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.

# DonorsChoose

## About the DonorsChoose Data Set

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

| Feature | |
|---|---|
| **`project_id`** | A unique identifier for the proposed project |
| **`project_title`** | Title of tl<br>• `Art Wil`<br>• |
| **`project_grade_category`** | Grade level of students for which the project is targetec<br>•<br>•<br>•<br>• |

| Feature | |
|---|---|
| **project_subject_categories** | One or more (comma-separated) subject categories f following enur<br>•<br>•<br>•<br>•<br>• Li<br>•<br>•<br>•<br>•<br>•<br>• Literacy & Languag |
| **school_state** | State where school is located ([Two- (https://en.wikipedia.org/wiki/List_of_U.S._state_abbrevia](https://en.wikipedia.org/wiki/List_of_U.S._state_abbrevia) |
| **project_subject_subcategories** | One or more (comma-separated) subject subcat<br>•<br>• Literature & Writing |
| **project_resource_summary** | An explanation of the resources needed for t<br>• My students need hands on literacy ma sen |
| **project_essay_1** | F |
| **project_essay_2** | Sec |
| **project_essay_3** | Tl |
| **project_essay_4** | Fo |
| **project_submitted_datetime** | Datetime when project application was submitted. **Ex** |
| **teacher_id** | A unique identifier for the teacher of the propo bdf8baa8fedef6b |
| **teacher_prefix** | Teacher's title. One of the followin<br>•<br>•<br>•<br>•<br>•<br>• |
| **teacher_number_of_previously_posted_projects** | Number of project applications previously submitte |

[*] 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 [4]:

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

import sqlite3
import pandas as pd
import numpy as np
import nltk
import math
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 chart_studio import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter

from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier

import dill #To store session variables
#https://stackoverflow.com/questions/34342155/how-to-pickle-or-store-jupyter-ipy
```

## 1.1 Reading Data

In [5]:

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

In [6]:

```
project_data_1=project_data[project_data['project_is_approved']==1]
project_data_0=project_data[project_data['project_is_approved']==0]

print(project_data_1.shape)
print(project_data_0.shape)

#Creating a dataset of 0.2k points containg points from both the classes
project_data = project_data_1[0:33458].append(project_data_0[0:16542])
print(project_data['project_is_approved'].value_counts())
print(project_data.shape)
```

```
(92706, 17)
(16542, 17)
1    33458
0    16542
Name: project_is_approved, dtype: int64
(50000, 17)
```

In [7]:

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

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

In [8]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/408
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_da

#sort dataframe based on time pandas python: https://stackoverflow.com/a/4970249
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/13148611/4084
project_data = project_data[cols]

project_data.head(2)
```

Out[8]:

|  | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Dat |
|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 201<br>04-2<br>00:53:0 |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 201<br>04-2<br>01:10:0 |

In [9]:

```
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[9]:

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

## 1.2 preprocessing of `project_subject_categories`

In [10]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-
cat_list = []
for i in categories:
    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",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
        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 [11]:

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

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

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",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trail
        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/22898595/4
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

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

## 1.3 Text preprocessing

In [12]:

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

In [13]:
```
project_data.head(2)
```

Out[13]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Dat |
|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 201<br>04-2<br>00:53:0 |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 201<br>04-2<br>01:10:0 |

In [14]:

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

```
60302it [00:19, 8079.97it/s]

I recently read an article about giving students a choice about how they learn.
We already set goals; why not let them choose where to sit, and give them optio
ns of what to sit on?I teach at a low-income (Title 1) school. Every year, I ha
ve a class with a range of abilities, yet they are all the same age. They learn
differently, and they have different interests. Some have ADHD, and some are fa
st learners. Yet they are eager and active learners that want and need to be ab
le to move around the room, yet have a place that they can be comfortable to co
mplete their work.We need a classroom rug that we can use as a class for readin
g time, and students can use during other learning times. I have also requested
four Kore Kids wobble chairs and four Back Jack padded portable chairs so that
students can still move during whole group lessons without disrupting the clas
s. Having these areas will provide these little ones with a way to wiggle while
working.Benjamin Franklin once said, \"Tell me and I forget, teach me and I may
remember, involve me and I learn.\" I want these children to be involved in the
ir learning by having a choice on where to sit and how to learn, all by giving
them options for comfortable flexible seating.
==================================================
A unit that has captivated my students and one that has forced them to seek out
further resources on their own, is the Holocaust unit. This unit not only broug
ht their critical thinking skills to life, but it brought out their passion, lo
ve, dislikes, and fears about wars and prejudices to light.My 8th graders stude
nts live in a high-poverty school district and live in a large, urban area. The
y are reluctant readers unless introduced to life-changing books. This book mad
e my students work hard in improving their reading and writing skills. The Holo
caust unit brought compassion and history to life. The students wanted to read
ahead and learn about tolerance and discrimination.These materials will be used
in-class. We were read, discuss, and think critically about the world event tha
t still affects us. The Holocaust is part of our history and its victims and su
rvivors deserve our knowledge and recognition of the hardships they endured. We
will be researching the victims and survivors of the Holocaust, read non-fictio
nal text, watch documentaries, and overall broaden our education on this histor
ic event.This project will greatly benefit my students. It will not only help t
hem academically and help prepare them for high school, but it will make them w
ell-rounded individuals who better understand the power of tolerance and war. P
lease know that you have made a positive impact on my students and we sincerely
thank you in advance.
==================================================
Why learn coding in the 5th grade? I teach science through STEM. Instead of usi
ng only spaghetti and marshmallows for engineering, I want the students to use
coding. It is time to use interactive approaches to solving problems and testin
g ideas using real-life skills students may use in the future.My school is loca
ted in Jupiter, Florida, and we are an intermediate center, servicing only 3rd-
5th grades. I teach 3 classes of science to 5th grade students. My students are
a mix of gifted and advanced 10 and 11 year olds, of at which 20% have some typ
e of learning challenge, such as ADD or autism. They all have insatiable thirst
s for science. Most come to me with limited knowledge of science, but a tremend
ous understanding of technology. Most have a computer in their home and are fam
iliar with tablets and smartphones. At least 1/3 of my students know Scratch an
```

```
d JavaScript programming.\r\nMy goal is to pair my students incredible knowledg
e of technology with science concepts to deepen their understandings of that co
ncept. I also want to expose all of my students with coding since research has
shown that more computer coders will be needed for future jobs than ever befor
e.\r\nWhat I envision is the students working in groups using the specific codi
ng device, Raspberry Pi, to create codes to manipulate the sensors. These will
be attached to laptops at each table.  In the beginning, I will use the device
to teach basic coding to solve a problem. The students will be required to lear
n how to set up the motherboard during this process. Then I will move on to usi
ng it with my science content. One activity I found intriguing is the weather s
tation sensors. The students work together to find a way to code for each of th
ese sensors to turn on and off and collect, store, and manipulate the data. Thi
s will become a part of my weather unit.By pairing this type of technology with
science, I feel my lesson then is reflecting how science works in the real worl
d. Technology and science go hand in hand and I want my students to experience
that one influences the other. I want them to experience that scientists use te
chnology as a tool to further deepen their understanding of concepts. I also wa
nt both my boys and girls to learn and understanding coding as a viable future
career.
```

In [15]:

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

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

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

In [16]:
```
sent = decontracted(project_data['essay'].values[2000])
print(sent)
print("="*50)
```

```
My school is in a low socio-economic area with a high ELL population. The stude
nts in my classroom do not have a lot of academic practice outside of the schoo
l day. They love coming to school everyday and are eager to learn. They work ve
ry hard and are so excited when they master new concepts.  \r\n   At my school 
site we strive to make the most of every minute during the school day in order 
to ensure students are able to learn and feel successful. We know that the time
 we have with them is very precious!I am asking for the mini white boards and re
usable write and wipe pockets in order to help me monitor my students thinking 
and learning. Often times, when work is done on worksheets the feedback to stud
ents is not meaningful because it can take awhile to give each student individu
al feed back. The white boards and write and wipe pockets will give students a 
way to show written responses while we are gathered at the carpet together. Thi
s will allow me to give immediate feedback to students and then can modify thei
r responses right then and there. This will lead to more meaningful learning an
d processing.nannan
==================================================
```

In [17]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-bre
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My school is in a low socio-economic area with a high ELL population. The stude
nts in my classroom do not have a lot of academic practice outside of the schoo
l day. They love coming to school everyday and are eager to learn. They work ve
ry hard and are so excited when they master new concepts.       At my school si
te we strive to make the most of every minute during the school day in order to
 ensure students are able to learn and feel successful. We know that the time we
 have with them is very precious!I am asking for the mini white boards and reusa
ble write and wipe pockets in order to help me monitor my students thinking and 
learning. Often times, when work is done on worksheets the feedback to students 
is not meaningful because it can take awhile to give each student individual fe
ed back. The white boards and write and wipe pockets will give students a way t
o show written responses while we are gathered at the carpet together. This wil
l allow me to give immediate feedback to students and then can modify their res
ponses right then and there. This will lead to more meaningful learning and pro
cessing.nannan
```

In [18]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My school is in a low socio economic area with a high ELL population The studen
ts in my classroom do not have a lot of academic practice outside of the school
day They love coming to school everyday and are eager to learn They work very h
ard and are so excited when they master new concepts At my school site we striv
e to make the most of every minute during the school day in order to ensure stu
dents are able to learn and feel successful We know that the time we have with
them is very precious I am asking for the mini white boards and reusable write
and wipe pockets in order to help me monitor my students thinking and learning
Often times when work is done on worksheets the feedback to students is not mea
ningful because it can take awhile to give each student individual feed back Th
e white boards and write and wipe pockets will give students a way to show writ
ten responses while we are gathered at the carpet together This will allow me t
o give immediate feedback to students and then can modify their responses right
then and there This will lead to more meaningful learning and processing nannan
```

In [19]:
```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itsel
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'tha
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'ha
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'th
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'of
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than'
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should'v
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "d
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma'
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn
            'won', "won't", 'wouldn', "wouldn't"]
```

In [20]:
```python
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
 87%|████████████████████████████████████████████████████████████████▏
| 43492/50000 [00:25<00:03, 1724.43it/s]
 87%|████████████████████████████████████████████████████████████████▉
| 43669/50000 [00:25<00:03, 1734.10it/s]
 88%|█████████████████████████████████████████████████████████████████
| 43843/50000 [00:25<00:03, 1732.06it/s]
 88%|█████████████████████████████████████████████████████████████████▏
| 44017/50000 [00:25<00:03, 1730.61it/s]

 88%|█████████████████████████████████████████████████████████████████▋
| 44191/50000 [00:25<00:03, 1729.69it/s]
 89%|██████████████████████████████████████████████████████████████████
| 44364/50000 [00:25<00:03, 1720.86it/s]
 89%|██████████████████████████████████████████████████████████████████▋
| 44537/50000 [00:25<00:03, 1714.68it/s]
 89%|██████████████████████████████████████████████████████████████████▏
| 44712/50000 [00:25<00:03, 1721.46it/s]
 90%|██████████████████████████████████████████████████████████████████▋
| 44885/50000 [00:25<00:02, 1715.18it/s]
 90%|███████████████████████████████████████████████████████████████████
| 45059/50000 [00:26<00:02, 1718.79it/s]
```

In [21]:

```
#adding a new column for the processed essay text
project_data['clean_essay']=preprocessed_essays
print(project_data.columns)

# after preprocesing
preprocessed_essays[2000]
```

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

Out[21]:

```
'school low socio economic area high ell population students classroom not lot
academic practice outside school day love coming school everyday eager learn wo
rk hard excited master new concepts school site strive make every minute school
day order ensure students able learn feel successful know time precious asking
mini white boards reusable write wipe pockets order help monitor students think
ing learning often times work done worksheets feedback students not meaningful
take awhile give student individual feed back white boards write wipe pockets g
ive students way show written responses gathered carpet together allow give imm
ediate feedback students modify responses right lead meaningful learning proces
sing nannan'
```

## 1.4.1 Preprocessing of `project_title`

In [22]:

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

Out[22]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Dat |
|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 2016<br>04-2<br>00:53:0 |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 2016<br>04-2<br>01:10:0 |

In [23]:

```
#Printing a few random review summaries

for i in range(1,3000,1000):
    sent = project_data['project_title'].values[i]
    print(sent,'--- Row No:',i)
    print("="*50)
```

```
Breakout Box to Ignite Engagement! --- Row No: 1
==================================================
Cozy Classroom Carpet for Learning --- Row No: 1001
==================================================
Community Circle Carpet: A Place to Call Home! --- Row No: 2001
==================================================
```

In [24]:
```
# The above random records show that there are no URLs or HTML tags, but we will

from tqdm import tqdm #for status bar
from bs4 import BeautifulSoup #for html tags

preprocessed_title=[]

for title in tqdm(project_data['project_title'].values):
    # To remove urls - https://stackoverflow.com/a/40823105/4084039
    title = re.sub(r"http\S+", "", title)

    # To remove all HTML tags
    #https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-re
    title = BeautifulSoup(title, 'lxml').get_text()

    # To split contractions - refer decontracted function defined above
    title = decontracted(title)

    # To remove alphanumerics (words with numbers in them) - https://stackoverfl
    title = re.sub("\S*\d\S*", "", title).strip()

    # To remove special characters - https://stackoverflow.com/a/5843547/4084039
    title = re.sub('[^A-Za-z]+', ' ', title)

    # To remove stop words from the summaries and convert to lowercase
    title = ' '.join(e.lower() for e in title.split() if e.lower() not in stopwo
    preprocessed_title.append(title.strip())

#adding a new column for cleaned titles
project_data['clean_title']=preprocessed_title
print(project_data.columns)
```

```
 99%|████████████████████████████████████████████████████████████
██ | 49643/50000 [00:15<00:00, 3389.30it/s]
100%|████████████████████████████████████████████████████████████
███| 49985/50000 [00:15<00:00, 3397.99it/s]
100%|████████████████████████████████████████████████████████████
███| 50000/50000 [00:15<00:00, 3274.63it/s]




Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title'],
      dtype='object')
```

## 1.4.2 Preprocessing of `teacher_prefix`

In [25]:

```
#replacing Nan values with 'Unknown'
project_data['teacher_prefix']=project_data['teacher_prefix'].replace(np.nan,'Unl
```

### 1.4.3 Combining resource_data with project_data

In [26]:

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

### 1.4.4 Adding word counts for Title and Essay

In [27]:

```
#https://stackoverflow.com/questions/54397096/how-to-do-word-count-on-pandas-data

project_data['title_wc'] = project_data['clean_title'].str.count(' ')+1

project_data['essay_wc'] = project_data['clean_essay'].str.count(' ')+1

project_data.columns
```

Out[27]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title', 'price', 'quantity', 'title_wc', 'essay_wc'],
      dtype='object')
```

### 1.4.5 Adding sentiment scores for each essay

In [28]:

```
#http://t-redactyl.io/blog/2017/04/using-vader-to-handle-sentiment-analysis-with

import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

nltk.download('vader_lexicon')

project_data['senti_score'] = 0
project_data['senti_score'] = project_data['senti_score'].astype(float)

anlyzr = SentimentIntensityAnalyzer()

for index in project_data.index:
  project_data.at[index, 'senti_score'] = anlyzr.polarity_scores(project_data.at

print(project_data.columns)
```

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

Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title', 'price', 'quantity', 'title_wc', 'essay_wc',
       'senti_score'],
      dtype='object')
```

In [29]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
analyzer = SentimentIntensityAnalyzer()
neg=[];pos=[];neu=[]; compound = []

for i in tqdm(range(len(project_data['clean_essay']))):
    sentiment_scores = analyzer.polarity_scores(project_data['clean_essay'][i])
    neg.append(sentiment_scores['neg'])
    pos.append(sentiment_scores['pos'])
    neu.append(sentiment_scores['neu'])
    compound.append(sentiment_scores['compound'])
```

```
  0%|
| 0/50000 [00:00<?, ?it/s]
  0%|
| 51/50000 [00:00<01:39, 501.35it/s]
  0%|▏
| 107/50000 [00:00<01:36, 515.38it/s]
  0%|▏
| 159/50000 [00:00<01:36, 515.62it/s]
  0%|▎
| 214/50000 [00:00<01:35, 521.41it/s]
  1%|▍
| 267/50000 [00:00<01:35, 521.29it/s]
  1%|▍
| 322/50000 [00:00<01:34, 526.95it/s]
  1%|▍
| 370/50000 [00:00<01:37, 509.10it/s]
  1%|▌
| 424/50000 [00:00<01:36, 515.44it/s]
```

In [30]:

```
#new columns indicating the sentiment score of each project essay
project_data['neg'] = neg
project_data['neu'] = neu
project_data['pos'] = pos
project_data['compound'] = compound
```

# 1.5 Preparing data for models

In [31]:

```
project_data.columns
```

Out[31]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title', 'price', 'quantity', 'title_wc', 'essay_wc',
       'senti_score', 'neg', 'neu', 'pos', '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
```

In [32]:

```
project_data.drop(labels='senti_score',inplace=True,axis=1)
```

# 2.GBDT

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

In [33]:

```
from sklearn.model_selection import train_test_split

import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)

#Checking if there are any values other than 0 and 1
project_data['project_is_approved'].unique()

#https://answers.dataiku.com/2352/split-dataset-by-stratified-sampling
df_train, df_test = train_test_split(project_data, test_size = 0.3, stratify=proj
print(df_train.shape,df_test.shape)
```

```
(35000, 28) (15000, 28)
```

## 2.2 Make Data Model Ready: encoding numerical, categorical features

### 2.2.1 Vectorizing Categorical data using class probabilities (Response Coding)

```
In [34]: print(df_train.columns)
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title', 'price', 'quantity', 'title_wc', 'essay_wc', 'neg',
       'neu', 'pos', 'compound'],
      dtype='object')
```

#### 2.2.1.1 Feature encoding for categories

In [35]:

```
#https://stackoverflow.com/questions/3839729/count-unique-values-with-pandas-per

# Fetching unique value counts for each class
clean_cat_count = pd.DataFrame()
clean_cat_count[1] = df_train['clean_categories'].where(df_train['project_is_appr
clean_cat_count[0] = df_train['clean_categories'].where(df_train['project_is_appr

#Replacing nan value counts with zeros
clean_cat_count[1]=clean_cat_count[1].replace(np.nan,0)
clean_cat_count[0]=clean_cat_count[0].replace(np.nan,0)

#print(clean_cat_count)

#Calculating probs for each class
for i in clean_cat_count.iterrows():
  clean_cat_count['1_prob'] = clean_cat_count[1]/(clean_cat_count[1]+clean_cat_co
  clean_cat_count['0_prob'] = clean_cat_count[0]/(clean_cat_count[1]+clean_cat_co

#print(clean_cat_count)

#appending prob values to train data in a new column

for idx,j in clean_cat_count.iterrows():
  for indx,i in df_train.iterrows():
    if idx == df_train.at[indx, 'clean_categories']:
      df_train.at[indx, 'cat_1'] = clean_cat_count.at[idx, '1_prob']
      df_train.at[indx, 'cat_0'] = clean_cat_count.at[idx, '0_prob']

print(df_train.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix
\
21523       65163  p166386  211ee18bf18a4d132284f2de565ef18a           Mrs.
4975       102990  p194349  406518edf1c30d599de90e2055a697fc           Mrs.

      school_state                 Date project_grade_category  \
21523           KY  2016-09-09 17:28:19          Grades PreK-2
4975            GA  2016-06-26 22:40:41             Grades 3-5

                               project_title  \
21523                 Wiggle While You Work!
4975   Working in Small Groups Is a Big Deal

                                         project_essay_1  \
21523  As the librarian, I am privileged to work with...
4975   My students come from diverse backgrounds, and...

                                         project_essay_2  ...   price  \
21523  My Project\r\nMy K-5 students are active, enth...  ...   96.01
4975   My students will use this carpet each day duri...  ...  546.08

      quantity title_wc  essay_wc    neg    neu    pos  compound     cat_1  \
21523        8        2       113  0.043  0.581  0.376    0.9927  0.656489
4975         7        5       240  0.098  0.564  0.338    0.9973  0.651769

          cat_0
```

```
21523  0.343511
4975   0.348231

[2 rows x 30 columns]
```

In [36]:

```
df_train.isna().any()
```

Out[36]:

```
Unnamed: 0                                      False
id                                              False
teacher_id                                      False
teacher_prefix                                  False
school_state                                    False
Date                                            False
project_grade_category                          False
project_title                                   False
project_essay_1                                 False
project_essay_2                                 False
project_essay_3                                  True
project_essay_4                                  True
project_resource_summary                        False
teacher_number_of_previously_posted_projects    False
project_is_approved                             False
clean_categories                                False
clean_subcategories                             False
essay                                           False
clean_essay                                     False
clean_title                                     False
price                                           False
quantity                                        False
title_wc                                        False
essay_wc                                        False
neg                                             False
neu                                             False
pos                                             False
compound                                        False
cat_1                                            True
cat_0                                            True
dtype: bool
```

In [37]:

```
#appending prob values to test data in a new column. Incase the class is not par
for idx,j in clean_cat_count.iterrows():
  for indx,i in df_test.iterrows():
    if idx == df_test.at[indx, 'clean_categories']:
      df_test.at[indx, 'cat_1'] = clean_cat_count.at[idx, '1_prob']
      df_test.at[indx, 'cat_0'] = clean_cat_count.at[idx, '0_prob']

df_test['cat_1']=df_test['cat_0'].replace(np.nan,0.5)
df_test['cat_0']=df_test['cat_0'].replace(np.nan,0.5)

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix  \
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.   
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.   

      school_state                Date project_grade_category  \
33973           LA 2016-12-07 15:03:46             Grades 3-5   
27635           TX 2016-10-16 21:20:21          Grades PreK-2   

                                          project_title  \
33973                                Silence is Golden!   
27635  Robotics in the classroom. Bring on the IPads!   

                                         project_essay_1  \
33973  My school is an at risk school located in the ...   
27635  As a teacher in a low-income/high poverty scho...   

                                         project_essay_2  ...    price  \
33973  Silence is golden!  My students just received ...  ...   134.90   
27635  My students' lives will be changed, because th...  ...  1226.45   

      quantity title_wc  essay_wc    neg    neu    pos compound     cat_1  \
33973        3        2       118  0.076  0.579  0.345   0.9917  0.327586   
27635        3        4       140  0.031  0.660  0.309   0.9911  0.382998   

          cat_0  
33973  0.327586  
27635  0.382998  

[2 rows x 30 columns]
```

In [38]:

```
df_train['cat_1']=df_train['cat_1'].replace(np.nan,0.5)
df_train['cat_0']=df_train['cat_0'].replace(np.nan,0.5)
```

### 2.2.1.2 Feature encoding for subcategories

In [39]:

```
#https://stackoverflow.com/questions/3839729/count-unique-values-with-pandas-per

# Fetching unique value counts for each class
clean_subcat_count = pd.DataFrame()
clean_subcat_count[1] = df_train['clean_subcategories'].where(df_train['project_
clean_subcat_count[0] = df_train['clean_subcategories'].where(df_train['project_

#Replacing nan value counts with zeros
clean_subcat_count[1]=clean_subcat_count[1].replace(np.nan,0)
clean_subcat_count[0]=clean_subcat_count[0].replace(np.nan,0)

#print(clean_subcat_count)

#Calculating probs for each class
for i in clean_subcat_count.iterrows():
  clean_subcat_count['1_prob'] = clean_subcat_count[1]/(clean_subcat_count[1]+cl
  clean_subcat_count['0_prob'] = clean_subcat_count[0]/(clean_subcat_count[1]+cl

#print(clean_subcat_count)

#appending prob values to train data in a new column

for idx,j in clean_subcat_count.iterrows():
  for indx,i in df_train.iterrows():
    if idx == df_train.at[indx, 'clean_subcategories']:
      df_train.at[indx, 'subcat_1'] = clean_subcat_count.at[idx, '1_prob']
      df_train.at[indx, 'subcat_0'] = clean_subcat_count.at[idx, '0_prob']

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix  \
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.

      school_state                 Date project_grade_category  \
33973           LA 2016-12-07 15:03:46             Grades 3-5
27635           TX 2016-10-16 21:20:21          Grades PreK-2

                                        project_title  \
33973                                Silence is Golden!
27635  Robotics in the classroom. Bring on the IPads!

                                         project_essay_1  \
33973  My school is an at risk school located in the ...
27635  As a teacher in a low-income/high poverty scho...

                                         project_essay_2  ...    price  \
33973  Silence is golden!  My students just received ...  ...   134.90
27635  My students' lives will be changed, because th...  ...  1226.45

      quantity title_wc  essay_wc    neg    neu    pos compound     cat_1  \
33973        3        2       118  0.076  0.579  0.345   0.9917  0.327586
27635        3        4       140  0.031  0.660  0.309   0.9911  0.382998

          cat_0
33973  0.327586
```

```
27635  0.382998

[2 rows x 30 columns]
```

In [40]:

```
#appending prob values to test data in a new column. Incase the class is not par
for idx,j in clean_subcat_count.iterrows():
  for indx,i in df_test.iterrows():
    if idx == df_test.at[indx, 'clean_subcategories']:
      df_test.at[indx, 'subcat_1'] = clean_subcat_count.at[idx, '1_prob']
      df_test.at[indx, 'subcat_0'] = clean_subcat_count.at[idx, '0_prob']

df_test['subcat_1']=df_test['subcat_1'].replace(np.nan,0.5)
df_test['subcat_0']=df_test['subcat_0'].replace(np.nan,0.5)

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix  \
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.   
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.   

      school_state                Date project_grade_category  \
33973           LA 2016-12-07 15:03:46             Grades 3-5   
27635           TX 2016-10-16 21:20:21          Grades PreK-2   

                                        project_title  \
33973                              Silence is Golden!   
27635  Robotics in the classroom. Bring on the IPads!   

                                         project_essay_1  \
33973  My school is an at risk school located in the ...   
27635  As a teacher in a low-income/high poverty scho...   

                                         project_essay_2  ... title_wc  \
33973  Silence is golden!  My students just received ...  ...        2   
27635  My students' lives will be changed, because th...  ...        4   

      essay_wc    neg    neu    pos compound     cat_1     cat_0  subcat_1  \
33973      118  0.076  0.579  0.345   0.9917  0.327586  0.327586  0.673077   
27635      140  0.031  0.660  0.309   0.9911  0.382998  0.382998  0.604038   

       subcat_0  
33973  0.326923  
27635  0.395962  

[2 rows x 32 columns]
```

In [41]:

```
df_train['subcat_1']=df_train['subcat_1'].replace(np.nan,0.5)
df_train['subcat_0']=df_train['subcat_0'].replace(np.nan,0.5)
```

### 2.2.1.3 Feature encoding for state

In [42]:

```
#https://stackoverflow.com/questions/3839729/count-unique-values-with-pandas-per

# Fetching unique value counts for each class
state_count = pd.DataFrame()
state_count[1] = df_train['school_state'].where(df_train['project_is_approved']=
state_count[0] = df_train['school_state'].where(df_train['project_is_approved']=

#Replacing nan value counts with zeros
state_count[1]=state_count[1].replace(np.nan,0)
state_count[0]=state_count[0].replace(np.nan,0)

#print(state_count)

#Calculating probs for each class
for i in state_count.iterrows():
  state_count['1_prob'] = state_count[1]/(state_count[1]+state_count[0])
  state_count['0_prob'] = state_count[0]/(state_count[1]+state_count[0])

#print(state_count)

#appending prob values to train data in a new column

for idx,j in state_count.iterrows():
  for indx,i in df_train.iterrows():
    if idx == df_train.at[indx, 'school_state']:
      df_train.at[indx, 'state_1'] = state_count.at[idx, '1_prob']
      df_train.at[indx, 'state_0'] = state_count.at[idx, '0_prob']

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix
\
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.

      school_state                Date project_grade_category  \
33973           LA 2016-12-07 15:03:46             Grades 3-5
27635           TX 2016-10-16 21:20:21          Grades PreK-2

                                        project_title  \
33973                              Silence is Golden!
27635  Robotics in the classroom. Bring on the IPads!

                                         project_essay_1  \
33973  My school is an at risk school located in the ...
27635  As a teacher in a low-income/high poverty scho...

                                         project_essay_2  ... title_wc  \
33973  Silence is golden!  My students just received ...  ...        2
27635  My students' lives will be changed, because th...  ...        4

      essay_wc    neg    neu    pos compound     cat_1     cat_0  subcat_1
\
33973      118  0.076  0.579  0.345   0.9917  0.327586  0.327586  0.673077
27635      140  0.031  0.660  0.309   0.9911  0.382998  0.382998  0.604038
```

```
       subcat_0
33973  0.326923
27635  0.395962

[2 rows x 32 columns]
```

In [43]:
```
#appending prob values to test data in a new column. Incase the class is not par
for idx,j in state_count.iterrows():
  for indx,i in df_test.iterrows():
    if idx == df_test.at[indx, 'school_state']:
      df_test.at[indx, 'state_1'] = state_count.at[idx, '1_prob']
      df_test.at[indx, 'state_0'] = state_count.at[idx, '0_prob']

df_test['state_1']=df_test['state_1'].replace(np.nan,0.5)
df_test['state_0']=df_test['state_0'].replace(np.nan,0.5)

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix  \
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.

      school_state                Date project_grade_category  \
33973           LA 2016-12-07 15:03:46            Grades 3-5
27635           TX 2016-10-16 21:20:21         Grades PreK-2

                                  project_title  \
33973                        Silence is Golden!
27635  Robotics in the classroom. Bring on the IPads!

                                     project_essay_1  \
33973  My school is an at risk school located in the ...
27635  As a teacher in a low-income/high poverty scho...

                                     project_essay_2  ...    neg    neu  \
33973  Silence is golden!  My students just received ...  ...  0.076  0.579
27635  My students' lives will be changed, because th...  ...  0.031  0.660

         pos  compound     cat_1     cat_0  subcat_1  subcat_0   state_1  \
33973  0.345    0.9917  0.327586  0.327586  0.673077  0.326923  0.638217
27635  0.309    0.9911  0.382998  0.382998  0.604038  0.395962  0.615479

        state_0
33973  0.361783
27635  0.384521

[2 rows x 34 columns]
```

### 2.2.1.4 Feature encoding for teacher_prefix

In [44]:

```
#https://stackoverflow.com/questions/3839729/count-unique-values-with-pandas-per

# Fetching unique value counts for each class
teacherprefix_count = pd.DataFrame()
teacherprefix_count[1] = df_train['teacher_prefix'].where(df_train['project_is_a
teacherprefix_count[0] = df_train['teacher_prefix'].where(df_train['project_is_a

#Replacing nan value counts with zeros
teacherprefix_count[1]=teacherprefix_count[1].replace(np.nan,0)
teacherprefix_count[0]=teacherprefix_count[0].replace(np.nan,0)

#print(teacherprefix_count)

#Calculating probs for each class
for i in teacherprefix_count.iterrows():
  teacherprefix_count['1_prob'] = teacherprefix_count[1]/(teacherprefix_count[1]
  teacherprefix_count['0_prob'] = teacherprefix_count[0]/(teacherprefix_count[1]

#print(teacherprefix_count)

#appending prob values to train data in a new column

for idx,j in teacherprefix_count.iterrows():
  for indx,i in df_train.iterrows():
    if idx == df_train.at[indx, 'teacher_prefix']:
      df_train.at[indx, 'teacherprefix_1'] = teacherprefix_count.at[idx, '1_prob
      df_train.at[indx, 'teacherprefix_0'] = teacherprefix_count.at[idx, '0_prob
```

In [45]:

```
print(df_train['teacherprefix_0'].head(2))
```

```
21523    0.32013
4975     0.32013
Name: teacherprefix_0, dtype: float64
```

In [46]:

```
#appending prob values to test data in a new column. Incase the class is not par
for idx,j in teacherprefix_count.iterrows():
  for indx,i in df_test.iterrows():
    if idx == df_test.at[indx, 'teacher_prefix']:
      df_test.at[indx, 'teacherprefix_1'] = teacherprefix_count.at[idx, '1_prob'
      df_test.at[indx, 'teacherprefix_0'] = teacherprefix_count.at[idx, '0_prob'

df_test['teacherprefix_1']=df_test['teacherprefix_1'].replace(np.nan,0.5)
df_test['teacherprefix_0']=df_test['teacherprefix_0'].replace(np.nan,0.5)

print(df_test['teacherprefix_0'].head(2))
```

```
33973    0.336594
27635    0.336594
Name: teacherprefix_0, dtype: float64
```

In [47]:

```
df_train['teacherprefix_1']=df_train['teacherprefix_1'].replace(np.nan,0.5)
df_train['teacherprefix_0']=df_train['teacherprefix_0'].replace(np.nan,0.5)
```

### 2.2.1.5 Feature encoding for project_grade_category

In [48]:

```
#https://stackoverflow.com/questions/3839729/count-unique-values-with-pandas-per

# Fetching unique value counts for each class
project_grade_category_count = pd.DataFrame()
project_grade_category_count[1] = df_train['project_grade_category'].where(df_tra
project_grade_category_count[0] = df_train['project_grade_category'].where(df_tra

#Replacing nan value counts with zeros
project_grade_category_count[1]=project_grade_category_count[1].replace(np.nan,0
project_grade_category_count[0]=project_grade_category_count[0].replace(np.nan,0

#print(project_grade_category_count)

#Calculating probs for each class
for i in project_grade_category_count.iterrows():
  project_grade_category_count['1_prob'] = project_grade_category_count[1]/(proje
  project_grade_category_count['0_prob'] = project_grade_category_count[0]/(proje

#print(project_grade_category_count)

#appending prob values to train data in a new column

for idx,j in project_grade_category_count.iterrows():
  for indx,i in df_train.iterrows():
    if idx == df_train.at[indx, 'project_grade_category']:
      df_train.at[indx, 'project_grade_category_1'] = project_grade_category_coun
      df_train.at[indx, 'project_grade_category_0'] = project_grade_category_coun

print(df_train.head(2))
```

```
                              project_title  \
21523                  Wiggle While You Work!
4975   Working in Small Groups Is a Big Deal

                                      project_essay_1  \
21523  As the librarian, I am privileged to work with...
4975   My students come from diverse backgrounds, and...

                                      project_essay_2  ...     cat_1  \
21523  My Project\r\nMy K-5 students are active, enth...  ...  0.656489
4975   My students will use this carpet each day duri...  ...  0.651769

          cat_0  subcat_1  subcat_0   state_1   state_0 teacherprefix_1  \
21523  0.343511  0.664634  0.335366  0.704492  0.295508         0.67987
4975   0.348231  0.593939  0.406061  0.651772  0.348228         0.67987

      teacherprefix_0 project_grade_category_1 project_grade_category_0
21523         0.32013                 0.668596                 0.331404
4975          0.32013                 0.680718                 0.319282
```

In [49]:

```
#appending prob values to test data in a new column. Incase the class is not part
for idx,j in project_grade_category_count.iterrows():
  for indx,i in df_test.iterrows():
    if idx == df_test.at[indx, 'project_grade_category']:
      df_test.at[indx, 'project_grade_category_1'] = project_grade_category_count
      df_test.at[indx, 'project_grade_category_0'] = project_grade_category_count

df_test['project_grade_category_1']=df_test['project_grade_category_1'].replace(n
df_test['project_grade_category_0']=df_test['project_grade_category_0'].replace(n

print(df_test.head(2))
```

```
       Unnamed: 0       id                        teacher_id teacher_prefix  \
33973      112656  p208177  3fe3dd300b49b1bcb20c5ce7c770c9c3            Ms.
27635      131772  p217130  931402be87fef92c660e68d12cc108d9            Ms.

      school_state                Date project_grade_category  \
33973           LA 2016-12-07 15:03:46             Grades 3-5
27635           TX 2016-10-16 21:20:21          Grades PreK-2

                                    project_title  \
33973                           Silence is Golden!
27635  Robotics in the classroom. Bring on the IPads!

                                         project_essay_1  \
33973  My school is an at risk school located in the ...
27635  As a teacher in a low-income/high poverty scho...

                                         project_essay_2  ...     cat_1  \
33973  Silence is golden!  My students just received ...  ...  0.327586
27635  My students' lives will be changed, because th...  ...  0.382998

          cat_0  subcat_1  subcat_0   state_1   state_0 teacherprefix_1  \
33973  0.327586  0.673077  0.326923  0.638217  0.361783        0.663406
27635  0.382998  0.604038  0.395962  0.615479  0.384521        0.663406

      teacherprefix_0 project_grade_category_1 project_grade_category_0
33973        0.336594                 0.680718                 0.319282
27635        0.336594                 0.668596                 0.331404

[2 rows x 38 columns]
```

In [50]:

```
print(len(df_train.columns), len(df_test.columns))
```

```
38 38
```

## 2.2.2 Vectorizing Numerical features

### 2.2.2.1 Vectorizing price

In [51]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/skle
from sklearn.preprocessing import StandardScaler

# Reshape your data either using array.reshape(-1, 1)
print(df_train.columns)
price_scalar = StandardScaler()
price_scalar.fit(df_train['price'].values.reshape(-1,1)) # finding the mean and 
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scal

# Now standardize the data with above maen and variance.
price_train_standardized = price_scalar.transform(df_train['price'].values.resha
price_test_standardized = price_scalar.transform(df_test['price'].values.reshape
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_essay',
       'clean_title', 'price', 'quantity', 'title_wc', 'essay_wc', 'neg',
       'neu', 'pos', 'compound', 'cat_1', 'cat_0', 'subcat_1', 'subcat_0',
       'state_1', 'state_0', 'teacherprefix_1', 'teacherprefix_0',
       'project_grade_category_1', 'project_grade_category_0'],
      dtype='object')
Mean : 312.1284854285714, Standard deviation : 377.19732859848654
```

### 2.2.2.2 Vectorizing no. of previously posted projects

In [52]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/skle
from sklearn.preprocessing import StandardScaler
import warnings
warnings.filterwarnings("ignore")

prev_proj_scalar = StandardScaler()
prev_proj_scalar.fit(df_train['teacher_number_of_previously_posted_projects'].va
print(f"Mean : {prev_proj_scalar.mean_[0]}, Standard deviation : {np.sqrt(prev_p

# Now standardize the data with above mean and variance.
prev_proj_train_standardized = prev_proj_scalar.transform(df_train['teacher_numb
prev_proj_test_standardized = prev_proj_scalar.transform(df_test['teacher_number
```

```
Mean : 10.376914285714285, Standard deviation : 26.557037133978444
```

### 2.2.2.3 Vectorizing word counts of project title

In [53]:

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

wc_title_scalar = StandardScaler()
wc_title_scalar.fit(df_train['title_wc'].values.reshape(-1,1)) # finding the mea
print(f"Mean : {wc_title_scalar.mean_[0]}, Standard deviation : {np.sqrt(wc_titl

# Now standardize the data with above mean and variance.
wc_title_train_standardized = wc_title_scalar.transform(df_train['title_wc'].valu
wc_title_test_standardized = wc_title_scalar.transform(df_test['title_wc'].value
```

```
Mean : 3.665542857142857, Standard deviation : 1.542806762140393
```

#### 2.2.2.4 Vectorizing word counts of essay text

In [54]:

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

wc_essay_scalar = StandardScaler()
wc_essay_scalar.fit(df_train['essay_wc'].values.reshape(-1,1)) # finding the mea
print(f"Mean : {wc_essay_scalar.mean_[0]}, Standard deviation : {np.sqrt(wc_essa

# Now standardize the data with above mean and variance.
wc_essay_train_standardized = wc_essay_scalar.transform(df_train['essay_wc'].valu
wc_essay_test_standardized = wc_essay_scalar.transform(df_test['essay_wc'].value
```

```
Mean : 136.5252, Standard deviation : 35.570028223451594
```

#### 2.2.2.5 Vectorizing sentimental scores of project essays

'neg', 'neu', 'pos', 'compound'

In [55]:

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

neg_score_scalar = StandardScaler()
neg_score_scalar.fit(df_train['neg'].values.reshape(-1,1)) # finding the mean and
print(f"Mean : {neg_score_scalar.mean_[0]}, Standard deviation : {np.sqrt(neg_sco

# Now standardize the data with above mean and variance.
neg_score_train_standardized = neg_score_scalar.transform(df_train['neg'].values
neg_score_test_standardized = neg_score_scalar.transform(df_test['neg'].values.re
```

```
Mean : 0.04848257142857143, Standard deviation : 0.036422845016583216
```

In [56]:

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

neu_score_scalar = StandardScaler()
neu_score_scalar.fit(df_train['neu'].values.reshape(-1,1)) # finding the mean and
print(f"Mean : {neu_score_scalar.mean_[0]}, Standard deviation : {np.sqrt(neu_sco

# Now standardize the data with above mean and variance.
neu_score_train_standardized = neu_score_scalar.transform(df_train['neu'].values
neu_score_test_standardized = neu_score_scalar.transform(df_test['neu'].values.re
```

```
Mean : 0.6680472857142857, Standard deviation : 0.07614768934532848
```

In [57]:

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

compound_score_scalar = StandardScaler()
compound_score_scalar.fit(df_train['compound'].values.reshape(-1,1)) # finding th
print(f"Mean : {compound_score_scalar.mean_[0]}, Standard deviation : {np.sqrt(co

# Now standardize the data with above mean and variance.
compound_score_train_standardized = compound_score_scalar.transform(df_train['com
compound_score_test_standardized = compound_score_scalar.transform(df_test['compo
```

```
Mean : 0.957751222857143, Standard deviation : 0.15834582202325045
```

In [58]:

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

pos_score_scalar = StandardScaler()
pos_score_scalar.fit(df_train['pos'].values.reshape(-1,1)) # finding the mean an
print(f"Mean : {pos_score_scalar.mean_[0]}, Standard deviation : {np.sqrt(pos_sc

# Now standardize the data with above mean and variance.
pos_score_train_standardized = pos_score_scalar.transform(df_train['pos'].values
pos_score_test_standardized = pos_score_scalar.transform(df_test['pos'].values.r
```

```
Mean : 0.2834720857142857, Standard deviation : 0.07832149800255407
```

#### 2.2.2.6 Vectorizing Quantity

In [59]:

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

qty_scalar = StandardScaler()
qty_scalar.fit(df_train['quantity'].values.reshape(-1,1)) # finding the mean and
print(f"Mean : {qty_scalar.mean_[0]}, Standard deviation : {np.sqrt(qty_scalar.va

# Now standardize the data with above mean and variance.
qty_train_standardized = qty_scalar.transform(df_train['quantity'].values.reshap
qty_test_standardized = qty_scalar.transform(df_test['quantity'].values.reshape(
```

```
Mean : 17.594514285714286, Standard deviation : 27.136284273876797
```

## 2.3 Make Data Model Ready: encoding eassay, and project_title

### 2.3.1 Vectorizing Text data

#### 2.3.1.2 TFIDF vectorizer for essay text

In [60]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)

text_train_tfidf = vectorizer.fit_transform(df_train['clean_essay'])
text_test_tfidf = vectorizer.transform(df_test['clean_essay'])
print("Shape of matrix after one hot encoding ",text_train_tfidf.shape, text_tes
```

```
Shape of matrix after one hot encoding  (35000, 10463) (15000, 10463)
```

### 2.3.1.2 Using Pretrained Models: TFIDF weighted W2V for essay text

In [61]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)

title_train_tfidf = vectorizer.fit_transform(df_train['clean_title'])
title_test_tfidf = vectorizer.transform(df_test['clean_title'])

print("Shape of matrix after one hot encodig ",title_train_tfidf.shape, title_te
```

```
Shape of matrix after one hot encodig  (35000, 1586) (15000, 1586)
```

In [62]:

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

In [63]:

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

```
Loading Glove Model
```

In [64]:

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

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

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

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


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

import pickle
with open('glove.42B.300d.txt', 'wb') as f:
    pickle.dump(words_courpus, f)
```

```
all the words in the coupus 7015309
the unique words in the coupus 43531
The number of words that are present in both glove vectors and our coupus 39363
( 90.425 %)
word 2 vec length 39363
```

In [65]:

```
# storing variables into pickle files python: http://www.jessicayung.com/how-to-
# make sure you have the glove_vectors file

with open('glove.42B.300d.txt', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [66]:

```
# glove_words
```

In [67]:
```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_train_text_vectors = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(df_train['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size o
    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_train_text_vectors.append(vector)

print(len(avg_w2v_train_text_vectors))
print(len(avg_w2v_train_text_vectors[0]))
```

```
  0%|
| 0/35000 [00:00<?, ?it/s]
  0%|
| 1/35000 [00:00<3:15:35,  2.98it/s]
  0%|▍
| 153/35000 [00:00<2:16:26,  4.26it/s]
  1%|█▌
| 446/35000 [00:00<1:34:45,  6.08it/s]
  2%|██▏
| 799/35000 [00:00<1:05:42,  8.68it/s]
  3%|██▏
| 1021/35000 [00:00<45:46, 12.37it/s]
  4%|███▎
| 1268/35000 [00:00<31:52, 17.63it/s]
  4%|███▏
| 1475/35000 [00:00<22:16, 25.08it/s]
  5%|████▎
| 1738/35000 [00:01<15:32, 35.68it/s]
```

In [68]:
```python
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_test_text_vectors = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(df_test['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size
    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_test_text_vectors.append(vector)

print(len(avg_w2v_test_text_vectors))
print(len(avg_w2v_test_text_vectors[0]))
```

```
  0%|
| 0/15000 [00:00<?, ?it/s]
  2%|██
| 327/15000 [00:00<00:04, 3246.01it/s]
  4%|███▍
| 656/15000 [00:00<00:04, 3252.05it/s]
  7%|█████
| 1011/15000 [00:00<00:04, 3329.50it/s]
  8%|██████▍
| 1274/15000 [00:00<00:04, 3074.18it/s]
 11%|████████
| 1607/15000 [00:00<00:04, 3140.27it/s]
 13%|██████████
| 1927/15000 [00:00<00:04, 3151.43it/s]
 15%|███████████▋
| 2298/15000 [00:00<00:03, 3294.08it/s]
 18%|█████████████▎
| 2643/15000 [00:00<00:03, 3332.28it/s]
 20%|███████████████
| 3003/15000 [00:00<00:03, 3401.26it/s]
 22%|█████████████████▏
| 3342/15000 [00:01<00:03, 3390.10it/s]
 25%|██████████████████▊
| 3697/15000 [00:01<00:03, 3429.11it/s]
 27%|████████████████████▍
| 4040/15000 [00:01<00:03, 3422.36it/s]
 29%|██████████████████████▋
| 4391/15000 [00:01<00:03, 3440.42it/s]
 32%|████████████████████████▎
| 4733/15000 [00:01<00:03, 3416.85it/s]
 34%|█████████████████████████▊
| 5094/15000 [00:01<00:02, 3465.28it/s]
 36%|███████████████████████████▍
| 5440/15000 [00:01<00:02, 3435.58it/s]
 39%|█████████████████████████████▊
| 5790/15000 [00:01<00:02, 3446.70it/s]
 41%|███████████████████████████████▎
```

```
| 6143/15000 [00:01<00:02, 3464.29it/s]
 43%|████████████████████████████████▋
| 6491/15000 [00:01<00:02, 3461.04it/s]
 46%|██████████████████████████████████▍
| 6855/15000 [00:02<00:02, 3505.56it/s]
 48%|████████████████████████████████████
| 7210/15000 [00:02<00:02, 3511.01it/s]
 50%|█████████████████████████████████████▉
| 7562/15000 [00:02<00:02, 3485.66it/s]
 53%|████████████████████████████████████████
| 7911/15000 [00:02<00:02, 3479.34it/s]
 55%|█████████████████████████████████████████▍
| 8259/15000 [00:02<00:02, 3363.87it/s]
 57%|███████████████████████████████████████████
| 8614/15000 [00:02<00:01, 3410.36it/s]
 60%|████████████████████████████████████████████▉
| 8961/15000 [00:02<00:01, 3421.10it/s]
 62%|██████████████████████████████████████████████
| 9313/15000 [00:02<00:01, 3442.42it/s]
 64%|████████████████████████████████████████████████▍
| 9666/15000 [00:02<00:01, 3460.69it/s]
 67%|█████████████████████████████████████████████████▌
| 10022/15000 [00:02<00:01, 3482.40it/s]
 69%|███████████████████████████████████████████████████▏
| 10378/15000 [00:03<00:01, 3498.24it/s]
 72%|████████████████████████████████████████████████████▉
| 10729/15000 [00:03<00:01, 3483.29it/s]
 74%|██████████████████████████████████████████████████████▊
| 11091/15000 [00:03<00:01, 3515.79it/s]
 76%|████████████████████████████████████████████████████████▌
| 11443/15000 [00:03<00:01, 3457.65it/s]
 79%|██████████████████████████████████████████████████████████▏
| 11806/15000 [00:03<00:00, 3500.30it/s]
 81%|████████████████████████████████████████████████████████████
| 12164/15000 [00:03<00:00, 3516.28it/s]
 83%|█████████████████████████████████████████████████████████████▊
| 12516/15000 [00:03<00:00, 3510.10it/s]
 86%|███████████████████████████████████████████████████████████████▌
| 12868/15000 [00:03<00:00, 3423.42it/s]
 88%|█████████████████████████████████████████████████████████████████▏
| 13225/15000 [00:03<00:00, 3458.66it/s]
 91%|██████████████████████████████████████████████████████████████████▉
| 13577/15000 [00:03<00:00, 3469.41it/s]
 93%|████████████████████████████████████████████████████████████████████▉
| 13941/15000 [00:04<00:00, 3511.44it/s]
 95%|██████████████████████████████████████████████████████████████████████
| 14300/15000 [00:04<00:00, 3527.03it/s]
 98%|████████████████████████████████████████████████████████████████████████▍
| 14663/15000 [00:04<00:00, 3549.66it/s]
100%|██████████████████████████████████████████████████████████████████████████
| 15000/15000 [00:04<00:00, 3443.40it/s]

15000
300
```

In [69]:

```
# Similarly you can vectorize for title also

# average Word2Vec
# compute average word2vec for each title
avg_w2v_title_train_vectors = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(df_train['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size
    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_title_train_vectors.append(vector)

print(len(avg_w2v_title_train_vectors))
print(len(avg_w2v_title_train_vectors[0]))
```

```
  0%|
| 0/35000 [00:00<?, ?it/s]
  4%|███
| 1494/35000 [00:00<00:02, 14829.21it/s]
 11%|████████
| 3693/35000 [00:00<00:01, 16134.14it/s]
 17%|█████████████
| 6091/35000 [00:00<00:01, 17868.30it/s]
 31%|██████████████████████                                                  |
10847/35000 [00:00<00:01, 21788.24it/s]
 52%|██████████████████████████████████████
| 18049/35000 [00:00<00:00, 27548.97it/s]
 73%|█████████████████████████████████████████████████████                   |
25684/35000 [00:00<00:00, 34051.49it/s]
 95%|████████████████████████████████████████████████████████████████████▍
| 33160/35000 [00:00<00:00, 40661.49it/s]
100%|████████████████████████████████████████████████████████████████████████|
35000/35000 [00:00<00:00, 44467.93it/s]

35000
300
```

In [70]:

```
# Similarly you can vectorize for title also

# average Word2Vec
# compute average word2vec for each title
avg_w2v_title_test_vectors = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(df_test['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size o
    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_title_test_vectors.append(vector)

print(len(avg_w2v_title_test_vectors))
print(len(avg_w2v_title_test_vectors[0]))
```

```
  0%|
| 0/15000 [00:00<?, ?it/s]
 51%|█████████████████████████████████████▍
| 7687/15000 [00:00<00:00, 76310.61it/s]
 75%|██████████████████████████████████████████████████████▏
| 11191/15000 [00:00<00:00, 56354.48it/s]
100%|████████████████████████████████████████████████████████████████████████|
15000/15000 [00:00<00:00, 58217.94it/s]

15000
300
```

In [71]:

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

In [72]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_train_text_vectors = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(df_train['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size o
    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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_train_text_vectors.append(vector)

print(len(tfidf_w2v_train_text_vectors))
print(len(tfidf_w2v_train_text_vectors[0]))
```

```
  0%|
| 0/35000 [00:00<?, ?it/s]
  0%|
| 53/35000 [00:00<01:07, 515.76it/s]
  0%|▏
| 86/35000 [00:00<01:19, 440.60it/s]
  0%|▎
| 135/35000 [00:00<01:16, 453.41it/s]
  1%|▍
| 188/35000 [00:00<01:13, 473.03it/s]
  1%|▎
| 240/35000 [00:00<01:11, 483.86it/s]
  1%|▌
| 295/35000 [00:00<01:09, 500.97it/s]
  1%|▋
| 346/35000 [00:00<01:08, 502.56it/s]
  1%|▋
| 402/35000 [00:00<01:07, 516.02it/s]
  1%|▍
```

In [73]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_test_text_vectors = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(df_test['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size 
    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 val
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_test_text_vectors.append(vector)

print(len(tfidf_w2v_test_text_vectors))
print(len(tfidf_w2v_test_text_vectors[0]))
```

```
| 13572/15000 [00:28<00:03, 463.39it/s]
 91%|███████████████████████████████████████████████████████████████████
| 13624/15000 [00:29<00:02, 476.76it/s]
 91%|███████████████████████████████████████████████████████████████████▌
| 13673/15000 [00:29<00:02, 478.70it/s]
 91%|████████████████████████████████████████████████████████████████████
| 13723/15000 [00:29<00:02, 483.82it/s]
 92%|████████████████████████████████████████████████████████████████████▉
| 13772/15000 [00:29<00:02, 459.71it/s]
 92%|█████████████████████████████████████████████████████████████████████▎
| 13825/15000 [00:29<00:02, 478.45it/s]
 93%|█████████████████████████████████████████████████████████████████████▋
| 13881/15000 [00:29<00:02, 499.33it/s]
 93%|██████████████████████████████████████████████████████████████████████
| 13933/15000 [00:29<00:02, 502.82it/s]
 93%|██████████████████████████████████████████████████████████████████████▍
| 13989/15000 [00:29<00:01, 516.23it/s]
 94%|██████████████████████████████████████████████████████████████████████▊
| 14042/15000 [00:29<00:01, 510.89it/s]
 94%|███████████████████████████████████████████████████████████████████████
```

### 2.3.1.4 Using Pretrained Models: TFIDF weighted W2V for title

In [74]:
```
# Similarly you can vectorize for title also

tfidf_model = TfidfVectorizer()
tfidf_model.fit_transform(df_train['clean_title'])
# 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 [75]:

```python
# average Word2Vec
# compute average word2vec for each project title.
tfidf_w2v_train_title_vectors = []; # the avg-w2v for each sentence/review is sto
for sentence in tqdm(df_train['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size o
    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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_train_title_vectors.append(vector)

print(len(tfidf_w2v_train_title_vectors))
print(len(tfidf_w2v_train_title_vectors[0]))
```

```
  0%|
| 0/35000 [00:00<?, ?it/s]
 10%|███████▌
| 3478/35000 [00:00<00:00, 34527.88it/s]
 19%|██████████████▍
| 6794/35000 [00:00<00:00, 34025.05it/s]
 29%|█████████████████████                                                     |
10119/35000 [00:00<00:00, 33713.45it/s]
 38%|████████████████████████████                                              |
13244/35000 [00:00<00:00, 32858.92it/s]
 47%|██████████████████████████████████▋
| 16396/35000 [00:00<00:00, 32372.67it/s]
 57%|█████████████████████████████████████████▊
| 19776/35000 [00:00<00:00, 32721.96it/s]
 66%|█████████████████████████████████████████████████▍
| 23240/35000 [00:00<00:00, 33201.30it/s]
 76%|███████████████████████████████████████████████████████▊
| 26730/35000 [00:00<00:00, 33621.95it/s]
 86%|██████████████████████████████████████████████████████████████▊
| 30067/35000 [00:00<00:00, 33476.01it/s]
 95%|██████████████████████████████████████████████████████████████████████    |
33336/35000 [00:01<00:00, 33162.41it/s]
100%|██████████████████████████████████████████████████████████████████████████|
35000/35000 [00:01<00:00, 33137.43it/s]

35000
300
```

In [76]:

```
# average Word2Vec
# compute average word2vec for each project title.
tfidf_w2v_test_title_vectors = []; # the avg-w2v for each sentence/review is sto
for sentence in tqdm(df_test['clean_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length. 50 is the size o
    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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_test_title_vectors.append(vector)

print(len(tfidf_w2v_test_title_vectors))
print(len(tfidf_w2v_test_title_vectors[0]))
```

```
  0%|
| 0/15000 [00:00<?, ?it/s]
 21%|████████████████
| 3205/15000 [00:00<00:00, 31806.00it/s]
 43%|████████████████████████████████
| 6460/15000 [00:00<00:00, 31956.17it/s]
 66%|█████████████████████████████████████████████████
| 9882/15000 [00:00<00:00, 32535.37it/s]
 89%|█████████████████████████████████████████████████████████████████
| 13304/15000 [00:00<00:00, 32953.90it/s]
100%|████████████████████████████████████████████████████████████████████████|
15000/15000 [00:00<00:00, 32908.36it/s]

15000
300
```

## 2.4 Applying Decision Tree Classifier on different kinds of featurizations as mentioned in the instructions

GBDT (xgboost/lightgbm) Appling Models on different kind of featurization as mentioned in the instructions

Apply GBDT on different kind of featurization as mentioned in the instructions For Every model that you work on make sure you do the step 2 and step 3 of instrucations

Apply GBDT on these feature sets

Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)+sentiment Score of eassay(check the bellow example, include all 4 values as 4 features).

Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V) The hyper paramter tuning (Consider any two hyper parameters) 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

### Hyper paramter tuning method: GridSearch

## Applying GBDT Classifier TFIDF, SET 1 (GridSearch)

Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)+sentiment Score of eassay(check the bellow example, include all 4 values as 4 features).

project_data['neg'] = neg project_data['neu'] = neu project_data['pos'] = pos project_data['compound'] = compound

### Hyper paramter tuning method: GridSearch

In [77]:

```
#https://www.digitalocean.com/community/tutorials/how-to-plot-data-in-python-3-us
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score
#https://scikit-learn.org/stable/modules/model_evaluation.html#scoring-parameter

from scipy.sparse import hstack
from sklearn.model_selection import RandomizedSearchCV

import matplotlib.patches as mpatches
from sklearn.metrics import roc_auc_score

x_train = hstack((df_train['cat_1'].values.reshape(-1,1), df_train['cat_0'].valu
                  df_train['subcat_0'].values.reshape(-1,1), df_train['state_1']
                  df_train['teacherprefix_1'].values.reshape(-1,1), df_train['te
                  df_train['project_grade_category_1'].values.reshape(-1,1), df_
                  price_train_standardized, prev_proj_train_standardized, wc_tit
                  pos_score_train_standardized,neu_score_train_standardized,neg_
                  qty_train_standardized, text_train_tfidf, title_train_tfidf))
y_train = df_train['project_is_approved']

x_test = hstack((df_test['cat_1'].values.reshape(-1,1), df_test['cat_0'].values.
                  df_test['subcat_0'].values.reshape(-1,1), df_test['state_1'].va
                  df_test['teacherprefix_1'].values.reshape(-1,1), df_test['teac
                 df_test['project_grade_category_1'].values.reshape(-1,1), df_te
                  prev_proj_test_standardized, wc_title_test_standardized, wc_es
                 pos_score_test_standardized,neu_score_test_standardized,neg_sco
y_test = df_test['project_is_approved']

print(x_train.shape, type(x_train), y_train.shape, type(y_train))
print(x_test.shape, type(x_test), y_test.shape, type(y_test))
```

```
(35000, 12068) <class 'scipy.sparse.coo.coo_matrix'> (35000,) <class 'pandas.co
re.series.Series'>
(15000, 12068) <class 'scipy.sparse.coo.coo_matrix'> (15000,) <class 'pandas.co
re.series.Series'>
```

In [78]:

```
#https://stackabuse.com/cross-validation-and-grid-search-for-model-selection-in-
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridS
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBClassifier

gbdt = XGBClassifier()

#Brute force approach for finding best K value
parameters = {'n_estimators': [10, 50, 100, 200, 500,1000],'max_depth':[2, 3, 4,

#Training the model on train data
gs = RandomizedSearchCV(gbdt,parameters ,cv=3, scoring='roc_auc',n_jobs=-1,retur
gs.fit(x_train, y_train)
```

Out[78]:

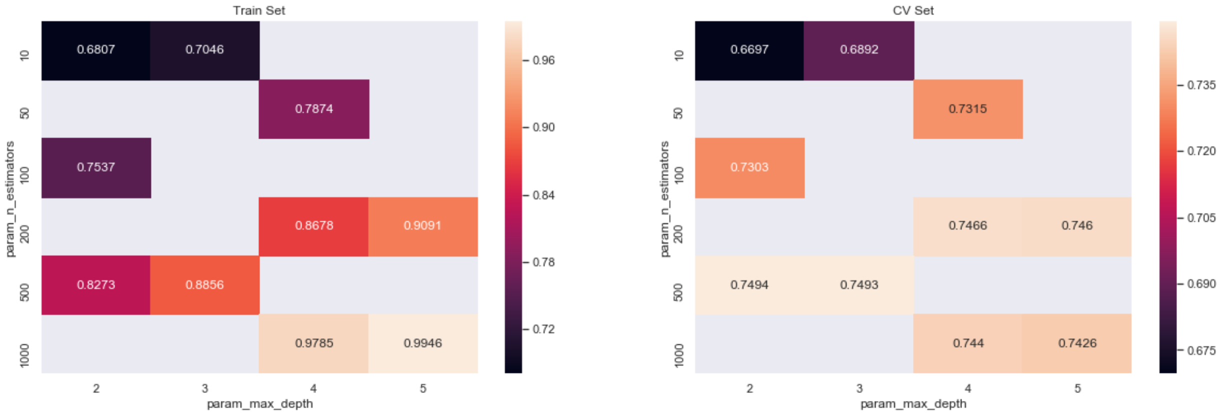
```
RandomizedSearchCV(cv=3, error_score='raise-deprecating',
          estimator=XGBClassifier(base_score=0.5, booster='gbtree', colsample_b
ylevel=1,
       colsample_bynode=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
       max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
       n_estimators=100, n_jobs=1, nthread=None,
       objective='binary:logistic', random_state=0, reg_alpha=0,
       reg_lambda=1, scale_pos_weight=1, seed=None, silent=None,
       subsample=1, verbosity=1),
          fit_params=None, iid='warn', n_iter=10, n_jobs=-1,
          param_distributions={'n_estimators': [10, 50, 100, 200, 500, 1000],
'max_depth': [2, 3, 4, 5]},
          pre_dispatch='2*n_jobs', random_state=None, refit=True,
          return_train_score=True, scoring='roc_auc', verbose=0)
```

In [79]:

```
print('Best score: ',gs.best_score_)
print('k value with best score: ',gs.best_params_)
print(' ')
print(' ')
print('Train AUC scores')
print(gs.cv_results_['mean_train_score'])
print('CV AUC scores')
print(gs.cv_results_['mean_test_score'])
```

```
Best score:  0.7493643154433881
k value with best score:  {'n_estimators': 500, 'max_depth': 2}


Train AUC scores
[0.78744269 0.75366858 0.88559228 0.68067226 0.90905401 0.70459099
 0.99455287 0.86782992 0.97850563 0.82725446]
CV AUC scores
[0.7314984  0.73027368 0.74927721 0.66968437 0.74596511 0.68923037
 0.74255738 0.74663995 0.74395347 0.74936432]
```

In [80]:
```python
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(gs.cv_results_).groupby(['param_n_estimators', 'param_
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```

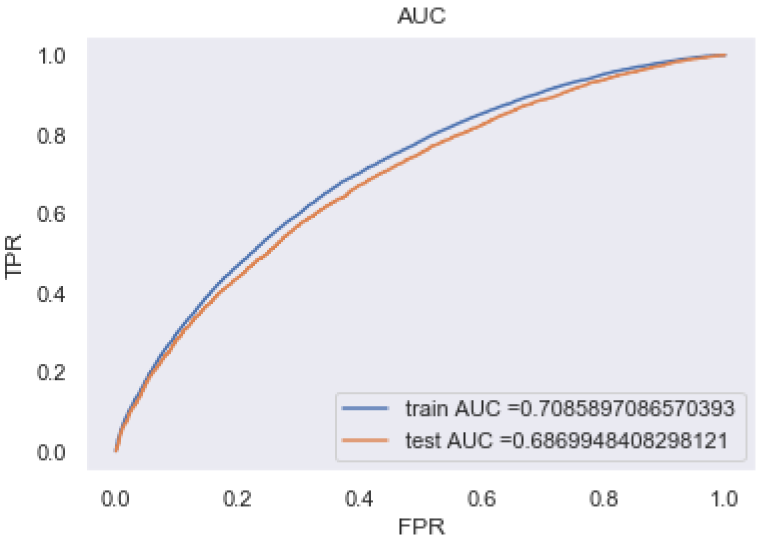


In [81]:
```python
max_d = gs.best_params_['max_depth']
n_est = gs.best_params_['n_estimators']
print(gs.best_params_)
```

```
{'n_estimators': 500, 'max_depth': 2}
```

In [82]:
```python
def pred_prob(clf, data):
    y_pred = []
    y_pred = clf.predict_proba(data)[:,1]
    return y_pred
```

In [83]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htm
from sklearn.metrics import roc_curve, auc
from sklearn.ensemble import RandomForestClassifier
from sklearn.datasets import make_classification
model = RandomForestClassifier(max_depth = max_d, n_estimators = n_est)

model.fit(x_train,y_train)

y_train_pred = pred_prob(model,x_train)
y_test_pred = pred_prob(model,x_test)

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.close
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("FPR")
plt.ylabel("TPR")
plt.title("AUC")
plt.grid()
plt.show()
```



In [84]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshold, fpr, tpr):
    t = threshold[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold",
    return t

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

In [85]:
```
#our objective here is to make auc the maximum
#so we find  the best threshold that will give the least fpr
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.4275978017458856 for threshold 0.669
Train confusion matrix
[[ 7604  3975]
 [ 8171 15250]]
```

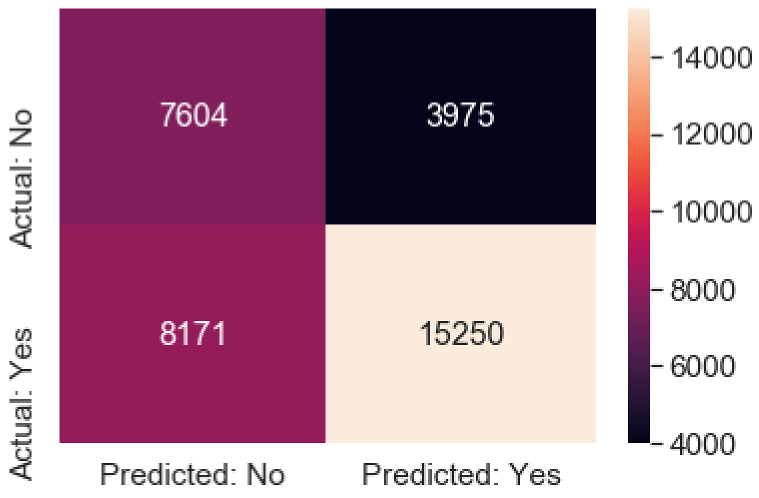
In [86]:

```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

print("Train data confusion matrix")

confusion_matrix_df_train = pd.DataFrame(confusion_matrix(y_train, predict_with_l
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_df_train, annot=True,annot_kws={"size": 16}, fmt='g
```

```
Train data confusion matrix
```

Out[86]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x22cc4c89be0>
```



In [87]:

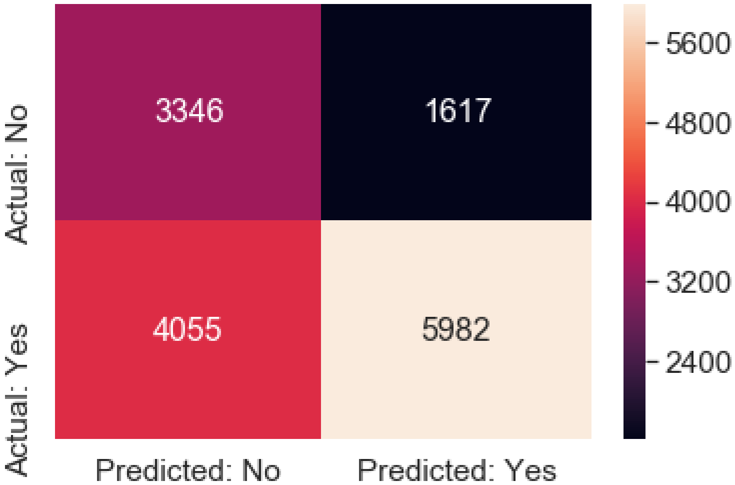
```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

```
Test confusion matrix
[[3346 1617]
 [4055 5982]]
```

In [88]:
```
print("Test data confusion matrix")

confusion_matrix_df_test = pd.DataFrame(confusion_matrix(y_test, predict_with_be
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_df_test, annot=True,annot_kws={"size": 16}, fmt='g'
```

```
Test data confusion matrix
```

Out[88]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x22dff41cbe0>
```



## Applying GBDT TFIDF W2V, SET 2

Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V) The hyper paramter tuning (Consider any two hyper parameters) 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

## Hyper paramter tuning method: GridSearch

In [89]:

```
#https://www.digitalocean.com/community/tutorials/how-to-plot-data-in-python-3-us
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score
#https://scikit-learn.org/stable/modules/model_evaluation.html#scoring-parameter

from scipy.sparse import hstack
from sklearn.model_selection import GridSearchCV
from sklearn import linear_model
import matplotlib.patches as mpatches
from sklearn.metrics import roc_auc_score

y_train_tfidf_w2v = df_train['project_is_approved']

y_test_tfidf_w2v = df_test['project_is_approved']

print( y_train_tfidf_w2v.shape, type(y_train_tfidf_w2v))
print( y_test_tfidf_w2v.shape, type(y_test_tfidf_w2v))
```

```
(35000,) <class 'pandas.core.series.Series'>
(15000,) <class 'pandas.core.series.Series'>
```

In [90]:

```
#https://blog.csdn.net/w55100/article/details/90369779
# if you use hstack without converting it into to a sparse matrix first,
#it shows an error: blocks must be 2-D

from scipy.sparse import coo_matrix, hstack
tr1 = coo_matrix(df_train['cat_1'].values.reshape(-1,1))
tr2 = coo_matrix(df_train['cat_0'].values.reshape(-1,1))
tr3 = coo_matrix(df_train['subcat_1'].values.reshape(-1,1))
tr4 = coo_matrix(df_train['subcat_0'].values.reshape(-1,1))
tr5 = coo_matrix(df_train['state_1'].values.reshape(-1,1))
tr6 = coo_matrix(df_train['state_0'].values.reshape(-1,1))
tr7 = coo_matrix(df_train['teacherprefix_1'].values.reshape(-1,1))
tr8 = coo_matrix(df_train['teacherprefix_0'].values.reshape(-1,1))
tr9 = coo_matrix(df_train['project_grade_category_1'].values.reshape(-1,1))
tr10 = coo_matrix(df_train['project_grade_category_0'].values.reshape(-1,1))
tr11 = coo_matrix(price_train_standardized)
tr12 = coo_matrix(prev_proj_train_standardized)
tr13 = coo_matrix(wc_title_train_standardized)
tr14 = coo_matrix(wc_essay_train_standardized)
tr15 = coo_matrix(qty_train_standardized)
tr16 = coo_matrix(tfidf_w2v_train_text_vectors)
tr17 = coo_matrix(tfidf_w2v_train_title_vectors)
```

In [91]:

```
X_train = hstack([tr1,tr2,tr3,tr4,tr5,tr6,tr7,tr8,tr9,tr10,tr11,tr12,tr13,tr14,t
```

In [92]:
```
from scipy.sparse import coo_matrix, hstack
te1 = coo_matrix(df_test['cat_1'].values.reshape(-1,1))
te2 = coo_matrix(df_test['cat_0'].values.reshape(-1,1))
te3 = coo_matrix(df_test['subcat_1'].values.reshape(-1,1))
te4 = coo_matrix(df_test['subcat_0'].values.reshape(-1,1))
te5 = coo_matrix(df_test['state_1'].values.reshape(-1,1))
te6 = coo_matrix(df_test['state_0'].values.reshape(-1,1))
te7 = coo_matrix(df_test['teacherprefix_1'].values.reshape(-1,1))
te8 = coo_matrix(df_test['teacherprefix_0'].values.reshape(-1,1))
te9 = coo_matrix(df_test['project_grade_category_1'].values.reshape(-1,1))
te10 = coo_matrix(df_test['project_grade_category_0'].values.reshape(-1,1))
te11 = coo_matrix(price_test_standardized)
te12 = coo_matrix(prev_proj_test_standardized)
te13 = coo_matrix(wc_title_test_standardized)
te14 = coo_matrix(wc_essay_test_standardized)
te15 = coo_matrix(qty_test_standardized)
te16 = coo_matrix(tfidf_w2v_test_text_vectors)
te17 = coo_matrix(tfidf_w2v_test_title_vectors)
```

In [93]:
```
X_test = hstack([te1,te2,te3,te4,te5,te6,te7,te8,te9,te10,te11,te12,te13,te14,te
```

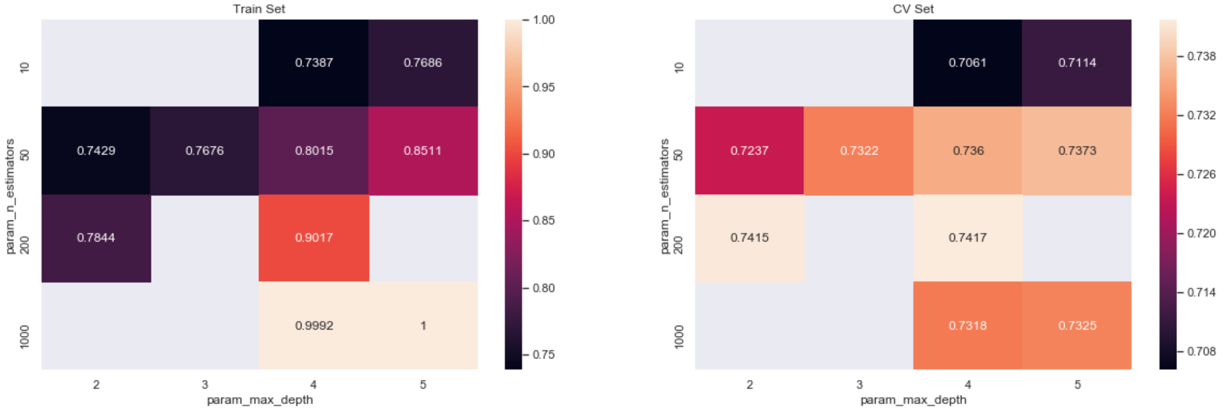
In [94]:
```
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBClassifier

gbdt = XGBClassifier()

parameters = {'n_estimators': [10, 50, 100, 200, 500,1000],'max_depth':[2, 3, 4,


rs = RandomizedSearchCV(gbdt,parameters ,cv=3, scoring='roc_auc',n_jobs=-1,retur
rs.fit(X_train, y_train_tfidf_w2v)
```

Out[94]:
```
RandomizedSearchCV(cv=3, error_score='raise-deprecating',
          estimator=XGBClassifier(base_score=0.5, booster='gbtree', colsample_b
ylevel=1,
       colsample_bynode=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
       max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
       n_estimators=100, n_jobs=1, nthread=None,
       objective='binary:logistic', random_state=0, reg_alpha=0,
       reg_lambda=1, scale_pos_weight=1, seed=None, silent=None,
       subsample=1, verbosity=1),
          fit_params=None, iid='warn', n_iter=10, n_jobs=-1,
          param_distributions={'n_estimators': [10, 50, 100, 200, 500, 1000],
'max_depth': [2, 3, 4, 5]},
          pre_dispatch='2*n_jobs', random_state=None, refit=True,
          return_train_score=True, scoring='roc_auc', verbose=0)
```

In [95]:
```
print('Best score: ',rs.best_score_)
print('k value with best score: ',rs.best_params_)
print(' ')
print('Train AUC scores')
print(rs.cv_results_['mean_train_score'])
print('CV AUC scores')
print(rs.cv_results_['mean_test_score'])
```

```
Best score:  0.7417198418225839
k value with best score:  {'n_estimators': 200, 'max_depth': 4}

Train AUC scores
[0.85107069 0.80154248 0.99921985 0.73867242 0.74290908 0.76855389
 0.78435855 0.99999999 0.76757806 0.9017058 ]
CV AUC scores
[0.73731885 0.73595594 0.73182936 0.70610419 0.72370543 0.71144459
 0.74148531 0.7325167  0.73221765 0.74171984]
```

In [96]:
```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(rs.cv_results_).groupby(['param_n_estimators', 'param_
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```

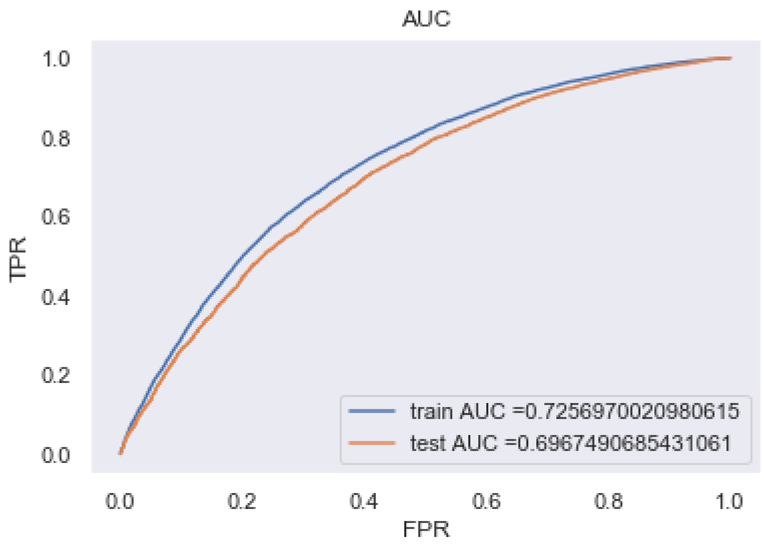


In [97]:
```
max_d = rs.best_params_['max_depth']
n_est = rs.best_params_['n_estimators']
print(rs.best_params_)
```

```
{'n_estimators': 200, 'max_depth': 4}
```

In [98]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.ht
from sklearn.metrics import roc_curve, auc
model = RandomForestClassifier(max_depth = max_d, n_estimators = n_est)

model.fit(X_train,y_train_tfidf_w2v)

y_train_pred = pred_prob(model,X_train)
y_test_pred = pred_prob(model,X_test)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train_tfidf_w2v, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test_tfidf_w2v, y_test_pred)

plt.close
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("FPR")
plt.ylabel("TPR")
plt.title("AUC")
plt.grid()
plt.show()
```



In [99]:

```
#our objective here is to make auc the maximum
#so we find  the best threshold that will give the least fpr
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train_tfidf_w2v, predict_with_best_t(y_train_pred, best_
```

```
the maximum value of tpr*(1-fpr) 0.4484977841822988 for threshold 0.659
Train confusion matrix
[[ 7589  3990]
 [ 7394 16027]]
```

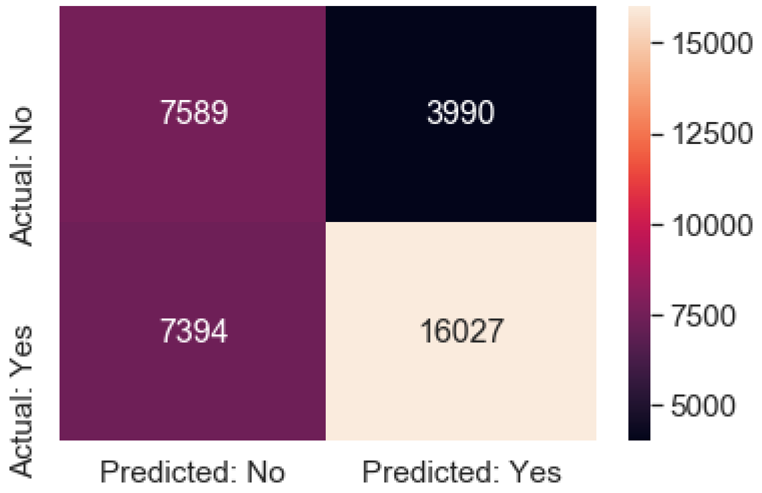
In [100]:

```
#plotting confusion matrix using seaborn's heatmap
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

print("Train data confusion matrix")

confusion_matrix_df_train = pd.DataFrame(confusion_matrix(y_train_tfidf_w2v, pre
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_df_train, annot=True,annot_kws={"size": 16}, fmt='g
```

```
Train data confusion matrix
```

Out[100]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x22cc389c6a0>
```



In [101]:

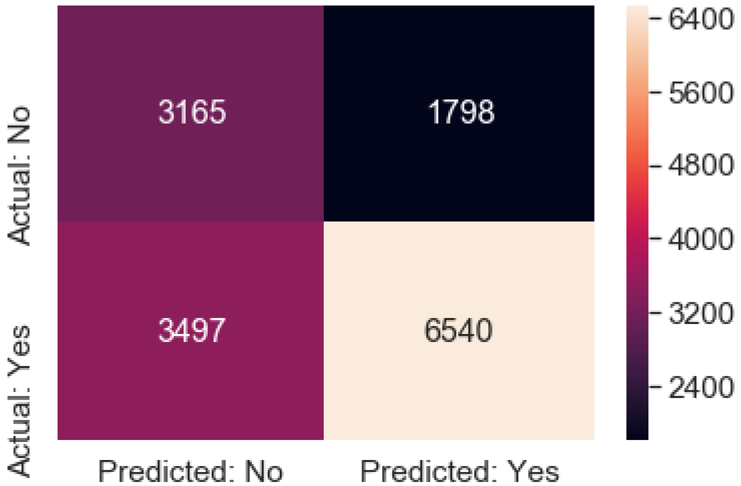
```
print("Test confusion matrix")
print(confusion_matrix(y_test_tfidf_w2v, predict_with_best_t(y_test_pred, best_t
```

```
Test confusion matrix
[[3165 1798]
 [3497 6540]]
```

In [102]:
```
print("Test data confusion matrix")

confusion_matrix_df_test = pd.DataFrame(confusion_matrix(y_test_tfidf_w2v, predi
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_df_test, annot=True,annot_kws={"size": 16}, fmt='g'
```

```
Test data confusion matrix
```

Out[102]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x22cc45176d8>
```



# 3. Conclusions

## 3.1 GBDT Results

In [107]:

```
x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyperparameter", "AUC(Train Data)", "AU


x.add_row(["TFIDF", "XGBOOST", "{'n_estimators': 500, 'max_depth': 2}", '0.70', 
x.add_row(["TFIDF AVG W2V", "XGBOOST", "{'n_estimators': 200, 'max_depth': 4}", 

print(x)
```

```
+---------------+---------+---------------------------------------+------------
-----+----------------+
|   Vectorizer  |  Model  |             Hyperparameter            | AUC(Train D
ata) | AUC(Test Data) |
+---------------+---------+---------------------------------------+------------
-----+----------------+
|     TFIDF     | XGBOOST | {'n_estimators': 500, 'max_depth': 2} |       0.70
|      0.68      |
| TFIDF AVG W2V | XGBOOST | {'n_estimators': 200, 'max_depth': 4} |       0.72
|      0.69      |
+---------------+---------+---------------------------------------+------------
-----+----------------+
```

In [ ]: