("Loading Glove Model")

    f = open(gloveFile,'r')

    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
```

In [49]:

```
model = loadGloveModel('glove.42B.300d.txt')
```

```
923it [00:00, 9229.90it/s]
```

```
Loading Glove Model
```

```
1917495it [03:37, 8830.04it/s]
```

```
('Done.', 1917495, ' words loaded!')
```

In [50]:

```
words_train_essays = []

for i in X_train["clean_essays"] :
    words_train_essays.extend(i.split(' '))
```

In [51]:

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

print("All the words in the corpus", len(words_train_essays))
```

```
('All the words in the corpus', 11081716)
```

In [52]:

```
## 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))
```

```
('the unique words in the corpus', 48135)
```

In [53]:

```
## 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)))
```

```
The number of words that are present in both glove vectors and our corpus are 43346 which is
nearly 90.0%
```

In [54]:

```
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))
```

```
('word 2 vec length', 43346)
```

In [55]:

```
# 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 [56]:

```
# 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 [57]:

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

avg_w2v_vectors_train = [];

for sentence in tqdm(X_train["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

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

```
100%|██████████| 73196/73196 [00:29<00:00, 2470.81it/s]
```

```
73196
300
```

Test - Essays

In [58]:

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

avg_w2v_vectors_test = [];

for sentence in tqdm(X_test["clean_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)

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

```
100%|██████████| 36052/36052 [00:12<00:00, 2966.68it/s]
```

```
36052
300
```

Train - Titles

In [59]:

```
# 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(X_train["clean_titles"]): # for each title
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_train.append(vector)

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

```
100%|██████████| 73196/73196 [00:02<00:00, 28240.03it/s]
```

```
73196
300
```

Test - Titles

In [60]:

```
# 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(X_test["clean_titles"]): # for each title
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_test.append(vector)
```

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

```
100%|██████████| 36052/36052 [00:01<00:00, 32863.73it/s]
```

```
36052
300
```

D) Using Pretrained Models: TFIDF weighted W2V

Train - Essays

In [61]:

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

In [62]:

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

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

```
100%|██████████| 73196/73196 [02:36<00:00, 468.18it/s]
```

```
73196
300
```

Test - Essays

In [63]:

```
# compute Tfidf word2vec for each review.

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

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

```
100%|██████████| 36052/36052 [01:16<00:00, 473.94it/s]
```

```
36052
300
```

Train - Titles

In [64]:

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

In [65]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_train = [];

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

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

```
100%|██████████| 73196/73196 [00:02<00:00, 26360.93it/s]
```

```
73196
300
```

Test - Titles

In [66]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_test = [];
```

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

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

```
100%|██████████| 36052/36052 [00:01<00:00, 25907.41it/s]
```

```
36052
300
```

2.2 Vectorizing Numerical features

In [67]:

```
# 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(2)
```

Out[67]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [68]:

```
# 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')
```

A) Price

In [69]:

```
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_test = normalizer.transform(X_test['price'].values.reshape(-1,1))
```

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

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

B) Quantity

In [70]:

```
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_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

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

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

C) Number of Projects previously proposed by Teacher

In [71]:

```
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_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_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

D) Title word Count

In [72]:

```
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_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_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

E) Essay word Count

In [73]:

```
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_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_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

F) Essay Sentiments - pos

In [74]:

```
normalizer = Normalizer()

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

essay_sent_pos_train = normalizer.transform(X_train['pos'].values.reshape(-1,1))
essay_sent_pos_test = normalizer.transform(X_test['pos'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_pos_train.shape, y_train.shape)
print(essay_sent_pos_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

G) Essay Sentiments - neg

In [75]:

```
normalizer = Normalizer()

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

essay_sent_neg_train = normalizer.transform(X_train['neg'].values.reshape(-1,1))
essay_sent_neg_test = normalizer.transform(X_test['neg'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_neg_train.shape, y_train.shape)
print(essay_sent_neg_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
===================================================================================================
```

H) Essay Sentiments - neu

In [76]:

```
normalizer = Normalizer()

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

essay_sent_neu_train = normalizer.transform(X_train['neu'].values.reshape(-1,1))
essay_sent_neu_test = normalizer.transform(X_test['neu'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_neu_train.shape, y_train.shape)
print(essay_sent_neu_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
===================================================================================================
```

I) Essay Sentiments - compound

In [77]:

```
normalizer = Normalizer()

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

essay_sent_comp_train = normalizer.transform(X_train['compound'].values.reshape(-1,1))
essay_sent_comp_test = normalizer.transform(X_test['compound'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_comp_train.shape, y_train.shape)
print(essay_sent_comp_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
===================================================================================================
```

2.3 Response coding for Categorical Data

2.5 Response Coding for Categorical Data

A) School State - Response Coding

Step 1 : Find counts of each

In [78]:

```
X_train.columns
```

Out[78]:

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

In [79]:

```
X_train_pos = X_train.loc[X_train['project_is_approved'] == 1]
```

In [80]:

```
school_state_pos = {}

for a in X_train_pos['school_state'] :
    if a not in school_state_pos :
        school_state_pos[a] = 1
    else :
        school_state_pos[a] += 1
```

In [81]:

```
school_state_pos
```

Out[81]:

```
{'AK': 190,
 'AL': 1005,
 'AR': 570,
 'AZ': 1218,
 'CA': 8834,
 'CO': 618,
 'CT': 958,
 'DC': 273,
 'DE': 208,
 'FL': 3434,
 'GA': 2287,
 'HI': 284,
 'IA': 389,
 'ID': 371,
 'IL': 2469,
 'IN': 1517,
 'KS': 342,
 'KY': 756,
 'LA': 1348,
 'MA': 1364,
 'MD': 861,
 'ME': 274,
 'MI': 1834,
 'MN': 702,
 'MO': 1444,
 'MS': 715,
 'MT': 136,
 'NC': 2872,
 'ND': 77,
 'NE': 186,
 'NH': 206,
 'NJ': 1263,
 'NM': 305,
 'NV': 779,
 'NY': 4231,
 'OH': 1459,
 'OK': 1257,
 'OR': 718,
 'PA': 1797,
 'RI': 176,
 'SC': 2271,
 'SD': 166,
 'TN': 967,
 'TX': 4050,
 'UT': 964,
 'VA': 1161,
 'VT': 36,
 'WA': 1375,
 'WI': 1042,
 'WV': 296,
 'WY': 58}
```

In [82]:

```
## Select only 0 = project is approved elements

X_train_neg = X_train.loc[X_train['project_is_approved'] == 0]
```

In [83]:

```
school_state_neg = {}

for a in X_train_neg['school_state'] :
    if a not in school_state_neg :
        school_state_neg[a] = 1
    else :
        school_state_neg[a] += 1
```

In [84]:

```
school_state_neg
```

Out[84]:

```
{'AK': 38,
 'AL': 163,
 'AR': 115,
 'AZ': 217,
 'CA': 1479,
 'CO': 127,
 'CT': 154,
 'DC': 70,
 'DE': 23,
 'FL': 695,
 'GA': 430,
 'HI': 46,
 'IA': 69,
 'ID': 76,
 'IL': 428,
 'IN': 259,
 'KS': 66,
 'KY': 120,
 'LA': 277,
 'MA': 221,
 'MD': 151,
 'ME': 48,
 'MI': 312,
 'MN': 106,
 'MO': 250,
 'MS': 150,
 'MT': 31,
 'NC': 505,
 'ND': 8,
 'NE': 27,
 'NH': 32,
 'NJ': 241,
 'NM': 57,
 'NV': 125,
 'NY': 707,
 'OH': 209,
 'OK': 245,
 'OR': 134,
 'PA': 290,
 'RI': 29,
 'SC': 355,
 'SD': 35,
 'TN': 173,
 'TX': 945,
 'UT': 178,
 'VA': 209,
 'VT': 11,
 'WA': 191,
 'WI': 192,
 'WV': 53,
 'WY': 11}
```

In [85]:

```
school_state_total = {}

for a in X_train['school_state'] :
    if a not in school_state_total :
        school_state_total[a] = 1
    else :
        school_state_total[a] += 1
```

In [86]:

```
school_state_total
```

Out[86]:

```
{'AK': 228,
 'AL': 1168,
 'AR': 685,
 'AZ': 1435,
 'CA': 10313,
 'CO': 745,
 'CT': 1112,
 'DC': 343,
 'DE': 231,
 'FL': 4129,
 'GA': 2717,
 'HI': 330,
 'IA': 458,
 'ID': 447,
 'IL': 2897,
 'IN': 1776,
 'KS': 408,
 'KY': 876,
 'LA': 1625,
 'MA': 1585,
 'MD': 1012,
 'ME': 322,
 'MI': 2146,
 'MN': 808,
 'MO': 1694,
 'MS': 865,
 'MT': 167,
 'NC': 3377,
 'ND': 85,
 'NE': 213,
 'NH': 238,
 'NJ': 1504,
 'NM': 362,
 'NV': 904,
 'NY': 4938,
 'OH': 1668,
 'OK': 1502,
 'OR': 852,
 'PA': 2087,
 'RI': 205,
 'SC': 2626,
 'SD': 201,
 'TN': 1140,
 'TX': 4995,
 'UT': 1142,
 'VA': 1370,
 'VT': 47,
 'WA': 1566,
 'WI': 1234,
 'WV': 349,
 'WY': 69}
```

In [87]:

```
xx = school_state_total.keys()[0]
```

In [88]:

```
school_state_pos[xx]
```

Out[88]:

```
1375
```

In [89]:

```
xx
```

Out[89]:

```
'WA'
```

In [90]:

```
school_state_neg[xx]
```

Out[90]:

```
191
```

Step 2 : Find Probabilities with respect to classes

In [91]:

```
pos_prob_state = {}

for state in school_state_total.keys():
    pos_prob_state[state] = (school_state_pos[state])/float(school_state_total[state])
```

In [92]:

```
pos_prob_state
```

Out[92]:

```
{'AK': 0.8333333333333334,
 'AL': 0.860445205479452,
 'AR': 0.8321167883211679,
 'AZ': 0.848780487804878,
 'CA': 0.8565887714535053,
 'CO': 0.8295302013422818,
 'CT': 0.8615107913669064,
 'DC': 0.7959183673469388,
 'DE': 0.9004329004329005
 'DE': 0.9004329004329005,
 'FL': 0.831678372487285,
 'GA': 0.8417372101582627,
 'HI': 0.8606060606060606,
 'IA': 0.8493449781659389,
 'ID': 0.8299776286353467,
 'IL': 0.8522609596133932,
 'IN': 0.8541666666666666,
 'KS': 0.8382352941176471,
 'KY': 0.863013698630137,
 'LA': 0.8295384615384616,
 'MA': 0.8605678233438486,
 'MD': 0.8507905138339921,
 'ME': 0.8509316770186336,
 'MI': 0.8546132339235788,
 'MN': 0.8688118811881188,
 'MO': 0.8524203069657615,
 'MS': 0.8265895953757225,
 'MT': 0.8143712574850299,
 'NC': 0.8504589872668049,
 'ND': 0.9058823529411765,
 'NE': 0.8732394366197183,
 'NH': 0.865546218487395,
 'NJ': 0.8397606382978723,
 'NM': 0.8425414364640884,
 'NV': 0.8617256637168141,
 'NY': 0.8568246253543945,
 'OH': 0.8747002398081535,
 'OK': 0.8368841544607191,
 'OR': 0.8427230046948356,
 'PA': 0.8610445615716339,
 'RI': 0.8585365853658536,
 'SC': 0.8648134044173648,
 'SD': 0.8258706467661692,
 'TN': 0.8482456140350877,
 'TX': 0.8108108108108109,
 'UT': 0.8441330998248686,
 'VA': 0.8474452554744526,
 'VT': 0.7659574468085106,
 'WA': 0.8780332056194126,
 'WI': 0.8444084278768234,
 'WV': 0.8481375358166189,
 'WY': 0.8405797101449275}
```

In [93]:

```
neg_prob_state = {}

for state in school_state_total.keys():
    neg_prob_state[state] = (school_state_neg[state])/float(school_state_total[state])
```

In [94]:

```
neg_prob_state
```

Out[94]:

```
{'AK': 0.16666666666666666,
 'AL': 0.13955479452054795,
 'AR': 0.1678832116788321,
 'AZ': 0.15121951219512195,
 'CA': 0.1434112285464947,
 'CO': 0.1704697986577181,
 'CT': 0.13848920863309352,
 'DC': 0.20408163265306123,
 'DE': 0.09956709956709957,
 'FL': 0.16832162751271496,
 'GA': 0.15826278984173722,
 'HI': 0.1393939393939394,
 'IA': 0.15065502183406113,
 'ID': 0.17002237136465326,
 'IL': 0.14773904038660685,
 'IN': 0.14583333333333334,
 'KS': 0.16176470588235295,
 'KY': 0.136986301369863,
 'LA': 0.17046153846153847,
 'MA': 0.13943217665615143,
 'MD': 0.1492094861660079,
 'ME': 0.14906832298136646,
 'MI': 0.14538676607642126,
 'MN': 0.1311881188118812,
 'MO': 0.14757969303423848,
 'MS': 0.17341040462427745,
 'MT': 0.18562874251497005,
 'NC': 0.14954101273319514,
 'ND': 0.09411764705882353,
 'NE': 0.1267605633802817,
 'NH': 0.13445378151260504,
 'NJ': 0.16023936170212766,
 'NM': 0.1574585635359116,
 'NV': 0.13827433628318583,
 'NY': 0.1431753746456055,
 'OH': 0.12529976019184652,
 'OK': 0.16311584553928096,
 'OR': 0.1572769953051643,
 'PA': 0.13895543842836608,
 'RI': 0.14146341463414633,
 'SC': 0.13518659558263518,
 'SD': 0.17412935323383086,
 'TN': 0.15175438596491228,
 'TX': 0.1891891891891892,
 'UT': 0.15586690017513136,
 'VA': 0.15255474452554746,
 'VT': 0.23404255319148937,
 'WA': 0.12196679438058748,
 'WI': 0.15559157212317667,
 'WV': 0.1518624641833811,
 'WY': 0.15942028985507245}
```

Step 3 : Apply probabilities to Train data

In [95]:

```
state_0_train = []
state_1_train = []

for a in X_train["school_state"] :
    state_0_train.append(neg_prob_state[a])
    state_1_train.append(pos_prob_state[a])
```

In [96]:

```
X_train["state_0"] =state_0_train
```

In [97]:

```
X_train["state_1"] = state_1_train
```

In [98]:

```
X_train.head(5)
```

Out[98]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2	p
0	107849	p138154	b49b78d370eb50f2890a28c780bf01af	Mrs.	IN	2016-07-29 19:49:09	Our school is in an urban community consisting...	The books will be used in order to attract and...	
1	55001	p024281	cdaec293d7d05b72484e58e7f7ca9295	Mrs.	CA	2016-10-24 13:28:05	My classroom is made up of a diverse group of ...	Each week, students and I take photos of their...	

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2	p
2	69830	p009834	43dde0654aca2a4c6e2b6d5515c6e98b	Mrs.	CA	2017-01-21 00:03:28	My third grade students are energetic and enth...	My students are excited to learn across the cu...	
3	162343	p211681	1c0033542d44d4ed8959d303175562a6	Ms.	CA	2016-11-03 00:59:14	Amazing, that is what describes the students t...	My students will use these iPads throughout th...	
4	22291	p195875	02b58251be73a2eadf89a2a7a197140c	Ms.	OR	2016-09-28 21:11:48	\"I used to hate reading and now I love it.\" ...	My 3rd students have a 30 minute block of time...	

5 rows × 28 columns

Step 4 : Apply probabilities to Test data

In [99]:

```
state_0_test = []
state_1_test = []

for a in X_test["school_state"] :
    state_0_test.append(neg_prob_state[a])
    state_1_test.append(pos_prob_state[a])
```

In [100]:

```
X_test["state_0"] =state_0_test
```

In [101]:

```
X_test["state_1"] =state_1_test
```

In [102]:

```
X_test.head(5)
```

Out[102]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_essay_1	project_essay_2	p
0	137859	p252401	fbc1400e8289f9d40f3d32d3353999e4	Mr.	WY	2017-02-25 20:20:09	Our school district serves four communities an...	I started a high school Inventors Club seeking...	
1	50674	p105446	ee54cd2151a66c5901fbed2ae15aa2cb	Mrs.	NC	2016-07-31 20:32:21	I teach middle class students who are eager to...	Who wants to sit at a desk all day and never b...	
2	30062	p240487	57cfebbc3b4f64e34656c56123d90dbf	Mrs.	IL	2017-03-10 00:02:20	My students are Kindergarteners at Rupley Elem...	My students come from low income homes where t...	
3	116425	p256363	111a37725bf44d807563d4889ddbabcd	Mrs.	CA	2017-01-19 11:25:33	My students are eager for knowledge. Together ...	Our classroom needs headphones to help bring 2...	
4	174481	p182629	7c82e1254f2c74af9ac169d33814e9f2	Mrs.	WA	2016-05-26 00:46:28	My little loves are so special to me for many ...	Having these wobble chairs in my classroom wil...	

5 rows × 28 columns

Step 5 : Normalize for 0

Step 5 : Normalize for 0

In [103]:

```
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["state_0"].values.reshape(-1,1))

state_0_train = normalizer.transform(X_train["state_0"].values.reshape(-1,1))
state_0_test = normalizer.transform(X_test["state_0"].values.reshape(-1,1))

print("After vectorizations")
print(state_0_train.shape, y_train.shape)
print(state_0_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Step 6 : Normalize for 1

In [104]:

```
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["state_1"].values.reshape(-1,1))

state_1_train = normalizer.transform(X_train["state_1"].values.reshape(-1,1))
state_1_test = normalizer.transform(X_test["state_1"].values.reshape(-1,1))

print("After vectorizations")
print(state_1_train.shape, y_train.shape)
print(state_1_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

B) Categories of Projects- Response Coding

Step 1 : Find counts of each

In [105]:

```
X_train.columns
```

Out[105]:

```
Index([u'Unnamed: 0', u'id', u'teacher_id', u'teacher_prefix', u'school_state',
       u'Date', u'project_essay_1', u'project_essay_2', u'project_essay_3',
       u'project_essay_4', u'project_resource_summary',
       u'teacher_number_of_previously_posted_projects', u'project_is_approved',
       u'project_grade_category', u'clean_categories', u'clean_subcategories',
       u'clean_titles', u'title_word_count', u'clean_essays',
       u'essay_word_count', u'pos', u'neg', u'neu', u'compound', u'price',
       u'quantity', u'state_0', u'state_1'],
      dtype='object')
```

In [106]:

```
clean_category_pos = {}

for a in X_train_pos['clean_categories'] :
    for b in a.split():
        if b not in clean_category_pos :
            clean_category_pos[b] = 1
        else :
            clean_category_pos[b] += 1
```

In [107]:

```
clean_category_pos
```

Out[107]:

```
{'AppliedLearning': 6776,
 'Care_Hunger': 829,
 'Health_Sports': 8029,
 'History_Civics': 3440,
 'Literacy_Language': 30386,
 'Math_Science': 23306,
 'Music_Arts': 5835,
 'SpecialNeeds': 7633,
 'Warmth': 829}
```

In [108]:

```
clean_category_neg = {}

for a in X_train_neg['clean_categories'] :
    for b in a.split():
        if b not in clean_category_neg :
            clean_category_neg[b] = 1
        else :
            clean_category_neg[b] += 1
```

In [109]:

```
clean_category_neg
```

Out[109]:

```
{'AppliedLearning': 1396,
 'Care_Hunger': 80,
 'Health_Sports': 1447,
 'History_Civics': 582,
 'Literacy_Language': 4696,
 'Math_Science': 4420,
 'Music_Arts': 1089,
 'SpecialNeeds': 1508,
 'Warmth': 80}
```

In [110]:

```
clean_category_total = {}

for a in X_train['clean_categories'] :
```

```
for a in x_train['clean_categories'] :
    for b in a.split():
        if b not in clean_category_total :
            clean_category_total[b] = 1
        else :
            clean_category_total[b] += 1
```

In [111]:

```
clean_category_total
```

Out[111]:

```
{'AppliedLearning': 8172,
 'Care_Hunger': 909,
 'Health_Sports': 9476,
 'History_Civics': 4022,
 'Literacy_Language': 35082,
 'Math_Science': 27726,
 'Music_Arts': 6924,
 'SpecialNeeds': 9141,
 'Warmth': 909}
```

Step 2 : Find Probabilities with respect to classes

In [112]:

```
pos_prob_category = {}

for st in clean_category_total.keys():
    pos_prob_category[st] = (clean_category_pos[st])/float(clean_category_total[st])
```

In [113]:

```
pos_prob_category
```

Out[113]:

```
{'AppliedLearning': 0.8291727851199217,
 'Care_Hunger': 0.911991199119912,
 'Health_Sports': 0.847298438159561,
 'History_Civics': 0.8552958727001492,
 'Literacy_Language': 0.8661421811755317,
 'Math_Science': 0.8405828464257376,
 'Music_Arts': 0.8427209705372617,
 'SpecialNeeds': 0.8350289902636473,
 'Warmth': 0.911991199119912}
```

In [114]:

```
neg_prob_category = {}

for stt in clean_category_total.keys():
    neg_prob_category[stt] = (clean_category_neg[stt])/float(clean_category_total[stt])
```

In [115]:

```
neg_prob_category
```

Out[115]:

```
{'AppliedLearning': 0.17082721488007832,
 'Care_Hunger': 0.08800880088008801,
 'Health_Sports': 0.152701561840439,
 'History_Civics': 0.14470412729985083,
 'Literacy_Language': 0.1338578188244684,
 'Math_Science': 0.15941715357426242,
 'Music_Arts': 0.1572790294627383,
 'SpecialNeeds': 0.1649710097363527,
 'Warmth': 0.08800880088008801}
```

Step 3 : Apply probabilities to Train data

In [116]:

```
cat_0_train = []
cat_1_train = []

for a in X_train["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        cat_0_train.append(neg_prob_category[a])
        cat_1_train.append(pos_prob_category[a])
    else :
        c = neg_prob_category[b[0]]
        d = neg_prob_category[b[1]]
        e = pos_prob_category[b[0]]
        f = pos_prob_category[b[1]]

        cat_0_train.append(c*d)
        cat_1_train.append(e*f)
```

In [117]:

```
cat_0_train[0:10]
```

Out[117]:

```
[0.1338578188244684,
 0.021053027830711453,
 0.15941715357426242,
 0.021339232460656075,
 0.1338578188244684,
 0.007745549032350981,
 0.15941715357426242,
 0.15941715357426242,
 0.1649710097363527,
 0.1649710097363527]
```

In [118]:

```
cat_1_train[0:10]
```

Out[118]:

```
[0.8661421811755317,
 0.7299161795435047,
 0.8405828464257376,
 0.7280642600619253,
 0.8661421811755317,
 0.831727947272175,
 0.8405828464257376,
 0.8405828464257376,
 0.8350289902636473,
 0.8350289902636473]
```

In [119]:

```
X_train["cat_0"] = cat_0_train
```

In [120]:

```
X_train["cat_1"] = cat_1_train
```

Step 4 : Apply probabilities to Test data

In [121]:

```
cat_0_test = []
cat_1_test = []

for a in X_test["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        cat_0_test.append(neg_prob_category[a])
        cat_1_test.append(pos_prob_category[a])
    else :
        c = neg_prob_category[b[0]]
        d = neg_prob_category[b[1]]
        e = pos_prob_category[b[0]]
        f = pos_prob_category[b[1]]

        cat_0_test.append(c*d)
        cat_1_test.append(e*f)
```

In [122]:

```
X_test["cat_0"] = cat_0_test
```

In [123]:

```
X_test["cat_1"] = cat_1_test
```

Step 5 : Normalize for 0

In [124]:

```
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["cat_0"].values.reshape(-1,1))

cat_0_train = normalizer.transform(X_train["cat_0"].values.reshape(-1,1))
cat_0_test = normalizer.transform(X_test["cat_0"].values.reshape(-1,1))

print("After vectorizations")
print(cat_0_train.shape, y_train.shape)
print(cat_0_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Step 6 : Normalize for 1

In [125]:

```
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 your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.

normalizer.fit(X_train["cat_1"].values.reshape(-1,1))

cat_1_train = normalizer.transform(X_train["cat_1"].values.reshape(-1,1))
cat_1_test = normalizer.transform(X_test["cat_1"].values.reshape(-1,1))

print("After vectorizations")
print(cat_1_train.shape, y_train.shape)
print(cat_1_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

C) Sub-Categories of Projects- Response Coding

Step 1 : Find counts of each

In [126]:

```
clean_subcategory_pos = {}

for a in X_train_pos['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_pos :
            clean_subcategory_pos[b] = 1
        else :
            clean_subcategory_pos[b] += 1
```

In [127]:

```
clean_subcategory_pos
```

Out[127]:

```
{'AppliedSciences': 5973,
 'Care_Hunger': 829,
 'CharacterEducation': 1124,
 'Civics_Government': 469,
 'College_CareerPrep': 1436,
 'CommunityService': 237,
 'ESL': 2472,
 'EarlyDevelopment': 2345,
 'Economics': 153,
 'EnvironmentalScience': 3057,
 'Extracurricular': 465,
 'FinancialLiteracy': 324,
 'ForeignLanguages': 482,
 'Gym_Fitness': 2574,
 'Health_LifeScience': 2321,
 'Health_Wellness': 5838,
 'History_Geography': 1848,
 'Literacy': 19777,
 'Literature_Writing': 12774,
 'Mathematics': 15944,
 'Music': 1873,
 'NutritionEducation': 748,
 'Other': 1341,
 'ParentInvolvement': 395,
 'PerformingArts': 1143,
 'SocialSciences': 1130,
 'SpecialNeeds': 7633,
 'TeamSports': 1164,
 'VisualArts': 3471,
 'Warmth': 829}
```

In [128]:

```
clean_subcategory_neg = {}

for a in X_train_neg['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_neg :
            clean_subcategory_neg[b] = 1
        else :
            clean_subcategory_neg[b] += 1
```

In [129]:

```
clean_subcategory_neg
```

Out[129]:

```
{'AppliedSciences': 1250,
 'Care_Hunger': 80,
 'CharacterEducation': 256,
 'Civics_Government': 93,
 'College_CareerPrep': 270,
 'CommunityService': 68,
 'ESL': 432,
 'EarlyDevelopment': 507,
 'Economics': 33,
 'EnvironmentalScience': 685,
 'Extracurricular': 91,
 'FinancialLiteracy': 65,
 'ForeignLanguages': 123,
 'Gym_Fitness': 470,
 'Health_LifeScience': 492,
 'Health_Wellness': 919,
 'History_Geography': 310,
 'Literacy': 2875,
 'Literature_Writing': 2089,
 'Mathematics': 2873,
 'Music': 251,
 'NutritionEducation': 167,
 'Other': 273,
 'ParentInvolvement': 66,
 'PerformingArts': 187,
 'SocialSciences': 180,
 'SpecialNeeds': 1508,
 'TeamSports': 312,
 'VisualArts': 751,
 'Warmth': 80}
```

In [130]:

```
clean_subcategory_total = {}

for a in X_train['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_total :
            clean_subcategory_total[b] = 1
        else :
            clean_subcategory_total[b] += 1
```

In [131]:

```
clean_subcategory_total
```

Out[131]:

```
{'AppliedSciences': 7223,
 'Care_Hunger': 909,
 'CharacterEducation': 1380,
 'Civics_Government': 562,
 'College_CareerPrep': 1706,
 'CommunityService': 305,
 'ESL': 2904,
 'EarlyDevelopment': 2852,
 'EarlyDevelopment': 2852,
 'Economics': 186,
 'EnvironmentalScience': 3742,
 'Extracurricular': 556,
 'FinancialLiteracy': 389,
 'ForeignLanguages': 605,
 'Gym_Fitness': 3044,
 'Health_LifeScience': 2813,
 'Health_Wellness': 6757,
 'History_Geography': 2158,
 'Literacy': 22652,
 'Literature_Writing': 14863,
 'Mathematics': 18817,
 'Music': 2124,
 'NutritionEducation': 915,
 'Other': 1614,
 'ParentInvolvement': 461,
 'PerformingArts': 1330,
 'SocialSciences': 1310,
 'SpecialNeeds': 9141,
 'TeamSports': 1476,
 'VisualArts': 4222,
 'Warmth': 909}
```

Step 2 : Find Probabilities with respect to classes

In [132]:

```
pos_prob_subcategory = {}

for sw in clean_subcategory_total.keys():
    pos_prob_subcategory[sw] = (clean_subcategory_pos[sw])/float(clean_subcategory_total[sw])
```

In [133]:

```
pos_prob_subcategory
```

Out[133]:

```
{'AppliedSciences': 0.8269417139692649,
 'Care_Hunger': 0.911991199119912,
 'CharacterEducation': 0.8144927536231884,
 'Civics_Government': 0.8345195729537367,
 'College_CareerPrep': 0.8417350527549824,
 'CommunityService': 0.7770491803278688,
 'ESL': 0.8512396694214877,
 'EarlyDevelopment': 0.8222300140252454,
 'Economics': 0.8225806451612904,
 'EnvironmentalScience': 0.8169428113308391,
 'Extracurricular': 0.8363309352517986,
 'FinancialLiteracy': 0.8329048843187661,
 'ForeignLanguages': 0.7966942148760331,
 'Gym_Fitness': 0.8455978975032852,
 'Health_LifeScience': 0.8250977603981514,
 'Health_Wellness': 0.8639928962557348,
 'History_Geography': 0.8563484708063022,
 'Literacy': 0.873079639766908,
 'Literature_Writing': 0.8594496400457512,
 'Mathematics': 0.8473189137482064,
 'Music': 0.8818267419962336,
 'NutritionEducation': 0.8174863387978142,
 'Other': 0.8308550185873605,
 'ParentInvolvement': 0.8568329718004338,
 'PerformingArts': 0.8593984962406015,
 'SocialSciences': 0.8625954198473282,
 'SpecialNeeds': 0.8350289902636473,
 'TeamSports': 0.7886178861788617,
 'VisualArts': 0.8221222169587873,
 'Warmth': 0.911991199119912}
```

In [134]:

```
neg_prob_subcategory = {}
```

```
for sw in clean_subcategory_total.keys():
    neg_prob_subcategory[sw] = (clean_subcategory_neg[sw])/float(clean_subcategory_total[sw])
```

In [135]:

```
neg_prob_subcategory
```

Out[135]:

```
{'AppliedSciences': 0.17305828603073514,
 'Care_Hunger': 0.08800880088008801,
 'CharacterEducation': 0.1855072463768116,
 'Civics_Government': 0.16548042704626334,
 'College_CareerPrep': 0.15826494724501758,
 'CommunityService': 0.22295081967213115,
 'ESL': 0.1487603305785124,
 'EarlyDevelopment': 0.17776998597475455,
 'Economics': 0.1774193548387097,
 'EnvironmentalScience': 0.18305718866916088,
 'Extracurricular': 0.16366906474820145,
 'FinancialLiteracy': 0.16709511568123395,
 'ForeignLanguages': 0.20330578512396694,
 'Gym_Fitness': 0.15440210249671485,
 'Health_LifeScience': 0.17490223960184856,
 'Health_Wellness': 0.1360071037442652,
 'History_Geography': 0.14365152919369786,
 'Literacy': 0.126920360233092,
 'Literature_Writing': 0.1405503599542488,
 'Mathematics': 0.15268108625179358,
 'Music': 0.11817325800376648,
 'NutritionEducation': 0.1825136612021858,
 'Other': 0.1691449814126394,
 'ParentInvolvement': 0.14316702819956617,
 'PerformingArts': 0.1406015037593985,
 'SocialSciences': 0.13740458015267176,
 'SpecialNeeds': 0.1649710097363527,
 'TeamSports': 0.21138211382113822,
 'VisualArts': 0.17787778304121268,
 'Warmth': 0.08800880088008801}
```

Step 3 : Apply probabilities to Train data

In [136]:

```
subcat_0_train = []
subcat_1_train = []

for a in X_train["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        subcat_0_train.append(neg_prob_subcategory[a])
        subcat_1_train.append(pos_prob_subcategory[a])
    else :
        c = neg_prob_subcategory[b[0]]
        d = neg_prob_subcategory[b[1]]
        e = pos_prob_subcategory[b[0]]
        f = pos_prob_subcategory[b[1]]

        subcat_0_train.append(c*d)
        subcat_1_train.append(e*f)
```

In [137]:

```
X_train["subcat_0"] = subcat_0_train
```

In [138]:

```
X_train["subcat_1"] = subcat_1_train
```

Step 4 : Apply probabilities to Test data

In [139]:

```
subcat_0_test = []
subcat_1_test = []

for a in X_test["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        subcat_0_test.append(neg_prob_subcategory[a])
        subcat_1_test.append(pos_prob_subcategory[a])
    else :
        c = neg_prob_subcategory[b[0]]
        d = neg_prob_subcategory[b[1]]
        e = pos_prob_subcategory[b[0]]
        f = pos_prob_subcategory[b[1]]

        subcat_0_test.append(c*d)
        subcat_1_test.append(e*f)
```

In [140]:

```
X_test["subcat_0"] = subcat_0_test
```

In [141]:

```
X_test["subcat_1"] = subcat_1_test
```

Step 5 : Normalize for 0

In [142]:

```
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["subcat_0"].values.reshape(-1,1))

subcat_0_train = normalizer.transform(X_train["subcat_0"].values.reshape(-1,1))
subcat_0_test = normalizer.transform(X_test["subcat_0"].values.reshape(-1,1))

print("After vectorizations")
print(subcat_0_train.shape, y_train.shape)
print(subcat_0_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Step 6 : Normalize for 1

In [143]:

```
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["subcat_1"].values.reshape(-1,1))

subcat_1_train = normalizer.transform(X_train["subcat_1"].values.reshape(-1,1))
subcat_1_test = normalizer.transform(X_test["subcat_1"].values.reshape(-1,1))

print("After vectorizations")
print(subcat_1_train.shape, y_train.shape)
print(subcat_1_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

D) Project Grade Category- Response Coding

Step 1 : Find counts of each

In [144]:

```
X_train.columns
```

Out[144]:

```
Index([u'Unnamed: 0', u'id', u'teacher_id', u'teacher_prefix', u'school_state',
       u'Date', u'project_essay_1', u'project_essay_2', u'project_essay_3',
       u'project_essay_4', u'project_resource_summary',
       u'teacher_number_of_previously_posted_projects', u'project_is_approved',
       u'project_grade_category', u'clean_categories', u'clean_subcategories',
       u'clean_titles', u'title_word_count', u'clean_essays',
       u'essay_word_count', u'pos', u'neg', u'neu', u'compound', u'price',
       u'quantity', u'state_0', u'state_1', u'cat_0', u'cat_1', u'subcat_0',
       u'subcat_1'],
      dtype='object')
```

In [145]:

```
project_grade_pos = {}

for a in X_train_pos['project_grade_category'] :
    if a not in project_grade_pos :
        project_grade_pos[a] = 1
    else :
        project_grade_pos[a] += 1
```

In [146]:

```
project_grade_pos
```

Out[146]:

```
{'Grades_3-5': 21020,
 'Grades_6-8': 9675,
 'Grades_9-12': 6353,
 'Grades_PreK-2': 25065}
```

In [147]:

```
project_grade_neg = {}
```

```
for a in X_train_neg['project_grade_category'] :
    if a not in project_grade_neg :
        project_grade_neg[a] = 1
    else :
        project_grade_neg[a] += 1
```

In [148]:

```
project_grade_neg
```

Out[148]:

```
{'Grades_3-5': 3781,
 'Grades_6-8': 1738,
 'Grades_9-12': 1088,
 'Grades_PreK-2': 4476}
```

In [149]:

```
project_grade_total = {}

for a in X_train['project_grade_category'] :
    if a not in project_grade_total :
        project_grade_total[a] = 1
    else :
        project_grade_total[a] += 1
```

In [150]:

```
project_grade_total
```

Out[150]:

```
{'Grades_3-5': 24801,
 'Grades_6-8': 11413,
 'Grades_9-12': 7441,
 'Grades_PreK-2': 29541}
```

Step 2 : Find Probabilities with respect to classes

In [151]:

```
pos_prob_grade_cat = {}

for sq in project_grade_total.keys():
    pos_prob_grade_cat[sq] = (project_grade_pos[sq])/float(project_grade_total[sq])
```

In [152]:

```
pos_prob_grade_cat
```

Out[152]:

```
{'Grades_3-5': 0.8475464699004073,
 'Grades_6-8': 0.8477175151143433,
 'Grades_9-12': 0.8537830936702057,
 'Grades_PreK-2': 0.8484817710977963}
```

In [153]:

```
neg_prob_grade_cat = {}

for sq in project_grade_total.keys():
    neg_prob_grade_cat[sq] = (project_grade_neg[sq])/float(project_grade_total[sq])
```

In [154]:

```
neg_prob_grade_cat
```

Out[154]:

```
{'Grades_3-5': 0.15245353009959275,
 'Grades_6-8': 0.1522824848856567,
 'Grades_9-12': 0.1462169063297944,
 'Grades_PreK-2': 0.1515182289022037}
```

Step 3 : Apply probabilities to Train data

In [155]:

```
proj_grade_0_train = []
proj_grade_1_train = []

for a in X_train["project_grade_category"] :
    proj_grade_0_train.append(neg_prob_grade_cat[a])
    proj_grade_1_train.append(pos_prob_grade_cat[a])
```

In [156]:

```
proj_grade_0_train[0:10]
```

Out[156]:

```
[0.1515182289022037,
 0.1515182289022037,
 0.1462169063297944,
 0.1462169063297944,
 0.1522824848856567,
 0.15245353009959275,
 0.15245353009959275,
 0.1515182289022037,
 0.15245353009959275,
 0.1522824848856567]
```

In [157]:

```
proj_grade_1_train[0:10]
```

Out[157]:

```
[0.8484817710977963,
 0.8484817710977963,
 0.8537830936702057,
 0.8537830936702057,
 0.8477175151143433,
 0.8475464699004073,
 0.8475464699004073,
 0.8484817710977963,
 0.8475464699004073,
 0.8477175151143433]
```

In [158]:

```
X_train["project_grade_category"][0:10]
```

Out[158]:

```
0    Grades_PreK-2
1    Grades_PreK-2
2      Grades_9-12
3      Grades_9-12
4       Grades_6-8
5       Grades_3-5
6       Grades_3-5
7    Grades_PreK-2
8       Grades_3-5
9       Grades_6-8
```

```
Name: project_grade_category, dtype: object
```

In [159]:

```
X_train["proj_grade_0"] = proj_grade_0_train
```

In [160]:

```
X_train["proj_grade_1"] = proj_grade_1_train
```

Step 4 : Apply probabilities to Test data

In [161]:

```
proj_grade_0_test = []
proj_grade_1_test = []

for a in X_test["project_grade_category"] :
    proj_grade_0_test.append(neg_prob_grade_cat[a])
    proj_grade_1_test.append(pos_prob_grade_cat[a])
```

In [162]:

```
proj_grade_0_test[0:10]
```

Out[162]:

```
[0.1522824848856567,
 0.15245353009959275,
 0.15245353009959275,
 0.1515182289022037,
 0.1522824848856567,
 0.1462169063297944,
 0.1462169063297944,
 0.15245353009959275,
 0.1515182289022037,
 0.15245353009959275]
```

In [163]:

```
proj_grade_1_test[0:10]
```

Out[163]:

```
[0.8477175151143433,
 0.8475464699004073,
 0.8475464699004073,
 0.8484817710977963,
 0.8477175151143433,
 0.8537830936702057,
 0.8537830936702057,
 0.8475464699004073,
 0.8484817710977963,
 0.8475464699004073]
```

In [164]:

```
X_test["project_grade_category"][0:10]
```

Out[164]:

```
0       Grades_6-8
1       Grades_3-5
2       Grades_3-5
3    Grades_PreK-2
4       Grades_6-8
5      Grades_9-12
6      Grades_9-12
7       Grades_3-5
```

```
7       Grades_3-5
8    Grades_PreK-2
9       Grades_3-5
Name: project_grade_category, dtype: object
```

In [165]:

```
X_test["proj_grade_0"] = proj_grade_0_test
```

In [166]:

```
X_test["proj_grade_1"] = proj_grade_1_test
```

Step 5 : Normalize for 0

In [167]:

```
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["proj_grade_0"].values.reshape(-1,1))

proj_grade_0_train = normalizer.transform(X_train["proj_grade_0"].values.reshape(-1,1))
proj_grade_0_test = normalizer.transform(X_test["proj_grade_0"].values.reshape(-1,1))

print("After vectorizations")
print(proj_grade_0_train.shape, y_train.shape)
print(proj_grade_0_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Step 6 : Normalize for 1

In [168]:

```
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["proj_grade_1"].values.reshape(-1,1))

proj_grade_1_train = normalizer.transform(X_train["proj_grade_1"].values.reshape(-1,1))
proj_grade_1_test = normalizer.transform(X_test["proj_grade_1"].values.reshape(-1,1))

print("After vectorizations")
print(proj_grade_1_train.shape, y_train.shape)
print(proj_grade_1_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
==================================================================================================
```

E) Teacher Prefix- Response Coding

Step 1 : Find counts of each

In [169]:

```
X_train.columns
```

Out[169]:

```
Index([u'Unnamed: 0', u'id', u'teacher_id', u'teacher_prefix', u'school_state',
       u'Date', u'project_essay_1', u'project_essay_2', u'project_essay_3',
       u'project_essay_4', u'project_resource_summary',
       u'teacher_number_of_previously_posted_projects', u'project_is_approved',
       u'project_grade_category', u'clean_categories', u'clean_subcategories',
       u'clean_titles', u'title_word_count', u'clean_essays',
       u'essay_word_count', u'pos', u'neg', u'neu', u'compound', u'price',
       u'quantity', u'state_0', u'state_1', u'cat_0', u'cat_1', u'subcat_0',
       u'subcat_1', u'proj_grade_0', u'proj_grade_1'],
      dtype='object')
```

In [170]:

```
teacher_prefix_pos = {}

for a in X_train_pos['teacher_prefix'] :
    if a not in teacher_prefix_pos :
        teacher_prefix_pos[a] = 1
    else :
        teacher_prefix_pos[a] += 1
```

In [171]:

```
teacher_prefix_pos
```

Out[171]:

```
{nan: 2, 'Dr.': 6, 'Mr.': 5977, 'Mrs.': 32823, 'Ms.': 22024, 'Teacher': 1281}
```

In [172]:

```
teacher_prefix_neg = {}

for a in X_train_neg['teacher_prefix'] :
    if a not in teacher_prefix_neg :
        teacher_prefix_neg[a] = 1
    else :
        teacher_prefix_neg[a] += 1
```

In [173]:

```
teacher_prefix_neg
```

Out[173]:

```
{'Dr.': 3, 'Mr.': 1154, 'Mrs.': 5522, 'Ms.': 4093, 'Teacher': 311}
```

In [174]:

```
teacher_prefix_neg[np.nan] =0
```

In [175]:

```
teacher_prefix_neg
```

Out[175]:

```
{nan: 0, 'Dr.': 3, 'Mr.': 1154, 'Mrs.': 5522, 'Ms.': 4093, 'Teacher': 311}
```

In [176]:

```
teacher_prefix_total = {}

for a in X_train['teacher_prefix'] :
    if a not in teacher_prefix_total :
        teacher_prefix_total[a] = 1
    else :
        teacher_prefix_total[a] += 1
```

In [177]:

```
teacher_prefix_total
```

Out[177]:

```
{nan: 2, 'Dr.': 9, 'Mr.': 7131, 'Mrs.': 38345, 'Ms.': 26117, 'Teacher': 1592}
```

Step 2 : Find Probabilities with respect to classes

In [178]:

```
pos_prob_teacher_prefix = {}

for sw in teacher_prefix_total.keys():
    pos_prob_teacher_prefix[sw] = (teacher_prefix_pos[sw])/float(teacher_prefix_total[sw])
```

In [179]:

```
pos_prob_teacher_prefix
```

Out[179]:

```
{nan: 1.0,
 'Dr.': 0.6666666666666666,
 'Mr.': 0.838171364465012,
 'Mrs.': 0.8559916547137828,
 'Ms.': 0.843282153386683,
 'Teacher': 0.8046482412060302}
```

In [180]:

```
neg_prob_teacher_prefix = {}

for sw in teacher_prefix_total.keys():
    neg_prob_teacher_prefix[sw] = (teacher_prefix_neg[sw])/float(teacher_prefix_total[sw])
```

In [181]:

```
neg_prob_teacher_prefix
```

Out[181]:

```
{nan: 0.0,
 'Dr.': 0.3333333333333333,
 'Mr.': 0.16182863553498808,
 'Mrs.': 0.14400834528621723,
 'Ms.': 0.156717846613317,
 'Teacher': 0.19535175879396985}
```

Step 3 : Apply probabilities to Train data

In [182]:

```
teacher_prefix_0_train = []
teacher_prefix_1_train = []

for a in X_train["teacher_prefix"] :
    teacher_prefix_0_train.append(neg_prob_teacher_prefix[a])
    teacher_prefix_1_train.append(pos_prob_teacher_prefix[a])
```

In [183]:

```
teacher_prefix_0_train[0:10]
```

Out[183]:

```
[0.14400834528621723,
 0.14400834528621723,
 0.14400834528621723,
 0.156717846613317,
 0.156717846613317,
 0.156717846613317,
 0.156717846613317,
 0.14400834528621723,
 0.156717846613317,
 0.14400834528621723]
```

In [184]:

```
teacher_prefix_1_train[0:10]
```

Out[184]:

```
[0.8559916547137828,
 0.8559916547137828,
 0.8559916547137828,
 0.843282153386683,
 0.843282153386683,
 0.843282153386683,
 0.843282153386683,
 0.8559916547137828,
 0.843282153386683,
 0.8559916547137828]
```

In [185]:

```
X_train['teacher_prefix'][0:10]
```

Out[185]:

```
0    Mrs.
1    Mrs.
2    Mrs.
3     Ms.
4     Ms.
5     Ms.
6     Ms.
7    Mrs.
8     Ms.
9    Mrs.
Name: teacher_prefix, dtype: object
```

In [186]:

```
X_train["teacher_prefix_0"] = teacher_prefix_0_train
```

In [187]:

In [187]:

```
X_train["teacher_prefix_1"] = teacher_prefix_1_train
```

Step 4 : Apply probabilities to Test data

In [188]:

```
teacher_prefix_0_test = []
teacher_prefix_1_test = []

for a in X_test["teacher_prefix"] :
    teacher_prefix_0_test.append(neg_prob_teacher_prefix[a])
    teacher_prefix_1_test.append(pos_prob_teacher_prefix[a])
```

In [189]:

```
X_test["teacher_prefix_0"] = teacher_prefix_0_test
```

In [190]:

```
X_test["teacher_prefix_1"] = teacher_prefix_1_test
```

Step 5 : Normalize for 0

In [191]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()

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

normalizer.fit(X_train["teacher_prefix_0"].values.reshape(-1,1))

teacher_prefix_0_train = normalizer.transform(X_train["teacher_prefix_0"].values.reshape(-1,1))
teacher_prefix_0_test = normalizer.transform(X_test["teacher_prefix_0"].values.reshape(-1,1))

print("After vectorizations")
print(teacher_prefix_0_train.shape, y_train.shape)
print(teacher_prefix_0_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Step 6 : Normalize for 1

In [192]:

```
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.
# array.reshape(1, -1)  if it contains a single sample.

normalizer.fit(X_train["teacher_prefix_1"].values.reshape(-1,1))

teacher_prefix_1_train = normalizer.transform(X_train["teacher_prefix_1"].values.reshape(-1,1))
teacher_prefix_1_test = normalizer.transform(X_test["teacher_prefix_1"].values.reshape(-1,1))

print("After vectorizations")
print(teacher_prefix_1_train.shape, y_train.shape)
print(teacher_prefix_1_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
((73196, 1), (73196,))
((36052, 1), (36052,))
====================================================================================================
```

Assignment 9: RF and GBDT

Response Coding: Example

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

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

    - Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

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

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

3. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
      with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

    or

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
      seaborn heat maps with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
    - You can choose either of the plotting techniques: 3d plot or heat map
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
    - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

4. **Conclusion**

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

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.

3. Random Forest

Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay (BOW with min_df=10)

In [193]:

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

X_tr = hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_tra
in, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
title_bow_train, text_bow_train)).tocsr()
X_te = hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test, pr
oj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, title_bow_test
, text_bow_test)).tocsr()
```

In [194]:

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

```
Final Data matrix
((73196, 16879), (73196,))
((36052, 16879), (36052,))
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [338]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
```

In [ ]:

```
rf = RandomForestClassifier()

parameters = {'n_estimators': [10, 100, 500, 1000], 'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
rf = RandomForestClassifier()

parameters = {'n_estimators': [10], 'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [195]:

```
import plotly.plotly as py
import plotly.graph_objs as go
```

In [196]:

```
import plotly
plotly.tools.set_credentials_file(username='harris13', api_key='rATYeYDgdcxNImJkbzlt')
```

In [214]:

```
x1 = [0.68775687, 0.81646807, 0.84587443, 0.85093174, 0.94693676,
       0.99936345, 0.99986994, 0.99989285, 0.99306249, 0.99998904,
       0.99999531, 0.99999573, 0.99971579, 0.99999989, 0.9999999 ,
       0.9999999 , 0.99965641, 0.99999989, 0.9999999 , 0.9999999 ]
```

In [215]:

```
x2 = [0.62233003, 0.66529121, 0.67627284, 0.67741767, 0.59224901,
       0.64771258, 0.66551124, 0.66886816, 0.56860355, 0.61920699,
       0.63837556, 0.64101423, 0.54682862, 0.5971678 , 0.61116801,
       0.61244187, 0.54870988, 0.59450501, 0.61058515, 0.6124806 ]
```

In [216]:

```
y1 = pd.Series([10,100,500,1000,10,100,500,1000,10,100,500,1000,10,100,500,1000,10,100,500,1000], i
ndex = x1)
```

In [217]:

```
z1 = pd.Series([10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500,1000,1000,1000,1000],index
z1 = pd.Series([10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500,1000,1000,1000,1000],index
= x1)
```

In [218]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [219]:

```
data = [trace1, trace2]
```

In [220]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- Random Forests - BOW',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
        aspectmode = 'manual'
    ),
)
```

In [221]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Random-Forests-a', height=700)
```

Out[221]:

Observations :

1) We understand from the 2 plots that the Random Forests with depth of 1000 performs great on Training Data but performs pretty bad on unseen data (cross validation data) . => Probably a case of Overfitting.

2) Number of estimators as 100, performs decently on both Train as well as Cross Validation Data.

3) 10 as the value for maximum depth is considered.

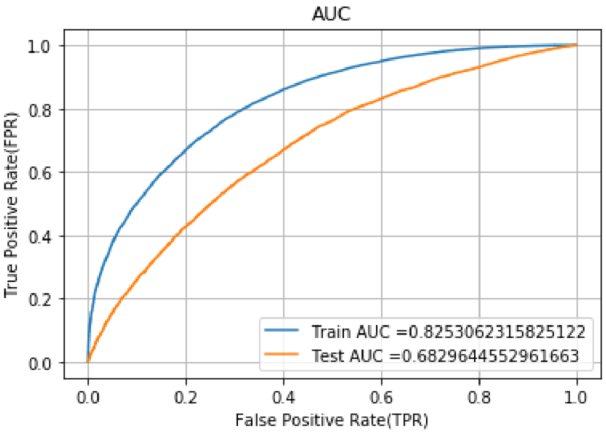
B) Train the model using the best hyper parameter value

In [356]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

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

    return y_data_pred
```

In [357]:

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

model = RandomForestClassifier(max_depth = 10, n_estimators = 1000)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [358]:

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

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

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

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    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 [359]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24999999796471448, 'for threshold', 0.837)
[[ 5541  5542]
 [ 5462 56651]]
```

In [360]:

```
conf_matr_df_train_1_rf = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

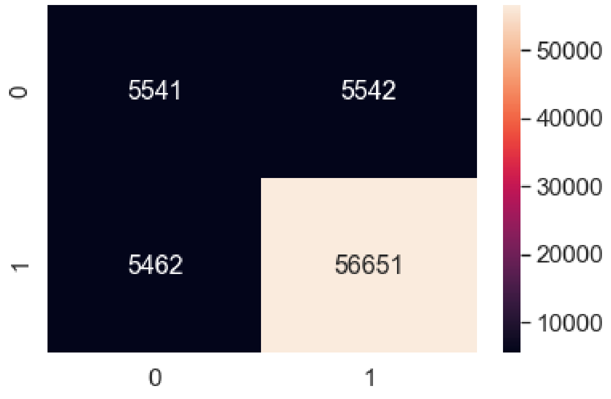
```
('the maximum value of tpr*(1-fpr)', 0.24999999796471448, 'for threshold', 0.837)
```

In [628]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[628]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a44df66d0>
```



Test data

In [361]:

```
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)', 0.24999999161092998, 'for threshold', 0.845)
[[ 3270  2189]
 [10079 20514]]
```

In [362]:

```
conf_matr_df_test_1_rf = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds,
test_fpr, test_fpr)), range(2),range(2))
```

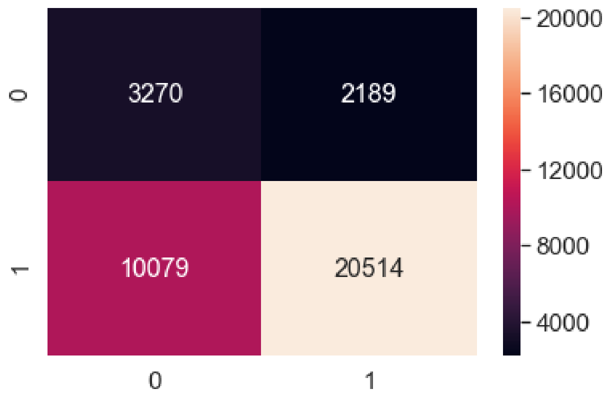
```
('the maximum value of tpr*(1-fpr)', 0.24999999161092998, 'for threshold', 0.845)
```

In [627]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[627]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a43c68b50>
```



D) Extracting top 20 features

In [363]:

```
aaa = model.feature_importances_
```

In [364]:

```
aaa.shape
```

Out[364]:

```
(16903,)
```

In [365]:

```
important_bow_features_value = list(aaa[::])
```

In [366]:

```
bow_features_names = []
```

In [367]:

```
bow_features_names.append("cat_0")
bow_features_names.append("cat_1")
bow_features_names.append("subcat_0")
bow_features_names.append("subcat_1")
bow_features_names.append("state_0")
bow_features_names.append("state_1")
bow_features_names.append("proj_grade_0")
bow_features_names.append("proj_grade_1")
bow_features_names.append("teacher_prefix_0")
bow_features_names.append("teacher_prefix_1")
```

In [368]:

```
len(bow_features_names)
```

Out[368]:

```
10
```

In [369]:

```
bow_features_names.append("price")
bow_features_names.append("quantity")
bow_features_names.append("prev_projects")
bow_features_names.append("title_word_count")
bow_features_names.append("essay_word_count")
bow_features_names.append("essay_sent_pos")
bow_features_names.append("essay_sent_neg")
bow_features_names.append("essay_sent_neu")
bow_features_names.append("essay_sent_comp")
```

In [370]:

```
len(bow_features_names)
```

Out[370]:

```
19
```

In [371]:

```
for a in vectorizer_bow_title.get_feature_names() :
    bow_features_names.append(a)
```

In [372]:

```
len(bow_features_names)
```

Out[372]:

```
2642
```

In [373]:

```
for a in vectorizer_bow_essay.get_feature_names() :
    bow_features_names.append(a)
```

In [374]:

```
len(bow_features_names)
```

Out[374]:

```
16903
```

In [375]:

```
final_bow_features = pd.DataFrame({'feature_prob_estimates' : important_bow_features_value,
'feature_names' : bow_features_names})
```

In [376]:

```
bow1 = final_bow_features.sort_values(by = ['feature_prob_estimates'], ascending = False)
```

In [377]:

```
final1 = bow1.head(20)
```

In [378]:

```
bow1.head(20)
```

Out[378]:

	feature_names	feature_prob_estimates
10460	materials	0.018383
15062	supplies	0.014559
4244	books	0.011474
16192	use	0.010922
4948	chromebooks	0.009586
12880	reading	0.008636
16719	wobble	0.008635
12	prev_projects	0.007608
4795	chairs	0.006998
12873	read	0.006940
14912	students	0.006698
14796	stools	0.006632
3301	allow	0.005496
4236	book	0.004871
3326	also	0.004748
9518	ipads	0.004489
9558	items	0.004399
1092	hands	0.004359
3892	balls	0.004204
15412	the	0.004079

E) WordCloud for top 20 features

In [379]:

```
from wordcloud import WordCloud

#convert list to string and generate
unique_string=(" ").join(final1['feature_names'])
wordcloud = WordCloud(width = 1000, height = 500, background_color ='white').generate(unique_string
)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("bow-rf"+".png", bbox_inches='tight')
plt.show()
plt.close()
```

use
items
ipads
balls
wobble

reading
materials
chairs
supplies
stools
book
allow
students
hands
read
chromebooks
prev_projects

Set 2 : Categorical, Numerical features + Project_title(TFIDF) + Preprocessed_essay (TFIDF min_df=10)

In [222]:

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

X_tr = hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_tra
in, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
title_tfidf_train, text_tfidf_train)).tocsr()
X_te = hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test, pr
oj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, title_tfidf_te
st, text_tfidf_test)).tocsr()
```

In [223]:

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

```
Final Data matrix
((73196, 16879), (73196,))
((36052, 16879), (36052,))
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [ ]:

```
rf = RandomForestClassifier()

parameters = {'n_estimators': [10, 100, 500, 1000], 'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [224]:

```
x1 = [0.685562  , 0.82288902, 0.84881871, 0.85728958, 0.95361686,
       0.99945537, 0.99992037, 0.9999465 , 0.99236202, 0.99997822,
       0.99998754, 0.99998563, 0.99966075, 0.9999999 , 0.9999999 ,
       0.9999999 , 0.99969814, 0.99999988, 0.9999999 , 0.9999999 ]
```

In [225]:

```
x2 = [0.61809514, 0.655087  , 0.67081169, 0.67383125, 0.58429271,
       0.65943456, 0.68343344, 0.68788744, 0.5803628 , 0.6634886 ,
       0.68149903, 0.68575756, 0.58691919, 0.66321182, 0.68309546,
       0.68216163, 0.58150236, 0.65985137, 0.67988075, 0.68303975]
```

In [226]:

```
y1 = pd.Series([10,100,500,1000,10,100,500,1000,10,100,500,1000,10,100,500,1000,10,100,500,1000], i
ndex = x1)
```

In [227]:

```
z1 = pd.Series([10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500,1000,1000,1000,1000],index
= x1)
```

In [233]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [234]:

```
data = [trace1, trace2]
```

In [235]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- Random Forests - TFIDF',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [236]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Random-Forests-c', height=700)
```

Out[236]:

Observations :

1) We understand from the 2 plots that the Random Forests with depth of 1000 performs great on Training Data but doesnt perform well on unseen data (cross validation data) . => Probably a case of Overfitting.

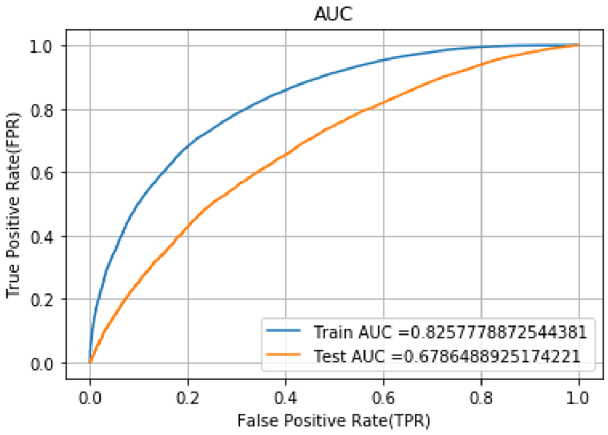
2) Number of estimators as 100, 500 & 1000 performs decently on both Train as well as Cross Validation Data.

3) 10 as the value for maximum depth is considered.

B) Train the model using the best hyper parameter value

In [396]:

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

model = RandomForestClassifier(max_depth = 10, n_estimators = 1000)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [397]:

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

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

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

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

Train Data

In [398]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.2499999979647145, 'for threshold', 0.836)
[[ 5542  5541]
 [ 5421 56692]]
```

In [399]:

```
conf_matr_df_train_2_rf = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

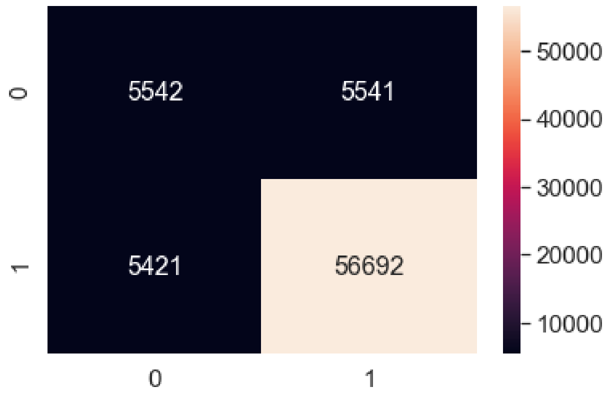
```
('the maximum value of tpr*(1-fpr)', 0.2499999979647145, 'for threshold', 0.836)
```

In [626]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_2_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[626]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a85d21590>
```



Test Data

In [400]:

```
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)', 0.24999999161092998, 'for threshold', 0.847)
[[ 3255  2204]
 [10489 20104]]
```

In [401]:

```
conf_matr_df_test_2_rf = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds,
test_fpr, test_fpr)), range(2),range(2))
```

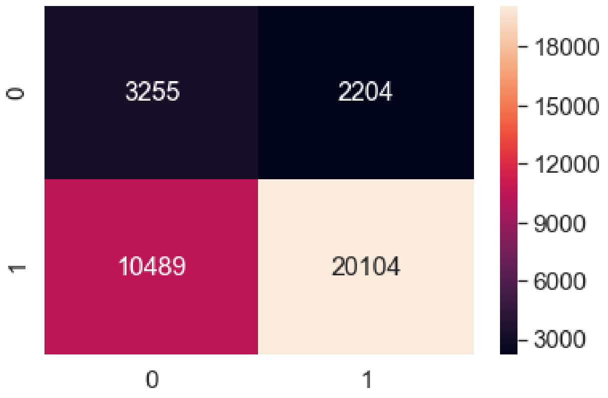
```
('the maximum value of tpr*(1-fpr)', 0.24999999161092998, 'for threshold', 0.847)
```

In [625]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_2_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[625]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a431a5050>
```



D) Extracting top 20 features

In [402]:

```
bbb = model.feature_importances_
```

In [403]:

```
bbb.shape
```

Out[403]:

```
(16903,)
```

In [404]:

```
important_tfidf_features_value = list(bbb[::])
```

In [405]:

```
tfidf_features_names = []
```

In [406]:

```
tfidf_features_names.append("cat_0")
tfidf_features_names.append("cat_1")
tfidf_features_names.append("subcat_0")
tfidf_features_names.append("subcat_1")
tfidf_features_names.append("state_0")
tfidf_features_names.append("state_1")
tfidf_features_names.append("proj_grade_0")
tfidf_features_names.append("proj_grade_1")
tfidf_features_names.append("teacher_prefix_0")
tfidf_features_names.append("teacher_prefix_1")
```

In [407]:

```
len(tfidf_features_names)
```

Out[407]:

```
10
```

In [408]:

```
tfidf_features_names.append("price")
tfidf_features_names.append("quantity")
tfidf_features_names.append("prev_projects")
tfidf_features_names.append("title_word_count")
tfidf_features_names.append("essay_word_count")
tfidf_features_names.append("essay_sent_pos")
tfidf_features_names.append("essay_sent_neg")
tfidf_features_names.append("essay_sent_neu")
tfidf_features_names.append("essay_sent_comp")
```

In [409]:

```
len(tfidf_features_names)
```

Out[409]:

```
19
```

In [410]:

```
for a in vectorizer_tfidf_titles.get_feature_names() :
    tfidf_features_names.append(a)
```

In [411]:

```
for a in vectorizer_tfidf_essay.get_feature_names() :
    tfidf_features_names.append(a)
```

In [412]:

```
len(tfidf_features_names)
```

Out[412]:

```
16903
```

In [413]:

```
final_tfidf_features = pd.DataFrame({'feature_prob_estimates' : important_tfidf_features_value, 'f
eature_names' : tfidf_features_names})
```

In [414]:

```
tfidf1 = final_tfidf_features.sort_values(by = ['feature_prob_estimates'], ascending = False)
```

In [415]:

```
final2 = tfidf1.head(20)
```

In [416]:

```
tfidf1.head(20)
```

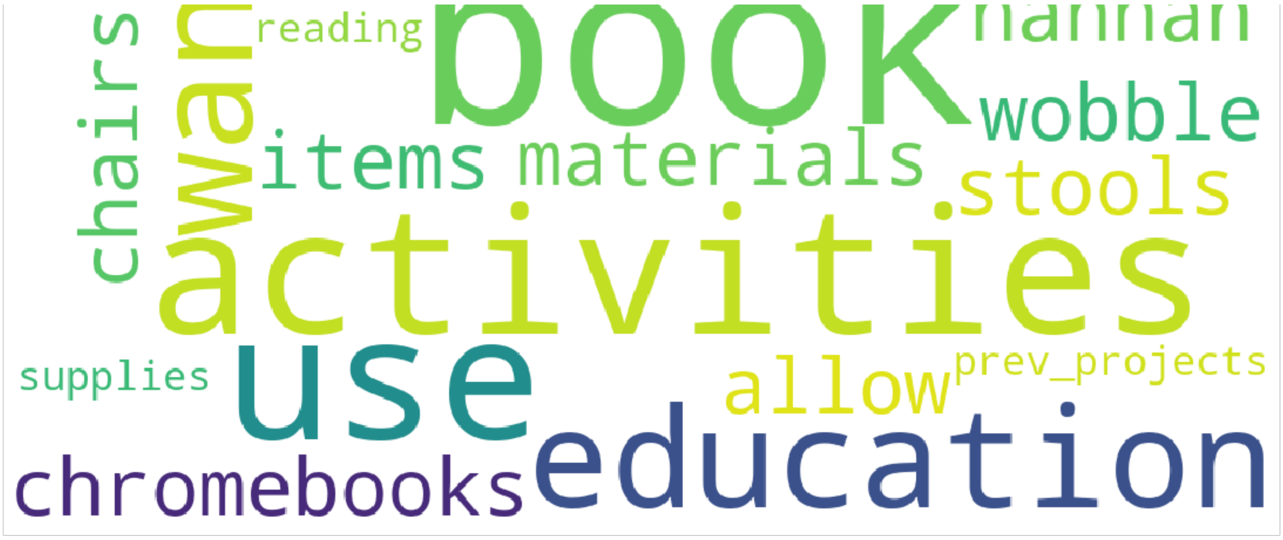
Out[416]:

	feature_names	feature_prob_estimates
10460	materials	0.020076
15062	supplies	0.013344
10996	nannan	0.012913
8515	hands	0.009696
4244	books	0.008236
16192	use	0.006864
12873	read	0.006062
16719	wobble	0.006011
9558	items	0.005859
4948	chromebooks	0.005484
12880	reading	0.005468
4795	chairs	0.004644
16461	want	0.004355
3049	activities	0.004254
12	prev_projects	0.004221
14796	stools	0.004119
6814	education	0.004071
4236	book	0.003837
3301	allow	0.003798
15446	these	0.003685

E) WordCloud for top 20 features

In [417]:

```
from wordcloud import WordCloud

#convert list to string and generate
unique_string=(" ").join(final2['feature_names'])
wordcloud = WordCloud(width = 1000, height = 500, background_color ='white').generate(unique_string
)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("tfidf-rf"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



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

In [237]:

```
avg_w2v_vectors_train2d = np.array(avg_w2v_vectors_train)
```

In [238]:

```
avg_w2v_vectors_train2d.shape
```

Out[238]:

```
(73196, 300)
```

In [239]:

```
avg_w2v_vectors_titles_train2d = np.array(avg_w2v_vectors_titles_train)
```

In [240]:

```
avg_w2v_vectors_titles_train2d.shape
```

Out[240]:

```
(73196, 300)
```

In [241]:

```
print(cat_0_train.shape)
print(cat_1_train.shape)
print(subcat_0_train.shape)
print(subcat_1_train.shape)
print(state_0_train.shape)
print(state_1_train.shape)
print(proj_grade_0_train.shape)
print(proj_grade_1_train.shape)
print(teacher_prefix_0_train.shape)
print(teacher_prefix_1_train.shape)
print(price_train.shape)
print(quantity_train.shape)
print(prev_projects_train.shape)
print(title_word_count_train.shape)
print(essay_word_count_train.shape)
print(essay_sent_pos_train.shape)
print(essay_sent_neg_train.shape)
print(essay_sent_neu_train.shape)
print(essay_sent_comp_train.shape)
print(avg_w2v_vectors_train2d.shape)
print(avg_w2v_vectors_titles_train2d.shape)
```

```
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 300)
(73196, 300)
```

In [242]:

```
X_tr = np.hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_
train, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
avg_w2v_vectors_train2d, avg_w2v_vectors_titles_train2d))
```

In [243]:

```
print(X_tr.shape)
print("="*100)
```

```
(73196, 619)
====================================================================================================
```

In [244]:

```
avg_w2v_vectors_test2d = np.array(avg_w2v_vectors_test)
```

In [245]:

```
avg_w2v_vectors_test2d.shape
```

Out[245]:

```
(36052, 300)
```

In [246]:

```
avg_w2v_vectors_titles_test2d = np.array(avg_w2v_vectors_titles_test)
```

In [247]:

```
avg_w2v_vectors_titles_test2d.shape
```

Out[247]:

```
(36052, 300)
```

In [248]:

```
print(cat_0_test.shape)
print(cat_0_test.shape)
print(cat_1_test.shape)
print(subcat_0_test.shape)
print(subcat_1_test.shape)
print(state_0_test.shape)
print(state_1_test.shape)
print(proj_grade_0_test.shape)
print(proj_grade_1_test.shape)
print(teacher_prefix_0_test.shape)
print(teacher_prefix_1_test.shape)
print(price_test.shape)
print(quantity_test.shape)
print(prev_projects_test.shape)
print(title_word_count_test.shape)
print(essay_word_count_test.shape)
print(essay_sent_pos_test.shape)
print(essay_sent_neg_test.shape)
print(essay_sent_neu_test.shape)
print(essay_sent_comp_test.shape)
print(avg_w2v_vectors_test2d.shape)
print(avg_w2v_vectors_titles_test2d.shape)
```

```
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 300)
(36052, 300)
```

In [249]:

```
X_te = np.hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test,
proj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, avg_w2v_vector
s_test2d, avg_w2v_vectors_titles_test2d))
```

In [250]:

```
print(X_te.shape)
print("="*100)
```

```
(36052, 619)
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [ ]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier(n_estimators = 10)

parameters = {'max_depth':[10, 50, 100, 500, 1000]}
```

```
clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier(n_estimators = 50)

parameters = {'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier(n_estimators = 100)

parameters = {'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
```

```
rf = RandomForestClassifier(n_estimators = 250)

parameters = {'max_depth':[10, 50, 100, 500, 1000]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [251]:

```
x1 = [0.84673233, 0.99948941, 0.99952133, 0.99950371, 0.99948851,
      0.91948596, 0.99999876, 0.99999958, 0.99999865, 0.9999996,
      0.93061507, 0.99999978, 0.99999987, 0.9999999 , 0.99999989,
      0.93709022, 0.99999991, 0.99999992, 0.99999992, 0.99999992]
```

In [252]:

```
x2 = [0.62095407, 0.56943484, 0.57448469, 0.5736693 , 0.57603487,
      0.65541158, 0.61195694, 0.61256132, 0.61521871, 0.61477603,
      0.66813703, 0.62271974, 0.62329389, 0.62331725, 0.62275901,
      0.67263273, 0.62947776, 0.62959031, 0.62805141, 0.6309876]
```

In [253]:

```
y1 = pd.Series([10,50,100,500,1000,10,50,100,500,1000,10,50,100,500,1000,10,50,100,500,1000], index
= x1)
```

In [254]:

```
z1 = pd.Series([10,10,10,10,10,50,50,50,50,50,100,100,100,100,100,250,250,250,250,250],index = x1)
```

In [255]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [256]:

```
data = [trace1, trace2]
```

In [257]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- Random Forests - AVG W2V',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [258]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Random-Forests-e', height=700)
```

Out[258]:

Observations :

1) We understand from the 2 plots that the Random Forests with maximum depth of trees as 1000 performs great (almost perfect) on Training Data but performs pretty bad on unseen data (cross validation data) . => Probably a case of Overfitting.

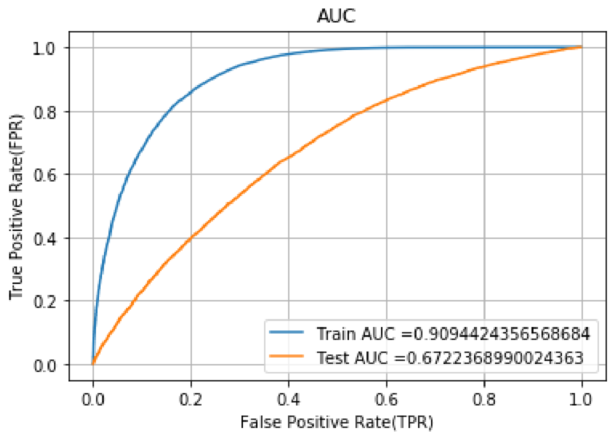
2) Number of estimators as 250, performs decently on both Train as well as Cross Validation Data.

3) 10 as the value for maximum depth is considered.

B) Train the model using the best hyper parameter value

In [446]:

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

model = RandomForestClassifier(max_depth = 10, n_estimators = 250)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [447]:

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

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

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

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

Train Data

In [448]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24999998168243034, 'for threshold', 0.775)
[[ 5540  5543]
 [  416 61697]]
```

In [449]:

```
conf_matr_df_train_3_rf = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

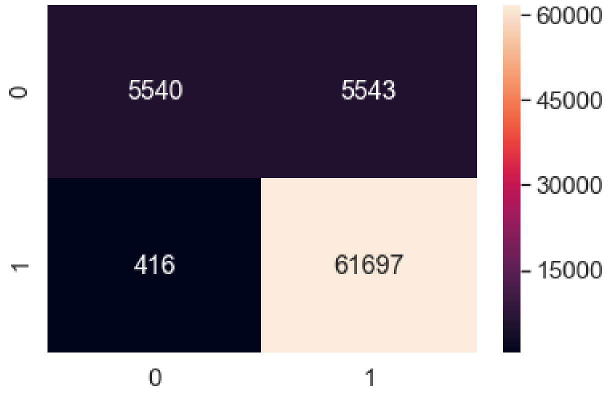
```
('the maximum value of tpr*(1-fpr)', 0.24999998168243034, 'for threshold', 0.775)
```

In [624]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_3_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[624]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a4a57f610>
```



Test Data

In [450]:

```
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)', 0.2499999244983697, 'for threshold', 0.828)
[[ 2535  2924]
 [ 6554 24039]]
```

In [451]:

```
conf_matr_df_test_3_rf = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds,
test_fpr, test_fpr)), range(2),range(2))
```

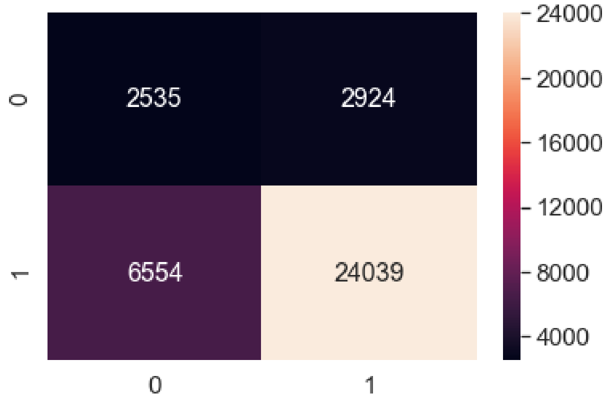
```
('the maximum value of tpr*(1-fpr)', 0.2499999244983697, 'for threshold', 0.828)
```

In [623]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_3_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[623]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a4447a4d0>
```



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

In [259]:

```
tfidf_w2v_vectors_train2d = np.array(tfidf_w2v_vectors_train)
```

In [260]:

```
tfidf_w2v_vectors_train2d.shape
```

Out[260]:

```
(73196, 300)
```

In [261]:

```
tfidf_w2v_vectors_titles_train2d = np.array(tfidf_w2v_vectors_titles_train)
```

In [262]:

```
tfidf_w2v_vectors_titles_train2d.shape
```

Out[262]:

```
(73196, 300)
```

In [263]:

```
print(cat_0_train.shape)
print(cat_1_train.shape)
print(subcat_0_train.shape)
print(subcat_1_train.shape)
print(state_0_train.shape)
print(state_1_train.shape)
print(proj_grade_0_train.shape)
print(proj_grade_1_train.shape)
print(teacher_prefix_0_train.shape)
print(teacher_prefix_1_train.shape)
print(price_train.shape)
print(quantity_train.shape)
print(prev_projects_train.shape)
print(title_word_count_train.shape)
print(essay_word_count_train.shape)
print(essay_sent_pos_train.shape)
print(essay_sent_neg_train.shape)
print(essay_sent_neu_train.shape)
print(essay_sent_comp_train.shape)
print(tfidf_w2v_vectors_train2d.shape)
print(tfidf_w2v_vectors_titles_train2d.shape)
```

```
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
(73196, 300)
(73196, 300)
```

In [264]:

```
X_tr = np.hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_
train, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
tfidf_w2v_vectors_train2d, tfidf_w2v_vectors_titles_train2d))
```

In [265]:

```
print(X_tr.shape)
print("="*100)
```

```
(73196, 619)
====================================================================================================
```

In [266]:

```
tfidf_w2v_vectors_test2d = np.array(tfidf_w2v_vectors_test)
```

In [267]:

```
tfidf_w2v_vectors_test2d.shape
```

Out[267]:

```
(36052, 300)
```

In [268]:

```
tfidf_w2v_vectors_titles_test2d = np.array(tfidf_w2v_vectors_titles_test)
```

In [269]:

```
tfidf_w2v_vectors_titles_test2d.shape
```

Out[269]:

```
(36052, 300)
```

In [270]:

```
print(cat_0_test.shape)
print(cat_1_test.shape)
print(subcat_0_test.shape)
print(subcat_1_test.shape)
print(state_0_test.shape)
print(state_1_test.shape)
print(proj_grade_0_test.shape)
print(proj_grade_1_test.shape)
print(teacher_prefix_0_test.shape)
print(teacher_prefix_1_test.shape)
print(price_test.shape)
print(quantity_test.shape)
print(prev_projects_test.shape)
print(title_word_count_test.shape)
print(essay_word_count_test.shape)
print(essay_sent_pos_test.shape)
print(essay_sent_neg_test.shape)
print(essay_sent_neu_test.shape)
print(essay_sent_comp_test.shape)
print(tfidf_w2v_vectors_test2d.shape)
print(tfidf_w2v_vectors_titles_test2d.shape)
```

```
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
```

```
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
(36052, 300)
(36052, 300)
```

In [271]:

```
X_te = np.hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test,
proj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, tfidf_w2v_vect
ors_test2d, tfidf_w2v_vectors_titles_test2d))
```

In [272]:

```
print(X_te.shape)
print("="*100)
```

```
(36052, 619)
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [ ]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier()

parameters = {'n_estimators': [10, 25, 50, 100, 250], 'max_depth':[10, 50, 100, 500]}

clf = GridSearchCV(rf, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [273]:

```
x1 = [0.53114756, 0.53280202, 0.53286782, 0.532964  , 0.53312063,
       0.53283393, 0.53298766, 0.53293651, 0.5331403 , 0.53314039,
       0.53287494, 0.53301328, 0.53294784, 0.53316433, 0.53316619,
       0.53289102, 0.53293372, 0.53309011, 0.5331474 , 0.53316773]
```

In [274]:

```
x2 = [0.52897712, 0.52773419, 0.52968157, 0.5293205 , 0.52784254,
       0.52744026, 0.5276696 , 0.52924379, 0.5276494 , 0.52783335,
       0.52750441, 0.52754582, 0.52906785, 0.52768812, 0.52766225,
       0.52757189, 0.52942785, 0.52748851, 0.52741293, 0.52752519]
```

In [275]:

```
y1 = pd.Series([10,25,50,100,250,10,25,50,100,250,10,25,50,100,250,10,25,50,100,250], index = x1)
```

In [276]:

```
z1 = pd.Series([10,10,10,10,10,50,50,50,50,50,100,100,100,100,100,500,500,500,500,500],index = x1)
```

In [277]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [278]:

```
data = [trace1, trace2]
```

In [279]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- Random Forests - TFIDF W2V',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [280]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Random-Forests-g', height=700)
```

Out[280]:

Observations :

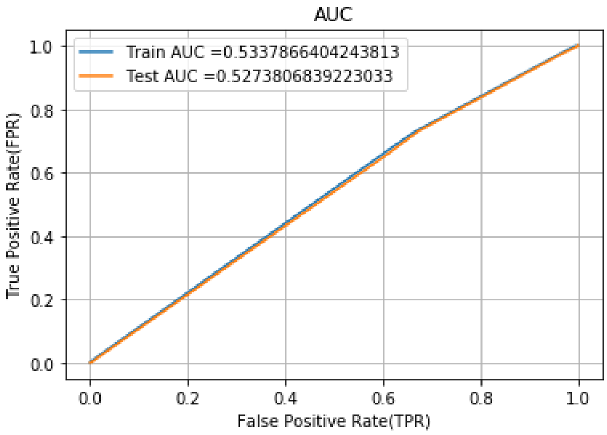
1) Number of estimators as 10, performs decently on both Train as well as Cross Validation Data.

2) 500 as the value for maximum depth is considered.

B) Train the model using the best hyper parameter value

In [479]:

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

model = RandomForestClassifier(max_depth = 500, n_estimators = 10)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [480]:

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

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

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

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

Train Data

In [481]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.23861619016385752, 'for threshold', 0.86)
[[ 4359  6724]
 [20748 41365]]
```

In [482]:

```
conf_matr_df_train_4_rf = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

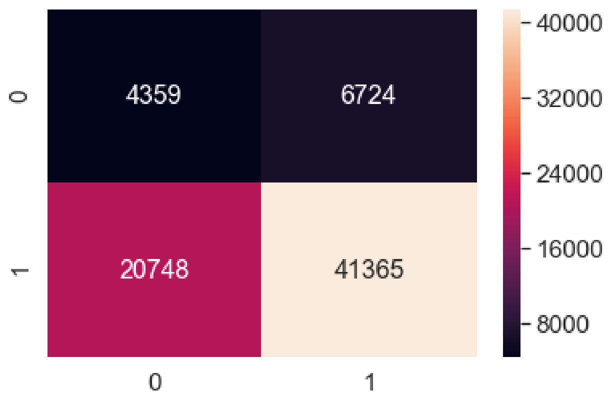
```
('the maximum value of tpr*(1-fpr)', 0.23861619016385752, 'for threshold', 0.86)
```

In [622]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_4_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[622]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a43d2a410>
```



Test Data

In [483]:

```
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)', 0.23666036356685943, 'for threshold', 0.9)
[[ 5446    13]
 [30537    56]]
```

In [484]:

```
conf_matr_df_test_4_rf = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds,
test_fpr, test_fpr)), range(2),range(2))
```

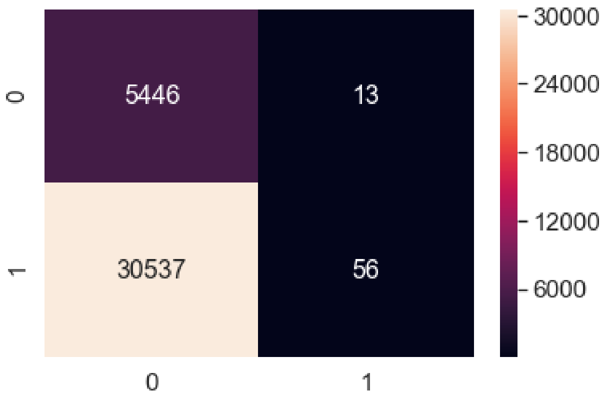
```
('the maximum value of tpr*(1-fpr)', 0.23666036356685943, 'for threshold', 0.9)
```

In [621]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4_rf, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[621]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a43fe1510>
```



4. Gradient Boosted Decision Trees

Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay (BOW with min_df=10)

In [281]:

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

X_tr = hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_tra
in, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
title_bow_train, text_bow_train)).tocsr()
X_te = hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test, pr
oj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, title_bow_test
, text_bow_test)).tocsr()
```

In [282]:

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

```
Final Data matrix
((73196, 16879), (73196,))
((36052, 16879), (36052,))
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [487]:

```
from sklearn.ensemble import GradientBoostingClassifier
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 5)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 10)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 15)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 20)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [283]:

```
x1 = [0.67582738, 0.72500528, 0.77143682, 0.82012709, 0.88460666,
      0.79045531, 0.86672091, 0.91705308, 0.95213486, 0.9805429,
      0.88769152, 0.95135135, 0.98170154, 0.99366322, 0.99832629,
      0.94014488, 0.98529687, 0.9972215 , 0.99911791, 0.99979793]
```

In [284]:

```
x2 = [0.64004457, 0.66192722, 0.6792036 , 0.69118161, 0.70065091,
      0.6505509 , 0.66652814, 0.68314909, 0.6925425 , 0.69962842,
      0.64314828, 0.66120248, 0.67646775, 0.68655422, 0.69627902,
      0.63211968, 0.65282809, 0.6703488 , 0.68034096, 0.68968672]
```

In [285]:

```
z1 = [5, 5, 5, 5, 5,
    10, 10, 10, 10, 10,
    15, 15, 15, 15, 15,
    20, 20, 20, 20, 20]
```

In [286]:

```
y1 = [10, 25, 50, 100, 250,
     10, 25, 50 ,100, 250,
     10, 25, 50, 100, 250,
     10, 25, 50, 100, 250]
```

In [287]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)
```

```
trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [288]:

```
data = [trace1, trace2]
```

In [289]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- GBDT - BOW',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [290]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='GBDT - a', height=700)
```

Out[290]:

Observations :

1) Number of estimators as 100 to 250, performs decently on both Train as well as Cross Validation Data.

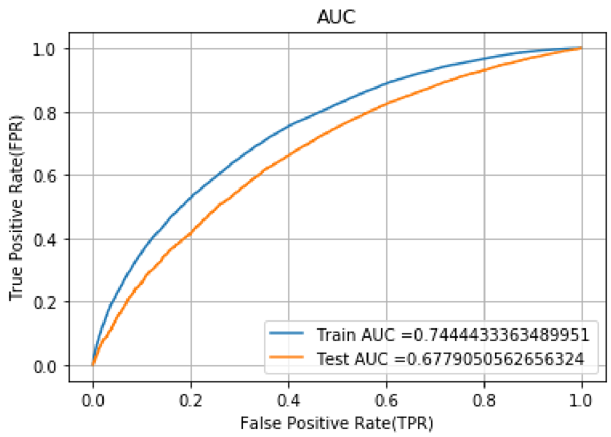
2) 5 as the value for maximum depth is considered. Shallow trees generally perform well for GBDT.

3) 250 as number of estimators is considered for training the final model.

B) Train the model using the best hyper parameter value

In [502]:

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

model = RandomForestClassifier(max_depth = 5, n_estimators = 500)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [503]:

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

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

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

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

Train Data

In [504]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.2499999979647145, 'for threshold', 0.844)
[[ 5542  5541]
 [10955 51158]]
```

In [505]:

```
conf_matr_df_train_1_gbdt = 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)', 0.2499999979647145, 'for threshold', 0.844)
```

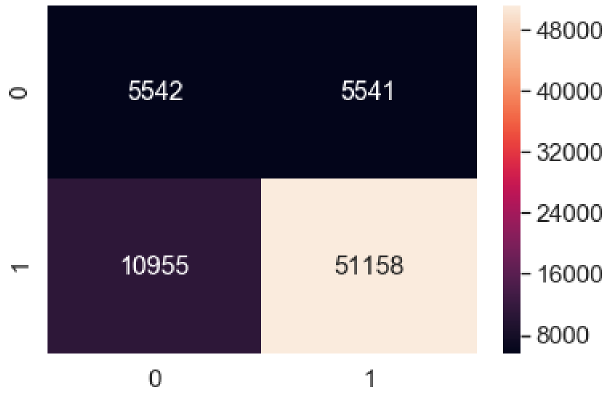
In [620]:

In [620]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[620]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a42ff9350>
```



Test Data

In [506]:

```
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)', 0.24999999161092995, 'for threshold', 0.848)
[[ 3855  1604]
 [13949 16644]]
```

In [507]:

```
conf_matr_df_test_1_gbdt = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds
, test_fpr, test_fpr)), range(2),range(2))
```

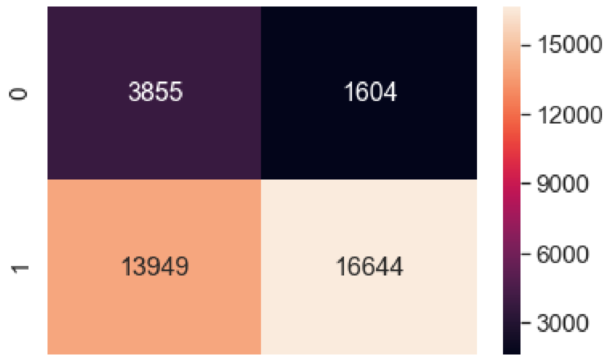
```
('the maximum value of tpr*(1-fpr)', 0.24999999161092995, 'for threshold', 0.848)
```

In [619]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[619]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a43d586d0>
```



0 1

D) Extracting top 20 features

In [508]:

```
ccc = model.feature_importances_
```

In [509]:

```
ccc.shape
```

Out[509]:

```
(16903,)
```

In [510]:

```
important_bow_features_value2 = list(ccc[::])
```

In [511]:

```
bow_features_names = []
```

In [512]:

```
bow_features_names.append("cat_0")
bow_features_names.append("cat_1")
bow_features_names.append("subcat_0")
bow_features_names.append("subcat_1")
bow_features_names.append("state_0")
bow_features_names.append("state_1")
bow_features_names.append("proj_grade_0")
bow_features_names.append("proj_grade_1")
bow_features_names.append("teacher_prefix_0")
bow_features_names.append("teacher_prefix_1")
```

In [513]:

```
len(bow_features_names)
```

Out[513]:

```
10
```

In [514]:

```
bow_features_names.append("price")
bow_features_names.append("quantity")
bow_features_names.append("prev_projects")
bow_features_names.append("title_word_count")
bow_features_names.append("essay_word_count")
bow_features_names.append("essay_sent_pos")
bow_features_names.append("essay_sent_neg")
bow_features_names.append("essay_sent_neu")
bow_features_names.append("essay_sent_comp")
```

In [515]:

```
len(bow_features_names)
```

Out[515]:

```
19
```

In [516]:

```
for a in vectorizer_bow_title.get_feature_names() :
    bow_features_names.append(a)
```

In [517]:

```
for a in vectorizer_bow_essay.get_feature_names() :
    bow_features_names.append(a)
```

In [518]:

```
len(bow_features_names)
```

Out[518]:

```
16903
```

In [519]:

```
final_bow_features2 = pd.DataFrame({'feature_prob_estimates' : important_bow_features_value2,
'feature_names' : bow_features_names})
```

In [520]:

```
bow2 = final_bow_features2.sort_values(by = ['feature_prob_estimates'], ascending = False)
```

In [521]:

```
final3 = bow2.head(20)
```

In [522]:

```
bow2.head(20)
```

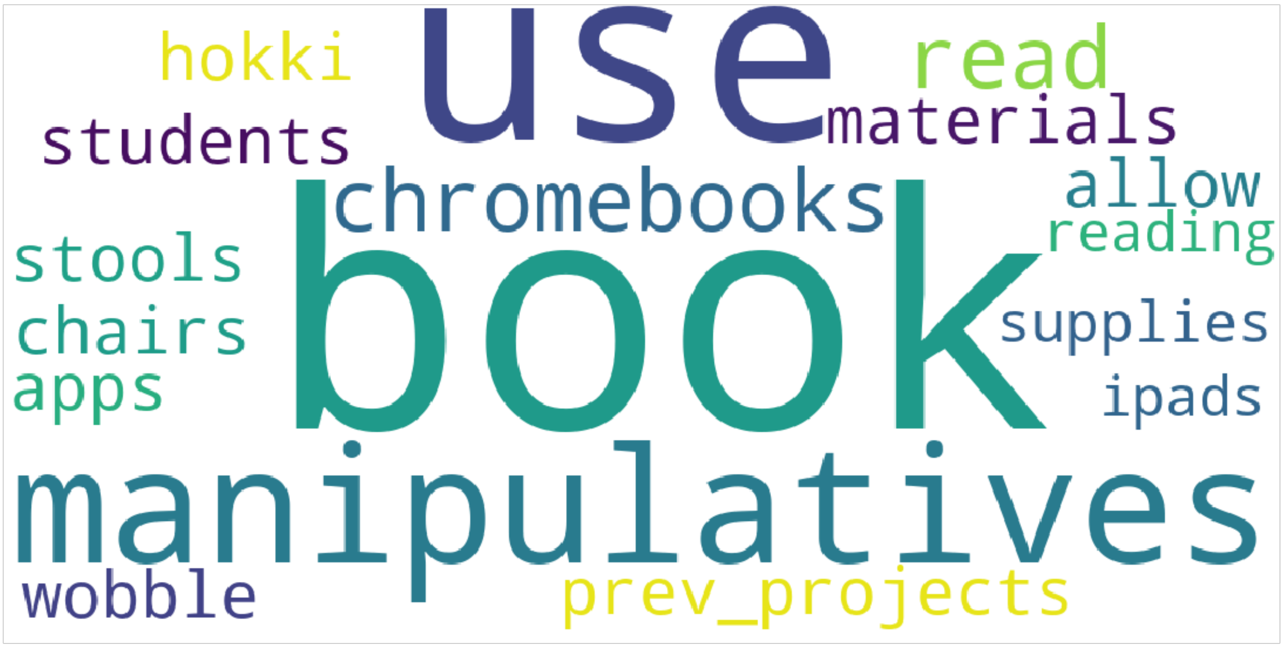
Out[522]:

	feature_names	feature_prob_estimates
10460	materials	0.021183
16192	use	0.020484
4244	books	0.014829
12880	reading	0.013258
15062	supplies	0.012769
12	prev_projects	0.011941
4948	chromebooks	0.011664
16719	wobble	0.010462
12873	read	0.009851
14796	stools	0.009619
3301	allow	0.009203
3326	also	0.008626
9518	ipads	0.007855
4236	book	0.007680
14912	students	0.007522
15412	the	0.007145
8742	hokki	0.007056
4795	chairs	0.006832
10379	manipulatives	0.006691
3531	apps	0.006588

E) WordCloud for top 20 features

In [523]:

```
from wordcloud import WordCloud

#convert list to string and generate
unique_string=(" ").join(final3['feature_names'])
wordcloud = WordCloud(width = 1000, height = 500, background_color ='white').generate(unique_string
)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("bow-gbdt"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



Set 2 : Categorical, Numerical features + Project_title(TFIDF) + Preprocessed_essay (TFIDF min_df=10)

In [524]:

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

X_tr = hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_tra
in, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
title_tfidf_train, text_tfidf_train)).tocsr()
X_te = hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test, pr
oj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, title_tfidf_te
st, text_tfidf_test)).tocsr()
```

In [525]:

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

```
Final Data matrix
((73196, 16903), (73196,))
((36052, 16903), (36052,))
==============================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 5)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 10)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
 cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 15)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 20)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Plot for Train & Cross Validation Data

In [291]:

```
x1 = [0.68185563, 0.73652587, 0.78343561, 0.83356098, 0.89585206,
      0.7963146 , 0.88325654, 0.93171969, 0.9614376 , 0.99083648,
      0.88866064, 0.96156783, 0.98712331, 0.99661058, 0.99973381,
      0.94028419, 0.98918665, 0.99799895, 0.99990567, 0.99999724]
```

In [292]:

```
x2 = [0.64434491, 0.66458129, 0.6785141 , 0.68681892, 0.69067573,
      0.64930291, 0.66634615, 0.67668473, 0.68090623, 0.68406166,
      0.64089905, 0.66098811, 0.66966531, 0.67464087, 0.67984691,
      0.62917969, 0.65115386, 0.66036358, 0.66829864, 0.67563431]
```

In [293]:

```
y1 = [10, 25, 50, 100, 250,
     10, 25, 50 ,100, 250,
     10, 25, 50, 100, 250,
     10, 25, 50, 100, 250]
```

In [294]:

```
z1 = [5, 5, 5, 5, 5,
    10, 10, 10, 10, 10,
    15, 15, 15, 15, 15,
    20, 20, 20, 20, 20]
```

In [295]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [296]:

```
data = [trace1, trace2]
```

In [297]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- GBDT - TFIDF',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [298]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='GBDT - c', height=700)
```

Out[298]:

Observations :

1) Number of estimators as 100, 250 performs decently on both Train as well as Cross Validation Data.

2) 5 as the value for maximum depth is considered. Shallow trees generally perform well for GBDT.

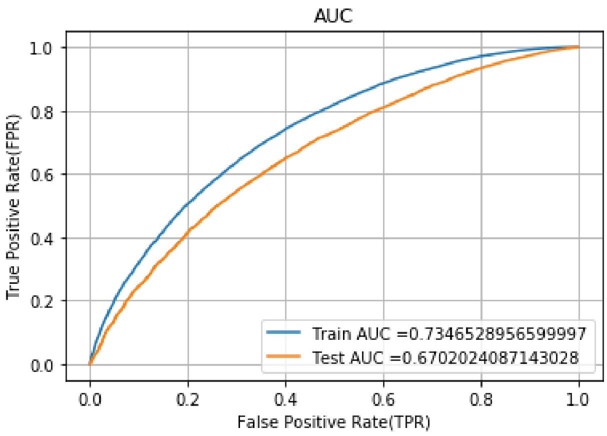
3) 250 as number of estimators is considered for training the final model.

B) Train the model using the best hyper parameter value

In [540]:

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

model = RandomForestClassifier(max_depth = 5, n_estimators = 250)

model.fit(X_tr, y_train)

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

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

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
```

```
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

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



C) Confusion Matrix

In [541]:

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

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

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

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

Train Data

In [542]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24999999796471448, 'for threshold', 0.844)
[[ 5541  5542]
 [11266 50847]]
```

In [543]:

```
conf_matr_df_train_2_gbdt = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

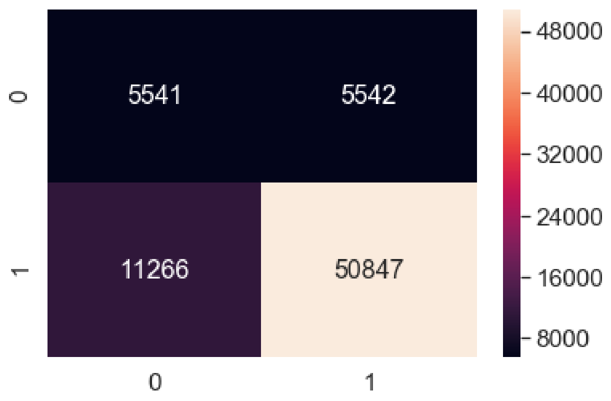
```
('the maximum value of tpr*(1-fpr)', 0.24999999796471448, 'for threshold', 0.844)
```

In [618]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_2_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[618]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a864f4610>
```



Test Data

In [544]:

```
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)', 0.24999999161092995, 'for threshold', 0.85)
[[ 4012  1447]
 [15163 15430]]
```

In [545]:

```
conf_matr_df_test_2_gbdt = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds
, test_fpr, test_fpr)), range(2),range(2))
```

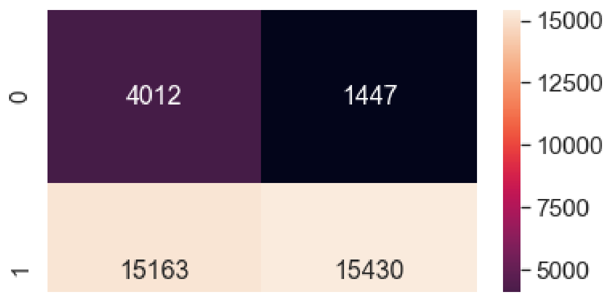
```
('the maximum value of tpr*(1-fpr)', 0.24999999161092995, 'for threshold', 0.85)
```

In [617]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_2_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[617]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a86121810>
```



D) Extracting top 20 features

In [546]:

```
ddd = model.feature_importances_
```

In [547]:

```
ddd.shape
```

Out[547]:

```
(16903,)
```

In [548]:

```
important_tfidf2_features_value = list(ddd[::])
```

In [549]:

```
len(tfidf_features_names)
```

Out[549]:

```
16903
```

In [550]:

```
final_tfidf_features2 = pd.DataFrame({'feature_prob_estimates' : important_tfidf2_features_value,
'feature_names' : tfidf_features_names})
```

In [551]:

```
tfidf2 = final_tfidf_features2.sort_values(by = ['feature_prob_estimates'], ascending = False)
```

In [552]:

```
final4 = tfidf2.head(20)
```

In [553]:

```
tfidf2.head(20)
```

Out[553]:

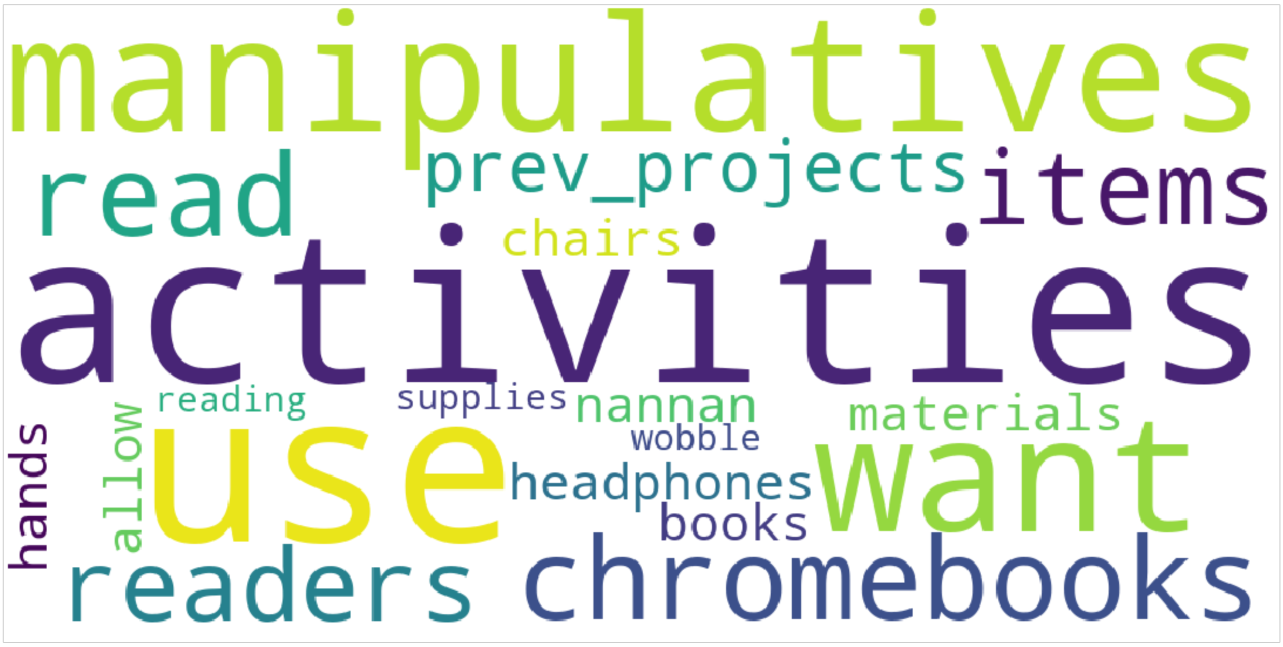
	feature_names	feature_prob_estimates
15062	supplies	0.017294
10460	materials	0.015861
12873	read	0.015680
10996	nannan	0.014087
9558	items	0.013980
4244	books	0.013662
16719	wobble	0.012422
12	prev_projects	0.008761
8515	hands	0.007675

	feature_names	feature_prob_estimates
10379	manipulatives	0.007657
4795	chairs	0.007463
12880	reading	0.007225
4948	chromebooks	0.007190
3049	activities	0.007167
16192	use	0.007137
16461	want	0.007077
3301	allow	0.006807
12877	readers	0.006678
3326	also	0.006163
8601	headphones	0.006083

E) WordCloud for top 20 features

In [554]:

```
from wordcloud import WordCloud

#convert list to string and generate
unique_string=(" ").join(final4['feature_names'])
wordcloud = WordCloud(width = 1000, height = 500, background_color ='white').generate(unique_string
)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("tfidf-gbdt"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



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

In [555]:

```
X_tr = np.hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_
train, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
avg_w2v_vectors_train2d, avg_w2v_vectors_titles_train2d))
```

```
X_te = np.hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test,
proj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, avg_w2v_vector
s_test2d, avg_w2v_vectors_titles_test2d))
```

In [556]:

```
print(X_tr.shape)
print(X_te.shape)

print("="*100)
```

```
(73196, 619)
(36052, 619)
====================================================================================================
```

A) GridSearchCV (K fold Cross Validation)

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 2)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 5)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

In [ ]:

```
gbdt = GradientBoostingClassifier(max_depth = 10)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }
```

```
clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [ ]:

```
train_auc
```

In [ ]:

```
cv_auc
```

Unable to carry out for more depth as my laptop is crashing due to low memory issues. The previous calculation took nearly 10 hours. Moreover Shallow trees are used in most cases for GBDT.

Plot for Train & Cross Validation Data

In [299]:

```
x1 = [0.64592223, 0.67092147, 0.69021391, 0.71261743, 0.7489713,
      0.71735295, 0.76664657, 0.81348949, 0.86699111, 0.945333,
      0.93382633, 0.98754178, 0.99887753, 0.99999036, 0.99999992]
```

In [300]:

```
x2 = [0.63104713, 0.65152349, 0.66550835, 0.67574236, 0.68565279,
      0.65071475, 0.66605464, 0.67614747, 0.68278406, 0.68486847,
      0.63231531, 0.65195024, 0.65869979, 0.66893646, 0.67398144]
```

In [301]:

```
y1 = [10, 25, 50, 100, 250,
     10, 25, 50 ,100, 250,
     10, 25, 50, 100, 250]
```

In [302]:

```
z1 = [2, 2, 2, 2, 2,
      5, 5, 5, 5, 5,
      10, 10, 10, 10, 10]
```

In [303]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [304]:

```
data = [trace1, trace2]
```

In [305]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- GBDT - AVG W2V',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [306]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='GBDT - e', height=700)
```

Out[306]:

Observations :

1) Number of estimators as 100, 250 performs decently on both Train as well as Cross Validation Data.

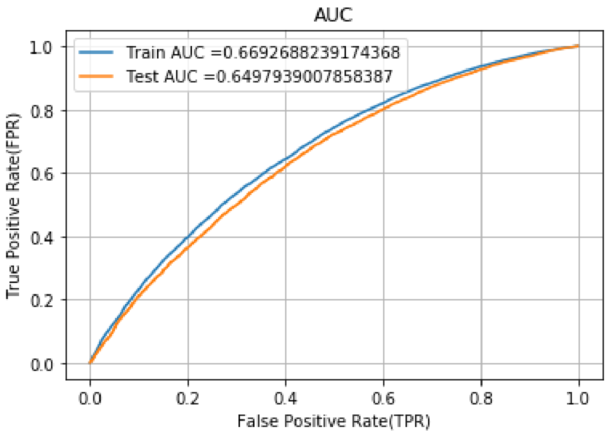
2) 2 as the value for maximum depth is considered. Shallow trees generally perform well for GBDT.

3) 250 as number of estimators is considered for training the final model.

B) Train the model using the best hyper parameter value

In [574]:

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

model = RandomForestClassifier(max_depth = 2, n_estimators = 250)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [575]:

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

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

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

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

Train Data

In [576]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.2499999979647145, 'for threshold', 0.842)
[[ 5542  5541]
 [15943 46170]]
```

In [577]:

```
conf_matr_df_train_3_gbdt = 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)', 0.2499999979647145, 'for threshold', 0.842)
```

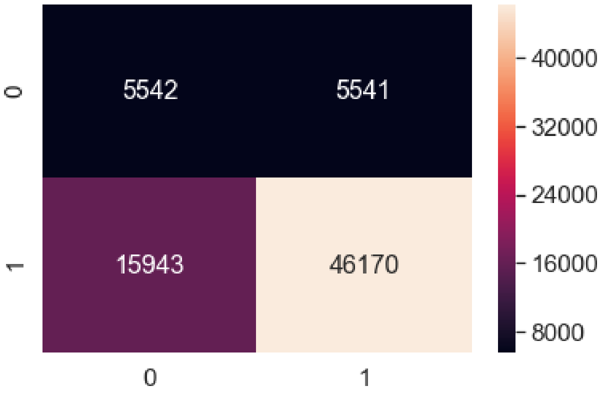
In [616]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_3_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[616]:

Out[616]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a85daf4d0>
```



Test Data

In [578]:

```
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)', 0.24999999161092998, 'for threshold', 0.852)
[[ 4048  1411]
 [16958 13635]]
```

In [579]:

```
conf_matr_df_test_3_gbdt = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds
, test_fpr, test_fpr)), range(2),range(2))
```

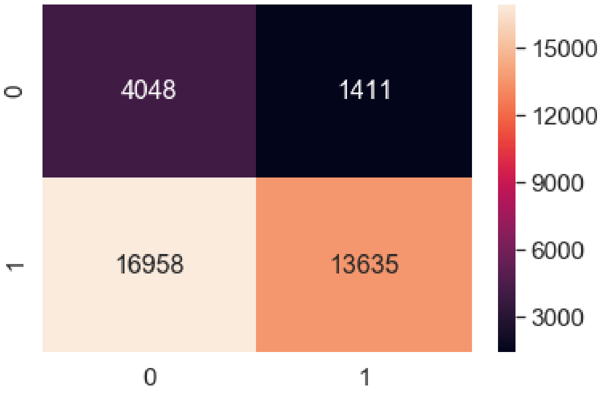
```
('the maximum value of tpr*(1-fpr)', 0.24999999161092998, 'for threshold', 0.852)
```

In [615]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_3_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[615]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a43d37d10>
```



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

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

In [580]:

```
X_tr = np.hstack((cat_0_train, cat_1_train, subcat_0_train, subcat_1_train, state_0_train, state_1_
train, proj_grade_0_train, proj_grade_1_train, teacher_prefix_0_train, teacher_prefix_1_train,
price_train, quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train, e
ssay_sent_pos_train, essay_sent_neg_train, essay_sent_neu_train, essay_sent_comp_train,
tfidf_w2v_vectors_train2d, tfidf_w2v_vectors_titles_train2d))
X_te = np.hstack((cat_0_test, cat_1_test, subcat_0_test, subcat_1_test, state_0_test, state_1_test,
proj_grade_0_test, proj_grade_1_test, teacher_prefix_0_test, teacher_prefix_1_test, price_test,
quantity_test, prev_projects_test, title_word_count_test, essay_word_count_test,
essay_sent_pos_test, essay_sent_neg_test, essay_sent_neu_test, essay_sent_comp_test, tfidf_w2v_vect
ors_test2d, tfidf_w2v_vectors_titles_test2d))

print(X_tr.shape)
print(X_te.shape)
print("="*100)
print("="*100)
```

```
(73196, 619)
(36052, 619)
====================================================================================================

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

A) GridSearchCV (K fold Cross Validation)

In [581]:

```
gbdt = GradientBoostingClassifier(max_depth = 2)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [582]:

```
train_auc
```

Out[582]:

```
array([0.53080052, 0.53246455, 0.53312984, 0.53393831, 0.53422282])
```

In [583]:

```
cv_auc
```

Out[583]:

```
array([0.52938404, 0.529733  , 0.52907367, 0.52925354, 0.52948713])
```

In [584]:

```
gbdt = GradientBoostingClassifier(max_depth = 5)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [585]:

```
train_auc
```

Out[585]:

```
array([0.5331676 , 0.53406131, 0.53431946, 0.53438263, 0.53438361])
```

In [586]:

```
cv_auc
```

Out[586]:

```
array([0.52949363, 0.52911152, 0.52872403, 0.52908516, 0.52914161])
```

In [587]:

```
gbdt = GradientBoostingClassifier(max_depth = 10)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [588]:

```
train_auc
```

Out[588]:

```
array([0.53374037, 0.53436044, 0.53438361, 0.53438361, 0.53438361])
```

In [589]:

```
cv_auc
```

Out[589]:

```
array([0.52934568, 0.52892982, 0.52944466, 0.52904353, 0.52890247])
```

In [590]:

```
gbdt = GradientBoostingClassifier(max_depth = 15)

parameters = {'n_estimators': [10, 25, 50, 100, 250] }

clf = GridSearchCV(gbdt, parameters, cv= 3, scoring='roc_auc')

clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [591]:

```
train_auc
```

Out[591]:

```
array([0.5343807 , 0.5343836 , 0.53438361, 0.53438361, 0.53438361])
```

In [592]:

```
cv_auc
```

Out[592]:

```
array([0.52961642, 0.52954167, 0.52960136, 0.52949611, 0.52900793])
```

Plot for Train & Cross Validation Data

In [307]:

```
x1 = [0.53080052, 0.53246455, 0.53312984, 0.53393831, 0.53422282,
      0.5331676 , 0.53406131, 0.53431946, 0.53438263, 0.53438361,
      0.53374037, 0.53436044, 0.53438361, 0.53438361, 0.53438361,
      0.5343807 , 0.5343836 , 0.53438361, 0.53438361, 0.53438361]
```

In [308]:

```
x2 = [0.52938404, 0.529733  , 0.52907367, 0.52925354, 0.52948713,
      0.52949363, 0.52911152, 0.52872403, 0.52908516, 0.52914161,
      0.52934568, 0.52892982, 0.52944466, 0.52904353, 0.52890247,
      0.52961642, 0.52954167, 0.52960136, 0.52949611, 0.52900793]
```

In [309]:

```
y1 = [10, 25, 50, 100, 250,
     10, 25, 50 ,100, 250,
     10, 25, 50, 100, 250,
     10, 25, 50, 100, 250]
```

In [310]:

```
z1 = [2, 2, 2, 2, 2,
      5, 5, 5, 5, 5,
      10, 10, 10, 10, 10,
      15, 15, 15, 15, 15]
```

In [311]:

```
trace1 = go.Scatter3d(
    x=x1, y=y1, z=z1,
    name = 'Train',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [312]:

```
data = [trace1, trace2]
```

In [313]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- GBDT - TFIDF W2V',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [314]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='GBDT - g', height=700)
```

Out[314]:

Observations :

1) Number of estimators as 100, 250 performs decently on both Train as well as Cross Validation Data.

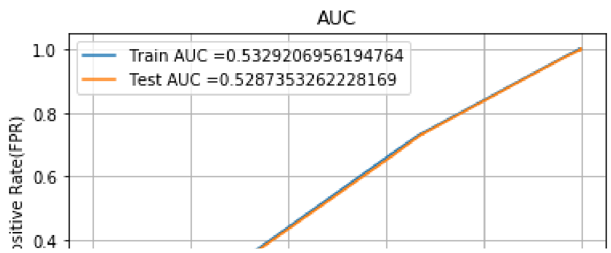
2) 5 as the value for maximum depth is considered. Shallow trees generally perform well for GBDT.

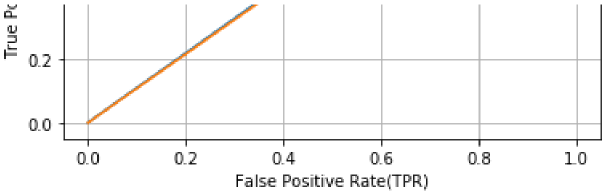
3) 250 as number of estimators is considered for training the final model.

B) Train the model using the best hyper parameter value

In [607]:

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

model = RandomForestClassifier(max_depth = 5, n_estimators = 250)

model.fit(X_tr, y_train)

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

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

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

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





C) Confusion Matrix

In [608]:

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

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

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

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

Train Data

In [609]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.23846163872283424, 'for threshold', 0.851)
[[ 4351  6732]
 [20759 41354]]
```

In [610]:

```
conf_matr_df_train_4_gbdt = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

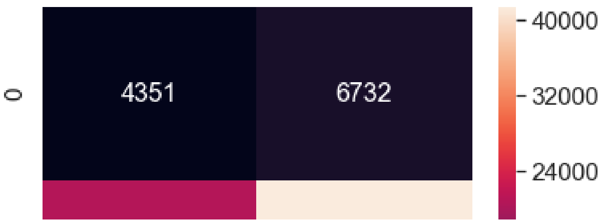
```
('the maximum value of tpr*(1-fpr)', 0.23846163872283424, 'for threshold', 0.851)
```

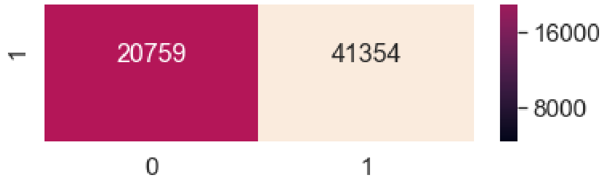
In [614]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_4_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[614]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a449d3ad0>
```





Test Data

In [611]:

```
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)', 0.2369549205939287, 'for threshold', 0.879)
[[ 5455     4]
 [30567    26]]
```

In [612]:

```
conf_matr_df_test_4_gbdt = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds
, test_fpr, test_fpr)), range(2),range(2))
```

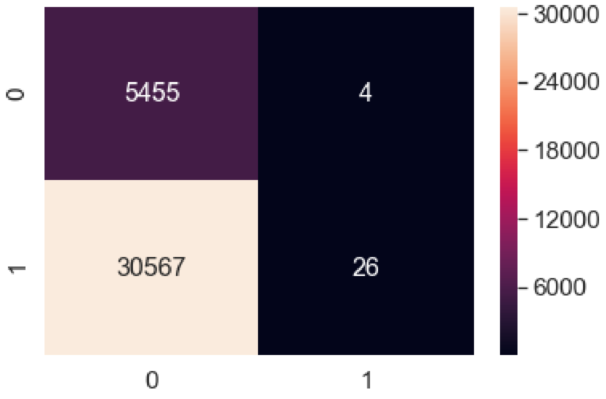
```
('the maximum value of tpr*(1-fpr)', 0.2369549205939287, 'for threshold', 0.879)
```

In [613]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4_gbdt, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[613]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a85711950>
```



5. Conclusion

In [630]:

```
# Please compare all your models using Prettytable library

# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

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

x = PrettyTable()
```

```
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameters(max depth,min samples split)", "Train AUC"
, "Test AUC"]

x.add_row(["BOW", "RF","(10, 1000)", 0.8253, 0.6829])
x.add_row(["TFIDF", "RF", "(10, 1000)", 0.8257, 0.6786])
x.add_row(["AVG W2V", "RF", "(10, 250)", 0.9094, 0.6722])
x.add_row(["TFIDF W2V", "RF", "(500, 10)", 0.5337, 0.5273])

x.add_row(["----- ---", "----", "-------------------------------", "---------", "--------"])

x.add_row(["BOW", "GBDT","(5, 500)", 0.7444, 0.6779])
x.add_row(["TFIDF", "GBDT", "(5, 250)", 0.7346, 0.6702])
x.add_row(["AVG W2V", "GBDT", "(2, 250)", 0.6692, 0.6498])
x.add_row(["TFIDF W2V", "GBDT", "(5, 250)", 0.5329, 0.5287])



print(x)
```

```
+------------+-------+----------------------------------------------+-----------+----------+
| Vectorizer | Model | Hyperparameters(max depth,min samples split) | Train AUC | Test AUC |
+------------+-------+----------------------------------------------+-----------+----------+
|    BOW     |   RF  |                  (10, 1000)                  |   0.8253  |  0.6829  |
|   TFIDF    |   RF  |                  (10, 1000)                  |   0.8257  |  0.6786  |
|  AVG W2V   |   RF  |                  (10, 250)                   |   0.9094  |  0.6722  |
| TFIDF W2V  |   RF  |                  (500, 10)                   |   0.5337  |  0.5273  |
| ----- ---  |  ---- |        -------------------------------       | --------- | -------- |
|    BOW     |  GBDT |                   (5, 500)                   |   0.7444  |  0.6779  |
|   TFIDF    |  GBDT |                   (5, 250)                   |   0.7346  |  0.6702  |
|  AVG W2V   |  GBDT |                   (2, 250)                   |   0.6692  |  0.6498  |
| TFIDF W2V  |  GBDT |                   (5, 250)                   |   0.5329  |  0.5287  |
+------------+-------+----------------------------------------------+-----------+----------+
```