DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

your neighborhood, and your school are all helpful.

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

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
from sklearn.linear_model import SGDClassifier
from sklearn.calibration import CalibratedClassifierCV

os.chdir('C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose')
```

1.1 Reading Data

In [2]:

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

In [3]:

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

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

```
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

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

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

Out[4]:

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

Preprocessing Project Grade Category Feature

In [5]:

```
project_grade_category = []

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

In [6]:

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

Out[6]:

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

In [7]:

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

In [8]:

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

In [9]:

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

Out[9]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Lite
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Hist Spo

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Hea
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Lite Scie
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Mat

1.2 preprocessing of `project_subject_categories`

In [10]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [11]:

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

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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
```

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

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

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

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

Text Preprocessing

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

- This can be used as Numerical Feature for Vectorisation

In [12]:

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

In [13]:

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

Out[13]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Edu Sup Eng Lea Hor
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Wa Pro Hur Lea
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Soc Equ AW Mid Stu.
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Tec Kin

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Inte Tod

Combining 4 Project essays into 1 Essay feature

In [14]:

```
# 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)
```

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

- This can be used as Numerical Feature for Vectorisation

In [15]:

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

In [16]:

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

Out[16]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Edu Sup Eng Lea Hor
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Wa Proj Hur Lea
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Soc Equ AW Mid Stu.
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Tec Kin
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Inte

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	Too
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	

Splitting Project_Data into Train and Test Datasets

In [17]:

```
from sklearn.model_selection import train_test_split

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

We don't need the 'project_is_approved' feature now

In [18]:

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

Printing some random essays

In [19]:

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

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves
to get together and celebrate. Around Halloween there is a whole school parade to show off the bea
utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by
the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t
he hard work put in during the school year, with a dunk tank being the most popular activity.My st
udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged
chairs. As I will only have a total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During independent reading time they
will be used as special chairs students will each use on occasion. I will utilize them in place of
```

chairs at my small group tables during math and reading times. The rest of the day they will be us
ed by the students who need the highest amount of movement in their life in order to stay focused
on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki
Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i
n group with me on the Hokki Stools, they are always moving, but at the same time doing their
work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are
disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours
a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th
e same time. These stools will help students to meet their 60 minutes a day of movement by
allowing them to activate their core muscles for balance while they sit. For many of my students,
these chairs will take away the barrier that exists in schools for a child who can't sit
still.nannan
==
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of
desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work
hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n
\r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in
Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq
ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage
r learners; they are like sponges, absorbing all the information and experiences and keep on wanti
ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin
g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to
be one of a themed nautical environment. Creating a classroom environment is very important in the
success in each and every child's education. The nautical photo props will be used with each child
as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic
tures of each child with them, have them developed, and then hung in our classroom ready for their
first day of 4th grade. This kind gesture will set the tone before even the first day of school!
The nautical thank you cards will be used throughout the year by the students as they create thank
you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our
classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of
my own pocket on resources to get our classroom ready. Please consider helping with this project t
o make our new school year a very successful one. Thank you!nannan
==
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch. Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju
mping and playing. Physical engagement is the key to our success. The number toss and color and sh
ape mats can make that happen. My students will forget they are doing work and just have the fun a
6 year old deserves.nannan
==
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The grea
t teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% Af
rican-American, making up the largest segment of the student body. A typical school in Dallas is m
ade up of 23.2% African-American students. Most of the students are on free or reduced lunch. We a
ren't receiving doctors, lawyers, or engineers children from rich backgrounds or neighborhoods. As
an educator I am inspiring minds of young children and we focus not only on academics but one smar
t, effective, efficient, and disciplined students with good character.In our classroom we can util
ize the Bluetooth for swift transitions during class. I use a speaker which doesn't amplify the so
und enough to receive the message. Due to the volume of my speaker my students can't hear videos o
r books clearly and it isn't making the lessons as meaningful. But with the bluetooth speaker my s
tudents will be able to hear and I can stop, pause and replay it at any time.\r\nThe cart will all
ow me to have more room for storage of things that are needed for the day and has an extra part to
it I can use. The table top chart has all of the letter, words and pictures for students to learn
about different letters and it is more accessible.nannan
==

In [20]:

```
# 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 [21]:

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

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids do not want to sit and do worksheets. They want to learn to count by j
umping and playing. Physical engagement is the key to our success. The number toss and color and s
hape mats can make that happen. My students will forget they are doing work and just have the fun
a 6 year old deserves.nannan
==================================================
```

In [22]:

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

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations.     The materials we have are the ones I seek out for
my students. I teach in a Title I school where most of the students receive free or reduced price
lunch.  Despite their disabilities and limitations, my students love coming to school and come eag
er to learn and explore.Have you ever felt like you had ants in your pants and you needed to groov
e and move as you were in a meeting? This is how my kids feel all the time. The want to be able to
move as they learn or so they say.Wobble chairs are the answer and I love then because they develo
p their core, which enhances gross motor and in Turn fine motor skills.   They also want to learn t
hrough games, my kids do not want to sit and do worksheets. They want to learn to count by jumping
and playing. Physical engagement is the key to our success. The number toss and color and shape ma
ts can make that happen. My students will forget they are doing work and just have the fun a 6 yea
r old deserves.nannan
```

In [23]:

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

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitiv
e delays gross fine motor delays to autism They are eager beavers and always strive to work their
hardest working past their limitations The materials we have are the ones I seek out for my studen
ts I teach in a Title I school where most of the students receive free or reduced price lunch
Despite their disabilities and limitations my students love coming to school and come eager to lea
rn and explore Have you ever felt like you had ants in your pants and you needed to groove and mov
e as you were in a meeting This is how my kids feel all the time The want to be able to move as th
ey learn or so they say Wobble chairs are the answer and I love then because they develop their co
re which enhances gross motor and in Turn fine motor skills They also want to learn through games
my kids do not want to sit and do worksheets They want to learn to count by jumping and playing Ph
ysical engagement is the key to our success The number toss and color and shape mats can make that
happen My students will forget they are doing work and just have the fun a 6 year old deserves nan
nan
```

In [24]:

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

Preprocessed Training data (Essay Feature)

In [25]:

```
# Combining all the above

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

```
100%|██████████████████████████████████| 49041/49041 [00:40<00:00, 1221.56it/s]
```

In [26]:

```
# after preprocesing
preprocessed_essays_train[1000]
```

Out[26]:

```
'students come low income families even first generation americans hungry learn explore new advent
ures classroom make priority create positive inviting nurturing learning environment classroom stu
dents tools need successful educational endeavors invite students family friends collaborate reinf
orce daily routines academic targets positive home school connection ensure success students stude
nts need seat pockets order learning tools easily accessible times rather bulky basket middle
tables would simply take away precious learning space seat pocket allows students keep supplies ne
at personal area students lack many things truly appreciate designated space belongings pockets in
troduce independence responsibility accountability self regulation no precious learning time waste
d getting grab materials pass notebooks students learn become independent thinkers quick access in
dividual reference sheets stored pockets nannan'
```

Preprocessed Test data (Essay Feature)

In [27]:

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

```
100%|██████████████████████████████████| 36052/36052 [00:29<00:00, 1230.04it/s]
```

In [28]:

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

Out[28]:

```
'students year creative driven interested topics learning want see applies lives either future giv
en spark need help guide reach full potential kids interested learning helping others know right i
deas materials creativity drive make difference whether big small students need knives currently u
sing steak knives cut vegetables really unsafe not help learn appropriate safe knife skills needed
imagine cutting vegetable press hard weight vegetable cutting board slip nip finger reality
nutrition nutrition science class teach knife safety hard follow using old steak knives cut foods
nerve racking watching teens cutting knowing not safe need new knives able safely cut foods give p
iece mind nannan'
```

Preprocessed Cross Validation data (Essay Feature)

In [29]:

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

```
100%|██████████████████████████████████| 24155/24155 [00:20<00:00, 1201.84it/s]
```

In [30]:

```
# after preprocesing
preprocessed_essays_cv[1000]
```

Out[30]:

```
'would describe classroom well tricky classroom actually involves 3 different grades 5 different i
nstructional levels 2 different subjects day despite differences students common group awesome spe
cial education students middle school students receive special education services learning support
classroom well co teaching environment wide range disabilities talents needs supports struggle com
municate ideas feelings school work others great speakers expressing thoughts comes easily
struggle writing need much support put words paper others find writing enjoyable task require
number lines counters perform basic math computations others getting ready algebra lastly reading
grade level novels independently others need hear texts read aloud order comprehend wide range
student needs service often pulled multiple directions need use tools chrome books center supplies
make sure students successful cannot assist students assignments use computers type work dictate t
```

```
make sure students successful cannot assist students assignments use computers type work dictate t
houghts program type struggling understand math concept watch videos virtual nerd khan academy
brain pop practice skills using programs like think math front row reading text class students nee
d hear read aloud use audio books pdfs provide listen reading time technology never substitute
staff members cannot help students understand concepts complete class tasks help students
successful chrome books classroom supplies help provide accommodations students require help indep
endent without relying much teacher support nannan'
```

Preprocessing Training data(Titles Feature)

In [31]:

```
preprocessed_titles_train = []

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

```
100%|██████████████████████████████████| 49041/49041 [00:01<00:00, 28100.03it/s]
```

In [32]:

```
preprocessed_titles_train[1000]
```

Out[32]:

```
'accessing learning tools via seat pockets'
```

Preprocessing Test data(Titles Feature)

In [33]:

```
preprocessed_titles_test = []

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

```
100%|██████████████████████████████████| 36052/36052 [00:01<00:00, 26489.77it/s]
```

In [34]:

```
preprocessed_titles_test[1000]
```

Out[34]:

```
'ouch dull knives are unsafe'
```

Preprocessing Cross Validation data(Titles Feature)

In [35]:

```
preprocessed_titles_cv = []

for titles in tqdm(X_cv["project_title"]):
    title = decontracted(titles)
    title = title.replace('\\r', ' ')
```

```
    title = title.replace('\\"', ' ')
    title = title.replace('\\n', ' ')
    title = re.sub('[^A-Za-z0-9]+', ' ', title)
    title = ' '.join(f for f in title.split() if f not in stopwords)
    preprocessed_titles_cv.append(title.lower().strip())
```

```
100%|████████████████████████████████| 24155/24155 [00:00<00:00, 26879.60it/s]
```

In [36]:

```
preprocessed_titles_cv[1000]
```

Out[36]:

```
'chrome holidays'
```

1.10 Preparing data for models

In [37]:

```
project_data.columns
```

Out[37]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', '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',
       'project_grade_category', 'clean_categories', 'clean_subcategories',
       'title_word_count', 'essay', 'essay_word_count'],
      dtype='object')
```

we are going to consider

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

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

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

1.11 Vectorizing Categorical data

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

One Hot Encoding - (Clean Categories Feature)

In [38]:

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

from sklearn.feature_extraction.text import CountVectorizer

vectorizer_proj = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary
```

```
=True)
vectorizer_proj.fit(X_train['clean_categories'].values)

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

print(vectorizer_proj.get_feature_names())

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

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

One Hot Encoding - (Clean Sub-Categories Feature)

In [39]:

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

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

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


print(vectorizer_sub_proj.get_feature_names())

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

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

One Hot Encoding - (School States Feature)

In [40]:

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

In [41]:

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

In [42]:

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

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

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

print(vectorizer_states.get_feature_names())

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

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

One Hot Encoding - (Project Grade Category Feature)

In [43]:

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

In [44]:

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

In [45]:

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

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

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

print(vectorizer_grade.get_feature_names())

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

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

One Hot Encoding - (Teacher Prefix Feature)

One Hot Encoding - (Teacher Prefix Feature)

In [46]:

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

In [47]:

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

In [48]:

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

In [49]:

```
## we use count vectorizer to convert the values into one hot encoded features
## Unlike the previous Categories this category returns a
## ValueError: np.nan is an invalid document, expected byte or unicode string.
## The link below explains h0w to tackle such discrepancies.
## https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-valueerror-np-nan-is-an-invalid-document/39308809#39308809

vectorizer_teacher = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lower
case=False, binary=True)
vectorizer_teacher.fit(X_train['teacher_prefix'].values.astype('U'))



teacher_prefix_categories_one_hot_train = vectorizer_teacher.transform(X_train['teacher_prefix'].v
alues.astype('U'))
teacher_prefix_categories_one_hot_test =
vectorizer_teacher.transform(X_test['teacher_prefix'].values.astype('U'))
teacher_prefix_categories_one_hot_cv = vectorizer_teacher.transform(X_cv['teacher_prefix'].values.
astype('U'))

print(vectorizer_teacher.get_feature_names())

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

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of matrix after one hot encoding  (49041, 5)
Shape of matrix after one hot encoding  (36052, 5)
Shape of matrix after one hot encoding  (24155, 5)
```

1.12 Vectorizing Text data

Bag of words - Training Data (Essays Feature)

In [50]:

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

```
Shape of matrix after one hot encoding  (49041, 12067)
```

Bag of words - Test Data (Essays Feature)

In [51]:

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

```
Shape of matrix after one hot encoding  (36052, 12067)
```

Bag of words - Cross Validation Data (Essays Feature)

In [52]:

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

```
Shape of matrix after one hot encoding  (24155, 12067)
```

Bag of words - Train Data - (Titles Feature)

In [53]:

```
vectorizer_bow_title = CountVectorizer(min_df=10)

vectorizer_bow_title.fit(preprocessed_titles_train)

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

```
Shape of matrix after one hot encoding  (49041, 2084)
```

Bag of words - Test Data - (Titles Feature)

In [54]:

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

```
Shape of matrix after one hot encoding  (36052, 2084)
```

Bag of words - Cross Validation Data -(Titles Feature)

In [55]:

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

```
Shape of matrix after one hot encoding  (24155, 2084)
```

TFIDF - Training Data - (Essays Feature)

In [56]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
vectorizer_tfidf_essay.fit(preprocessed_essays_train)
text_tfidf_train = vectorizer_tfidf_essay.transform(preprocessed_essays_train)
print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 12067)
```

TFIDF - Test Data -(Essays Feature)

In [57]:

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

```
Shape of matrix after one hot encoding  (36052, 12067)
```

TFIDF - Cross Validation Data - (Essays Feature)

In [58]:

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

```
Shape of matrix after one hot encoding  (24155, 12067)
```

TFIDF - Train Data - (Titles Feature)

In [59]:

```
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

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

```
Shape of matrix after one hot encoding  (49041, 2084)
```

TFIDF - Test Data - (Titles Feature)

In [60]:

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

```
Shape of matrix after one hot encoding  (36052, 2084)
```

TFIDF - Cross Validation Data - (Titles Feature)

In [61]:

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

```
Shape of matrix after one hot encoding  (24155, 2084)
```

Using Pretrained Models: Avg W2V

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

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

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

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

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

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

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

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


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

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


'''
```

Out[62]:

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

In [63]:

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

Avg_W2V for Train Data(Essays feature)

In [64]:

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

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

```
100%|████████████████████████████████████| 49041/49041 [00:20<00:00, 2368.13it/s]
```

```
49041
300
```

Avg_W2V for Test Data(Essays feature)

In [65]:

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

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

```
100%|████████████████████████████████████| 36052/36052 [00:15<00:00, 2369.48it/s]
```

```
36052
300
```

Avg_W2V for Cross Validation Data(Essays feature)

In [66]:

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

```
    avg_w2v_vectors_cv.append(vector)

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

```
100%|██████████████████████████████████| 24155/24155 [00:10<00:00, 2356.29it/s]
```

```
24155
300
```

Avg_W2V for Train Data(Titles feature)

In [67]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_train.append(vector)

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

```
100%|██████████████████████████████████| 49041/49041 [00:01<00:00, 39236.31it/s]
```

```
49041
300
```

Avg_W2V for Test Data(Titles feature)

In [68]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_test.append(vector)

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

```
100%|██████████████████████████████████| 36052/36052 [00:00<00:00, 41842.58it/s]
```

```
36052
300
```

Avg_W2V for Cross Validation Data(Titles feature)

In [69]:

```
# average Word2Vec
```

```
# compute average word2vec for each review.
avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_cv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_cv.append(vector)

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

```
100%|████████████████████████████████| 24155/24155 [00:00<00:00, 34286.64it/s]
```

```
24155
300
```

TFIDF weighted W2V for Train Data(Essays feature)

In [70]:

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

In [71]:

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

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

```
100%|████████████████████████████████| 49041/49041 [02:16<00:00, 360.59it/s]
```

```
49041
300
```

TFIDF weighted W2V for Test Data(Essays feature)

In [72]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_test)
# we are converting a dictionary with word as a key, and the idf as a value
```

```
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [73]:

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

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

```
100%|██████████████████████████████████| 36052/36052 [01:40<00:00, 357.12it/s]
```

```
36052
300
```

TFIDF weighted W2V for Cross Validation Data(Essays feature)

In [74]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_cv)
# 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]:

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

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

```
100%|██████████████████████████████████| 24155/24155 [01:04<00:00, 375.44it/s]
```

```
24155
300
```

300

TFIDF weighted W2V for Train Data(Titles feature)

In [76]:

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

In [77]:

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

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

```
100%|██████████████████████████████████| 49041/49041 [00:02<00:00, 18759.60it/s]
```

```
49041
300
```

TFIDF weighted W2V for Test Data(Titles feature)

In [78]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_test)
# 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 [79]:

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

```
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_test.append(vector)

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

```
100%|██████████████████████████████████| 36052/36052 [00:01<00:00, 18676.20it/s]
```

```
36052
300
```

TFIDF weighted W2V for Cross Validation Data(Titles feature)

In [80]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_cv)
# 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 [81]:

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

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

```
100%|██████████████████████████████████| 24155/24155 [00:01<00:00, 18961.41it/s]
```

```
24155
300
```

Vectorizing Numerical features

Normalise Numerical values instead of Standardising else it give Error that 'Negative Values not allowed'

- Normalising it will bound the data to 0 and 1

Price Feature

In [82]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in
-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[82]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [83]:

```
#Now join Price data to Train,Test and Cross Validation Data
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [84]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()

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

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

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

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Quantity Feature

In [85]:

```
normalizer = Normalizer()

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

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

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

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

```
After vectorizations
(49041, 1) (49041,)
```

```
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Number of Projects previously proposed by Teacher Feature

In [86]:

```
normalizer = Normalizer()

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

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

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

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Title word Count Feature

In [87]:

```
normalizer = Normalizer()

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

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

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Essay word Count

In [88]:

```
normalizer_ess_count = Normalizer()

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

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

```
,1))

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Apply Decision Trees

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
   - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
   - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **Hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**
   - Find the best hyper parameter which will give the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning
3. **Graphviz**
   - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
   - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
   - Make sure to print the words in each node of the decision tree instead of printing its index.
   - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.
4. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
   - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points
   - Once after you plot the confusion matrix with the test data, get all the `false positive data points`
     - Plot the WordCloud WordCloud
     - Plot the box plot with the `price` of these `false positive data points`
     - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`
5. **[Task-2]**
   - Select 5k best features from features of Set 2 using`feature_importances_`, discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3
6. **Conclusion**
   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

2. Decision Trees

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

In [89]:

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

X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, title_bow_train, text_bow_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, title_bow_test, text_bow_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, title_bow_cv, text_bow_cv)).tocsr()
```

In [90]:

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

```
Final Data matrix
(49041, 14184) (49041,)
(24155, 14184) (24155,)
(36052, 14184) (36052,)
```

RandomisedSearchCV Implementation (Decision Tree)

In [91]:

```
import scipy.stats as sc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
params = {   "min_samples_split":[5,10,100,500],
             "max_depth":[1, 5, 10, 50, 100, 500, 100],
         }

grid = RandomizedSearchCV(DecisionTreeClassifier(), params, cv = 3, scoring = 'roc_auc', verbose =
1, random_state = 0,n_jobs = -1)
grid.fit(X_tr,y_train)
print(grid.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed:  9.6min finished
```

```
{'min_samples_split': 500, 'max_depth': 10}
```

Summary

- Decision Tree with maximum depth 10, performs decently on both Train as well as Cross Validation Data.
- Minimum samples per split is 500.

3D Scatter Plots

In [96]:

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

In [97]:

```
train_auc
```

Out[97]:

```
array([0.5424443 , 0.976037  , 0.84287581, 0.94684114, 0.61794365,
       0.65137741, 0.94851349, 0.87201361, 0.99852705, 0.94479137])
```

In [98]:

```
cv_auc
```

Out[98]:

```
array([0.53881636, 0.53400262, 0.54757949, 0.50543813, 0.59845878,
       0.60866791, 0.49900696, 0.5255656 , 0.52179704, 0.50371343])
```

In [89]:

```
import plotly
plotly.tools.set_credentials_file(username='Subham27091995', api_key='K1wGeAeNfKl8T8Wx1bHl')
```

In [90]:

```
x1 = [0.5424443 , 0.976037  , 0.84287581, 0.94684114, 0.61794365,
       0.65137741, 0.94851349, 0.87201361, 0.99852705, 0.94479137]
```

In [91]:

```
x2= [0.53881636, 0.53400262, 0.54757949, 0.50543813, 0.59845878,
       0.60866791, 0.49900696, 0.5255656 , 0.52179704, 0.50371343]
```

In [92]:

```
z1 = pd.Series([1,5,10,10,50,50,100,100,500,500],index = x1)
```

In [93]:

```
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10], index = x1)
```

In [94]:

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

trace2 = go.Scatter3d(
    x=x2, y=y1, z=z1,
    name = 'Test',
    marker=dict(
        size=4,
        colorscale='Viridis',
```

```
    ),
    line=dict(
        color='#b45c1f',
        width=1
    )
)
```

In [95]:

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

In [96]:

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

In [97]:

```
import plotly.plotly as py

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

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

Out[97]:

B) Train the model using the best hyper parameter value

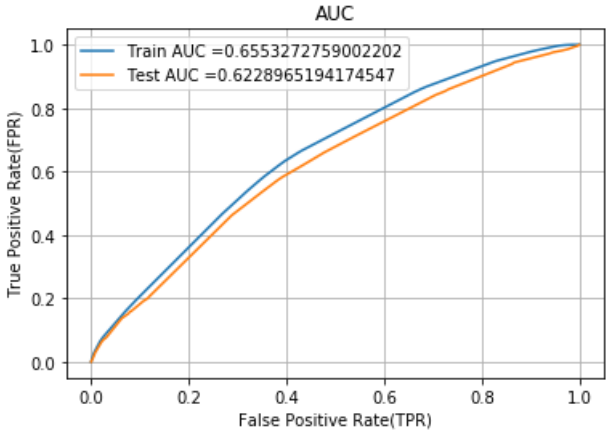
In [0]:

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

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

    return y_data_pred
```

In [0]:

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

model = DecisionTreeClassifier(max_depth = 10, min_samples_split = 500)

model.fit(X_tr, y_train)

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

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

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
```

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



C) Confusion Matrix

In [0]:

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

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

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

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

Train Data

In [0]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24661578766678885 for threshold 0.839
[[ 3281  4145]
 [10162 31453]]
```

In [0]:

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

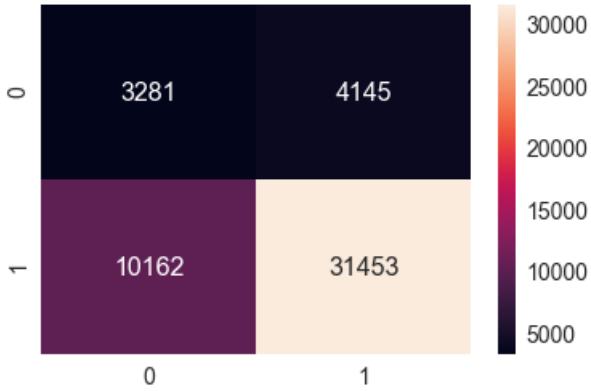
```
the maximum value of tpr*(1-fpr) 0.24661578766678885 for threshold 0.839
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc3cf85f8>
```



Test Data

In [0]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24272868126738445 for threshold 0.839
[[ 2264  3195]
 [ 7688 22905]]
```

In [0]:

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

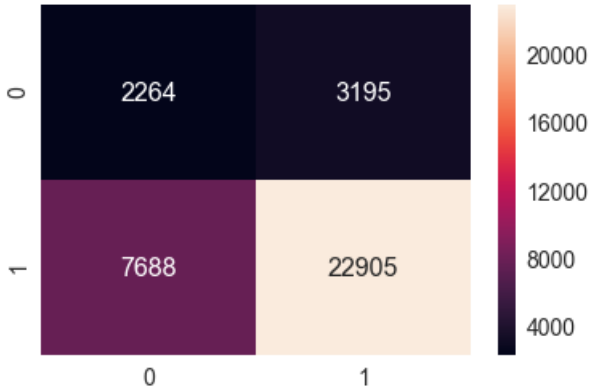
```
the maximum value of tpr*(1-fpr) 0.24272868126738445 for threshold 0.839
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc3d6ab00>
```



False Positives from BoW Essay feature

In [0]:

```
bow_test = text_bow_test.todense()
```

In [0]:

```
bow_test.shape
```

In [0]:

```
vectorizer_bow_essay = CountVectorizer(min_df=10)

av = vectorizer_bow_essay.fit(X_train["clean_essays"])
```

In [0]:

```
bow_features = av.get_feature_names()
```

In [0]:

```
len(bow_features)
```

Out[0]:

```
620
```

In [ ]:

```
y_test_converted = list(y_test[::])
```

In [0]:

```
false_positives_index_a = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= 0.839:
        false_positives_index_a.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████| 36052/36052 [00:00<00:00, 1732306.65it/s]
```

In [0]:

```
fp_count
```

Out[0]:

```
2893
```

In [0]:

```
false_positives_index_a[0:5]
```

Out[0]:

```
[8, 19, 21, 34, 38]
```

In [0]:

```
df1 = pd.DataFrame(bow_test)
```

In [0]:

```
df1_final = df1.iloc[false_positives_index_a,:]
```

In [0]:

```
df1_final.shape
```

Out[0]:

```
(2893, 14239)
```

In [0]:

```
df1_final[0].sum()
```

In [0]:

```
best_indices = []

for j in range(12068):

    s = df1_final[j].sum()

    if s >= 100 :
        best_indices.append(j)
    else :
        continue
```

In [0]:

```
len(best_indices)
```

Out[0]:

```
720
```

In [0]:

```
best_indices[0:10]
```

Out[0]:

```
[2, 3, 4, 5, 6, 7, 8, 27, 28, 29]
```

In [0]:

```
bow_features[0:10]
```

Out[0]:

```
['00', '000', '10', '100', '1000', '100th', '101', '102', '103', '105']
```

In [ ]:

```
fp_words = []

for a in best_indices :
    fp_words.append(str(bow_features[a]))
```

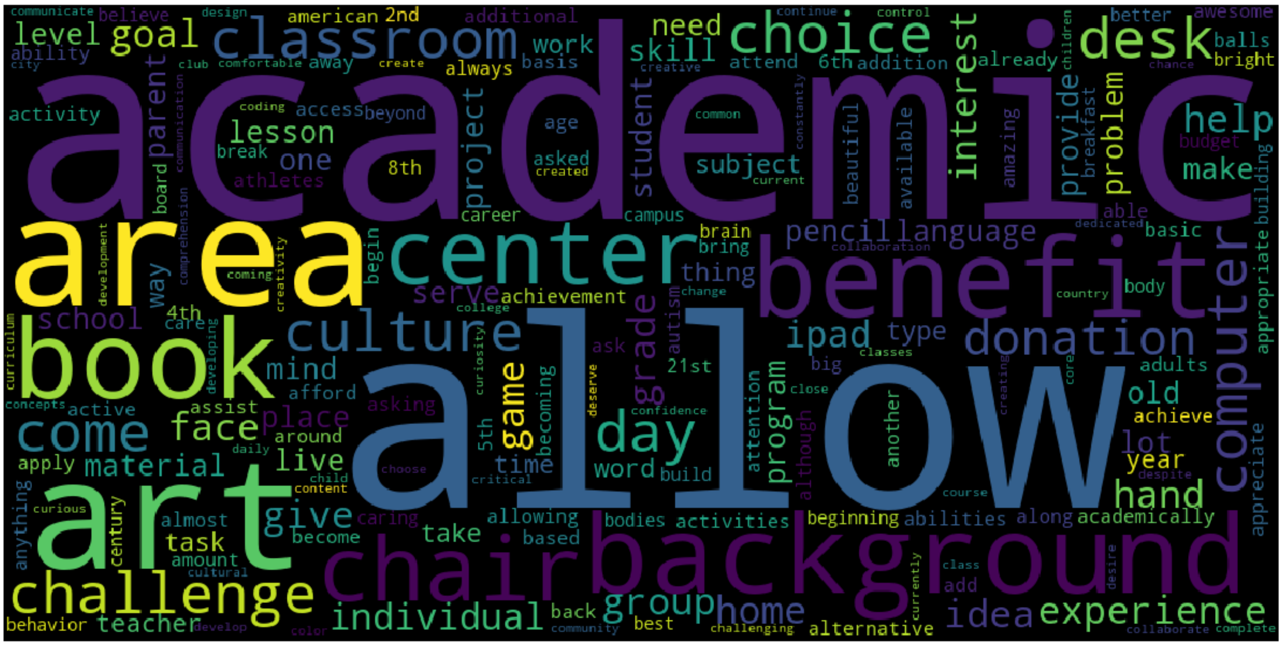
In [ ]:

```
fp_words[0:10]
```

Word Cloud

In [0]:

```
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



Visualize Decision Trees

In [94]:

```
bow_features_names = []

## Obtain Feature names for Project titles
for a in vectorizer_proj.get_feature_names() :
    bow_features_names.append(a)
## Obtain Feature names for Project Sub-titles
for a in vectorizer_sub_proj.get_feature_names() :
    bow_features_names.append(a)
## Obtain Feature names for states
for a in vectorizer_states.get_feature_names() :
    bow_features_names.append(a)
## Obtain Feature names for Project Grade Category
for a in vectorizer_grade.get_feature_names() :
    bow_features_names.append(a)
## Obtain Feature names for Teacher Title
for a in vectorizer_teacher.get_feature_names() :
    bow_features_names.append(a)
```

In [95]:

```
len(bow_features_names)
```

Out[95]:

```
99
```

In [96]:

```
bow_features_names.append("price")
bow_features_names.append("quantity")
bow_features_names.append("prev_proposed_projects")
bow_features_names.append("title_word_count")
bow_features_names.append("essay_word_count")
```

In [97]:

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

In [98]:

```
len(bow_features_names)
```

Out[98]:

```
14226
```

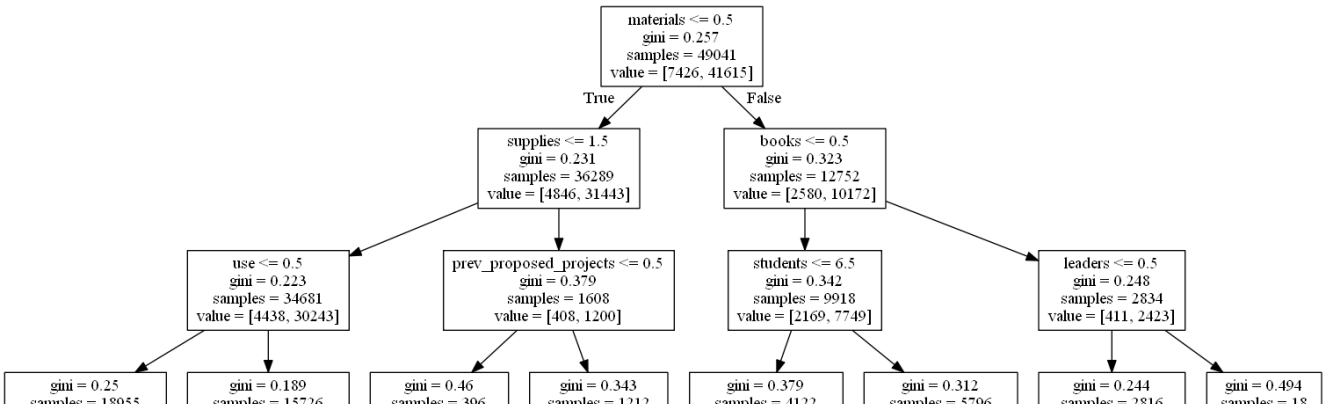
In [99]:

```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(max_depth=3)
clf = dtree.fit(X_tr, y_train)
```

In [101]:

```
# Importing libraries
from sklearn import tree
import pydotplus
from IPython.display import Image
from IPython.display import SVG
from graphviz import Source
from IPython.display import display
import os
## os.chdir("C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose/bin")
os.environ["PATH"] += os.pathsep +
'C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose/bin'
target = ['0','1']
# Create DOT data
dot_data = tree.export_graphviz(dtree, out_file=None, feature_names=bow_features_names)

# Draw graph
graph = pydotplus.graph_from_dot_data(dot_data)
#graph = Source(data)

# Show graph
Image(graph.create_png())
#display(SVG(graph.pipe(format='svg')))
```

Out[101]:



value = [2773, 16182] | value = [1665, 14061] | value = [142, 254] | value = [266, 946] | value = [1048, 3074] | value = [1121, 4675] | value = [401, 2415] | value = [10, 8]

F) Box - Plot with the price of these False positive data points

In [0]:

```
p = pd.DataFrame(X_test['price'])
```

In [0]:

```
price_final = p.iloc[false_positives_index_a,:]
```

In [0]:

```
plt.boxplot(price_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```

G) PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points

In [0]:

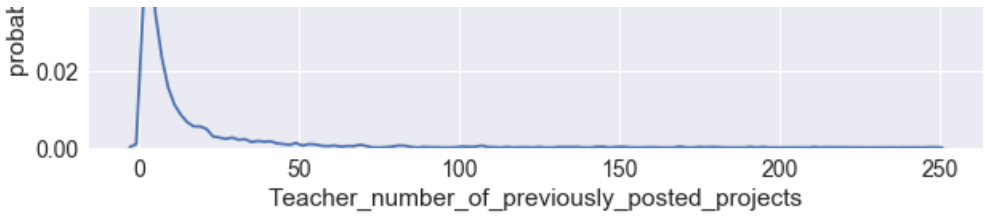
```
ppt = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
```

In [0]:

```
ppt_final = ppt.iloc[false_positives_index_a,:]
```

In [0]:

```
plt.figure(figsize=(10,3))
sns.distplot(ppt_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



Summary

- Majority of the cases have Teachers with previously posted projects as 0 (which is nearly 10% of the total data)

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

In [118]:

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

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

In [119]:

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

```
Final Data matrix
(49041, 14184) (49041,)
(24155, 14184) (24155,)
(36052, 14184) (36052,)
```

RandomisedSearchCV Implementation (Decision Tree)

In [120]:

```
import scipy.stats as sc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
params = {   "min_samples_split":[5,10,100,500],
             "max_depth":[1, 5, 10, 50, 100, 500, 100],
         }

grid = RandomizedSearchCV(DecisionTreeClassifier(), params, cv = 3, scoring = 'roc_auc', verbose =
1, random_state = 0,n_jobs = -1)
grid.fit(X_tr,y_train)
print(grid.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 12.5min finished
```

```
{'min_samples_split': 500, 'max_depth': 10}
```

Summary

- Decision Tree with maximum depth 10, performs decently on both Train as well as Cross Validation Data.
- Minimum samples per split is 500.

3D Scatter Plots

In [121]:

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

In [122]:

```
train_auc
```

Out[122]:

```
array([0.54882526, 0.97820774, 0.82563687, 0.93047811, 0.61229564,
       0.64940382, 0.93378494, 0.85592746, 0.9992774 , 0.93258899])
```

In [123]:

```
cv_auc
```

Out[123]:

```
array([0.54812406, 0.54461966, 0.55024122, 0.5115032 , 0.59540348,
       0.60574464, 0.50758831, 0.53225382, 0.53361451, 0.5150171 ])
```

In [98]:

```
x1=[0.54882526, 0.97820774, 0.82563687, 0.93047811, 0.61229564,
       0.64940382, 0.93378494, 0.85592746, 0.9992774 , 0.93258899]
```

In [99]:

```
x2=[0.54812406, 0.54461966, 0.55024122, 0.5115032 , 0.59540348,
       0.60574464, 0.50758831, 0.53225382, 0.53361451, 0.5150171 ]
```

In [100]:

```
z1 = pd.Series([1,5,10,10,50,50,100,100,500,500],index = x1)
```

In [101]:

```
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10], index = x1)
```

In [104]:

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

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

In [105]:

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

In [106]:

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

In [107]:

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

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

Out[107]:

B) Train the model using the best hyper parameter value

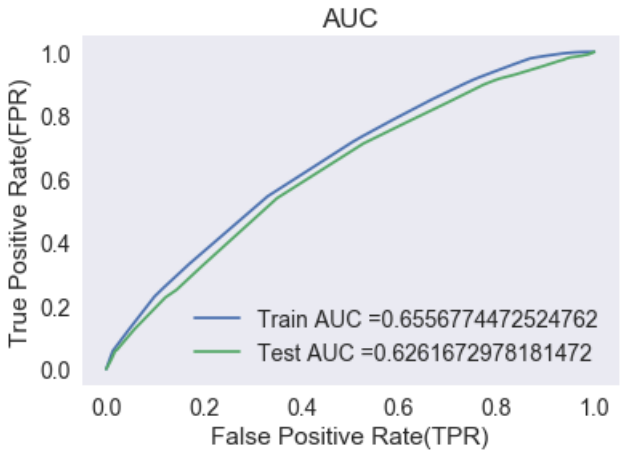
In [0]:

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

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

    return y_data_pred
```

In [0]:

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

model = DecisionTreeClassifier(max_depth = 10, min_samples_split = 500)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [0]:

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

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

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

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

Train Data

In [0]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24997778602908424 for threshold 0.847
[[ 3678  3748]
 [11813 29802]]
```

In [0]:

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

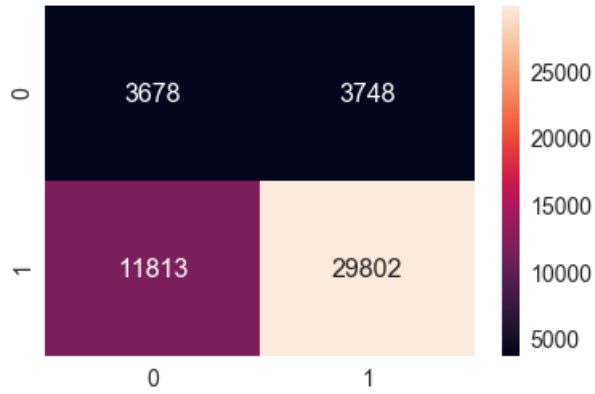
```
the maximum value of tpr*(1-fpr) 0.24997778602908424 for threshold 0.847
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc2eaabe0>
```



Test Data

In [0]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24926994118020324 for threshold 0.847
[[ 2582  2877]
 [ 8836 21757]]
```

In [0]:

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

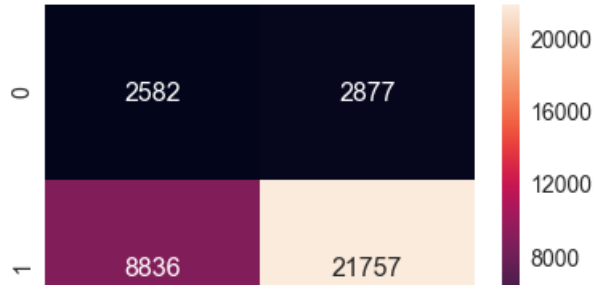
```
the maximum value of tpr*(1-fpr) 0.24926994118020324 for threshold 0.847
```

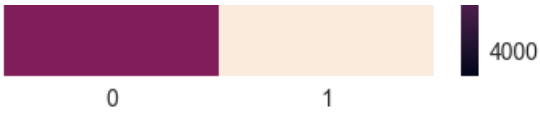
In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc3293630>
```





Visualise Decision Trees

In [104]:

```
tfidf_features_names = []
```

In [105]:

```
## Obtain Feature names for Project titles
for a in vectorizer_proj.get_feature_names() :
    tfidf_features_names.append(a)
## Obtain Feature names for Project Sub-titles
for a in vectorizer_sub_proj.get_feature_names() :
    tfidf_features_names.append(a)
## Obtain Feature names for states
for a in vectorizer_states.get_feature_names() :
    tfidf_features_names.append(a)
## Obtain Feature names for Project Grade Category
for a in vectorizer_grade.get_feature_names() :
    tfidf_features_names.append(a)
## Obtain Feature names for Teacher Title
for a in vectorizer_teacher.get_feature_names() :
    tfidf_features_names.append(a)
```

In [106]:

```
tfidf_features_names.append("price")
tfidf_features_names.append("quantity")
tfidf_features_names.append("prev_proposed_projects")
tfidf_features_names.append("title_word_count")
tfidf_features_names.append("essay_word_count")
```

In [107]:

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

In [108]:

```
len(tfidf_features_names)
```

Out[108]:

```
14226
```

In [109]:

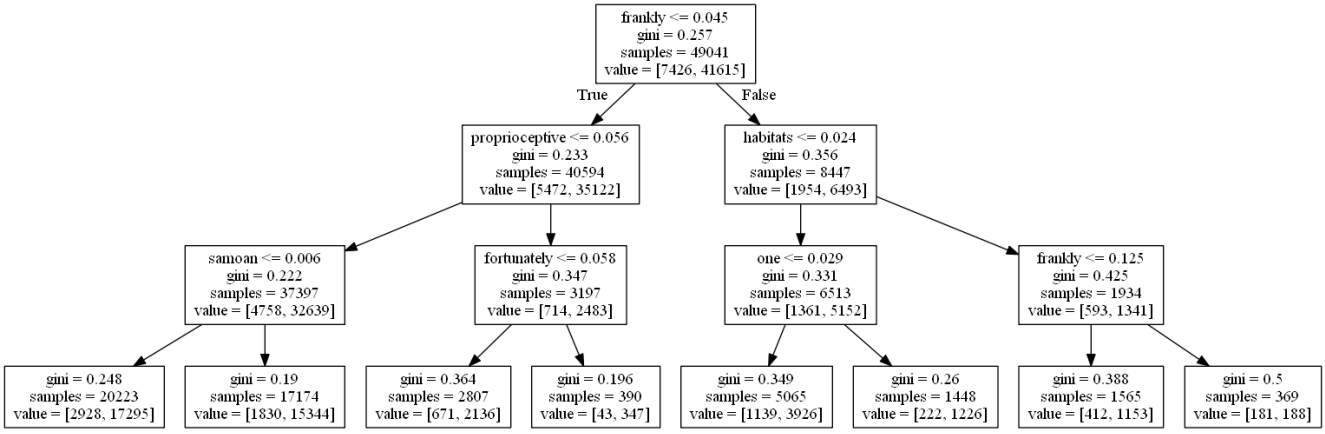
```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(max_depth=3)
clf = dtree.fit(X_tr, y_train)
```

In [110]:

```
# Importing libraries
from sklearn import tree
import pydotplus
from IPython.display import Image
from IPython.display import SVG
from graphviz import Source
from IPython.display import display
import os
```

```
## os.chdir("C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose/bin")
os.environ["PATH"] += os.pathsep +
'C:/Users/kingsubham27091995/Desktop/AppliedAiCouse/DonorsChoose/bin'
target = ['0','1']
# Create DOT data
dot_data = tree.export_graphviz(dtree, out_file=None, feature_names=tfidf_features_names)

# Draw graph
graph = pydotplus.graph_from_dot_data(dot_data)
#graph = Source(data)

# Show graph
Image(graph.create_png())
#display(SVG(graph.pipe(format='svg')))
```

Out[110]:



Find all the FALSE POSITIVES to see what is wrong with the model and plotting WORDCLOUD

In [0]:

```
tfidf_test = text_tfidf_test.todense()
```

In [0]:

```
tfidf_test.shape
```

Out[0]:

```
(36052, 12056)
```

In [0]:

```
vectorizer_tfidf_essay = CountVectorizer(min_df=10)

bv = vectorizer_tfidf_essay.fit(preprocessed_essays_train)
```

In [0]:

```
tfidf_features = bv.get_feature_names()
```

In [0]:

```
len(tfidf_features)
```

Out[0]:

```
12056
```

In [0]:

```
y_test_converted = list(y_test[::])
```

In [0]:

```
false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= 0.84:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████████████████████████| 36052/36052 [00:02<00:00, 17196.91it/s]
```

In [0]:

```
fp_count
```

Out[0]:

```
2747
```

In [0]:

```
false_positives_index_b[0:5]
```

Out[0]:

```
[12, 27, 38, 44, 52]
```

In [0]:

```
df2 = pd.DataFrame(tfidf_test)
```

In [0]:

```
df2_final = df2.iloc[false_positives_index_b,:]
```

In [0]:

```
df2_final.shape
```

Out[0]:

```
(2747, 12056)
```

In [0]:

```
best_indices_b = []

for j in range(12056):

    s = df2_final[j].sum()

    if s >= 10 :
        best_indices_b.append(j)
    else :
        continue
```

In [0]:

```
len(best_indices_b)
```

Out[0]:

489

In [0]:

```
best_indices_b[0:10]
```

Out[0]:

```
[3, 209, 210, 211, 236, 237, 253, 304, 333, 339]
```

In [0]:

```
tfidf_features[0:10]
```

Out[0]:

```
['00', '000', '10', '100', '1000', '100th', '101', '103', '104', '105']
```

In [0]:

```
fp_words_b = []

for a in best_indices_b :
    fp_words_b.append(str(tfidf_features[a]))
```

In [0]:

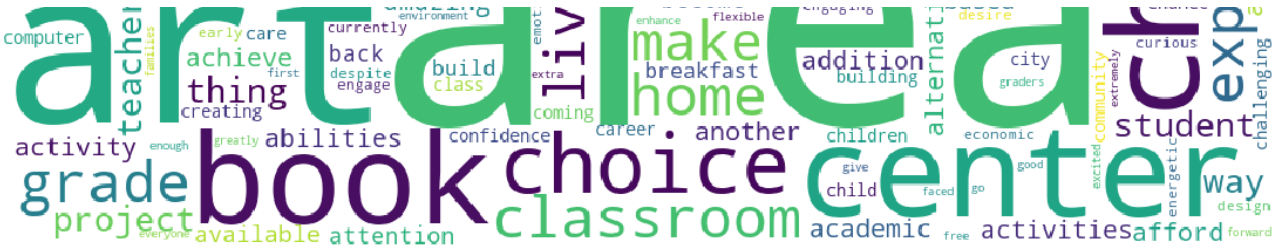
```
fp_words_b[0:10]
```

Out[0]:

```
['100',
 'abilities',
 'ability',
 'able',
 'academic',
 'academically',
 'access',
 'achieve',
 'active',
 'activities']
```

In [0]:

```
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words_b)
wordcloud = WordCloud(width = 1000, height = 500, background_color ='white').generate(unique_string
)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("Word_Cloud_tfidf"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



F) Box - Plot with the price of these False positive data points

In [0]:

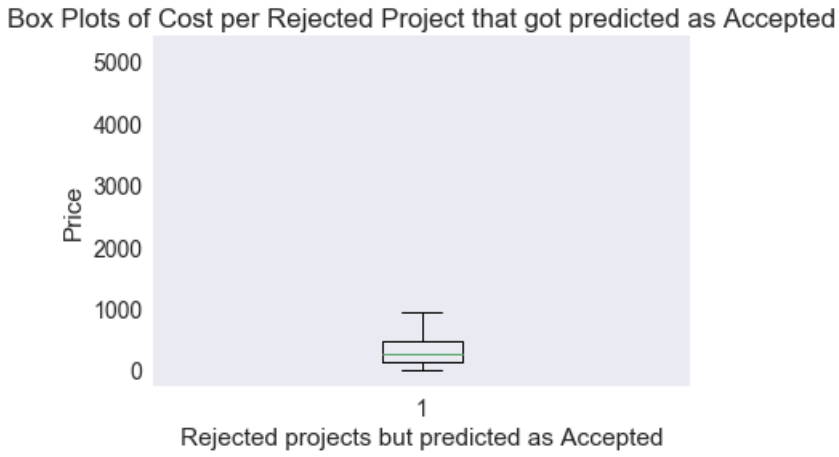
```
p_b = pd.DataFrame(X_test['price'])
```

In [0]:

```
price_b_final = p_b.iloc[false_positives_index_b,:]
```

In [0]:

```
plt.boxplot(price_b_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```



Inference

1) Majority of the projects that were rejected but predicted as accepted Costs almost less than 500 Dollars.

2) Good number of incorrectly prediced projects cost around 1000 - 2000 Dollars.

3) A Few of them are Extremely costly costing more than 2000 Dollars.

G) PDF with the Teacher_number_of_previously_posted_projects of these False Positive data points

In [0]:

```
ppt_b = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
```

In [0]:

```
ppt_b_final = ppt_b.iloc[false_positives_index_b,:]
```

In [0]:

```
plt.figure(figsize=(10,3))
sns.distplot(ppt_b_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data p
oints')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```

Inference

1) Majority of the cases have Teachers with previously posted projects as 0.

2) Good percent of Teachers have 10 or fewer projects previously posted projects.

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

In [138]:

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

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

In [139]:

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

```
Final Avg W2V Data matrix
(49041, 704) (49041,)
(24155, 704) (24155,)
```

(36052, 704) (36052,)

RandomisedSearchCV Implementation (Decision Tree)

In [140]:

```
import scipy.stats as sc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
params = {   "min_samples_split":[5,10,100,500],
             "max_depth":[1, 5, 10, 50, 100, 500, 100],
         }

grid = RandomizedSearchCV(DecisionTreeClassifier(), params, cv = 3, scoring = 'roc_auc', verbose =
1, random_state = 0,n_jobs = -1)
grid.fit(X_tr,y_train)
print(grid.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 36.4min finished
```

```
{'min_samples_split': 10, 'max_depth': 5}
```

Summary

- Decision Tree with maximum depth 5, performs decently on both Train as well as Cross Validation Data.
- Minimum samples per split is 10.

3D Scatter Plots

In [141]:

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

In [142]:

```
train_auc
```

Out[142]:

```
array([0.55577735, 0.94601595, 0.93692278, 0.99644721, 0.6399354 ,
       0.69435762, 0.99940186, 0.98896032, 0.99948385, 0.99642459])
```

In [143]:

```
cv_auc
```

Out[143]:

```
array([0.55227055, 0.55225314, 0.53802391, 0.52425717, 0.60377428,
       0.59695575, 0.51871648, 0.49083004, 0.52415175, 0.52530473])
```

In [108]:

```
x1=[0.55577735, 0.94601595, 0.93692278, 0.99644721, 0.6399354 ,
       0.69435762, 0.99940186, 0.98896032, 0.99948385, 0.99642459]
```

In [109]:

```
x2=[0.55227055, 0.55225314, 0.53802391, 0.52425717, 0.60377428,
```

```
       0.59695575, 0.51871648, 0.49083004, 0.52415175, 0.52530473]
```

In [110]:

```
z1 = pd.Series([1,5,10,10,50,50,100,100,500,500],index = x1)
```

In [111]:

```
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10], index = x1)
```

In [112]:

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

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

In [113]:

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

In [116]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- AVG_W2V Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
```

```
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [117]:

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

py.iplot(fig, filename='Decision-trees-d', height=900)
```

Out[117]:

B) Train the model using the best hyper parameter value

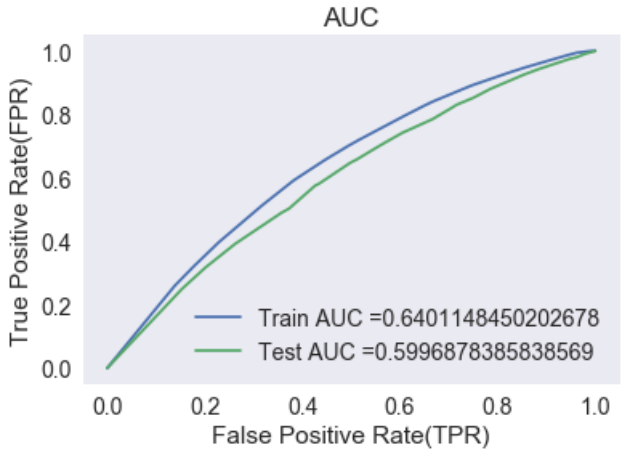
In [0]:

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

    y_data_pred = []
```

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

    return y_data_pred
```

In [0]:

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

model = DecisionTreeClassifier(max_depth = 5, min_samples_split = 10)

model.fit(X_tr, y_train)

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

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

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

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



C) Confusion Matrix

In [0]:

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

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

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

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

```
        else:
            predictions.append(0)
    return predictions
```

Train Data

In [0]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24997903726499707 for threshold 0.838
[[ 3747  3679]
 [12405 29210]]
```

In [0]:

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

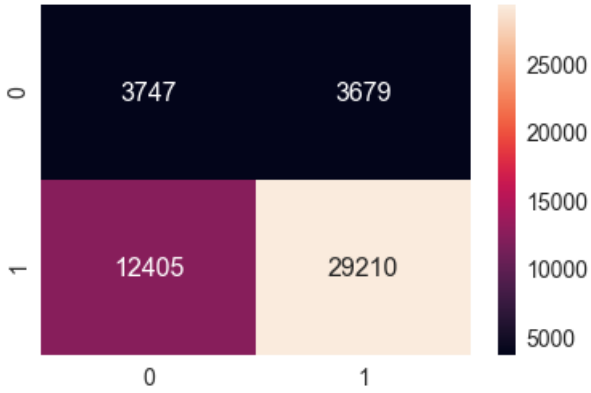
```
the maximum value of tpr*(1-fpr) 0.24997903726499707 for threshold 0.838
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc556fc88>
```



Test Data

In [0]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999388436794448 for threshold 0.849
[[ 2743  2716]
 [10805 19788]]
```

In [0]:

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

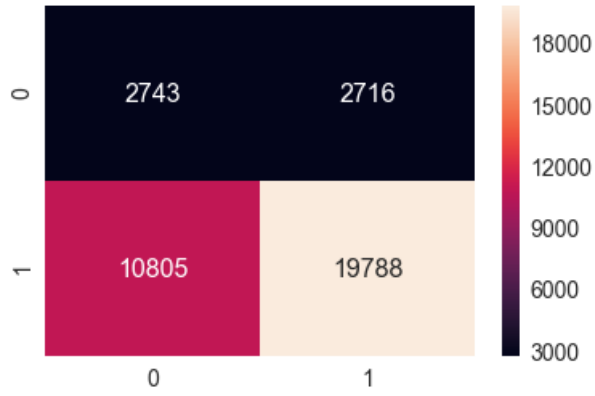
```
the maximum value of tpr*(1-fpr) 0.24999388436794448 for threshold 0.849
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc3ec12e8>
```



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

In [84]:

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

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

In [85]:

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

```
Final Data matrix
(49041, 704) (49041,)
(24155, 704) (24155,)
(36052, 704) (36052,)
```

RandomisedSearchCV Implementation (Decision Tree)

In [86]:

```
import scipy.stats as sc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
params = {   "min_samples_split":[5,10,100,500],
             "max_depth":[1, 5, 10, 50, 100, 500, 100],
         }

grid = RandomizedSearchCV(DecisionTreeClassifier(), params, cv = 3, scoring = 'roc_auc', verbose =
1, random_state = 0,n_jobs = -1)
grid.fit(X_tr,y_train)
print(grid.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 55.5min finished
```

```
{'min_samples_split': 10, 'max_depth': 5}
```

Summary

- Decision Tree with maximum depth 5, performs decently on both Train as well as Cross Validation Data.
- Minimum samples per split is 10.

3D Scatter Plots

In [87]:

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

In [88]:

```
train_auc
```

Out[88]:

```
array([0.56043441, 0.9401793 , 0.93676212, 0.99623801, 0.65211496,
       0.71726926, 0.9995209 , 0.99440639, 0.99953489, 0.99627564])
```

In [89]:

```
cv_auc
```

Out[89]:

```
array([0.55326183, 0.55455891, 0.54620284, 0.52583947, 0.61262427,
       0.60659608, 0.52236008, 0.51025936, 0.52221339, 0.52787058])
```

In [90]:

```
import plotly
plotly.tools.set_credentials_file(username='Subham27091995', api_key='UIByfud7j0socJjnGnOI')
```

In [118]:

```
x1=[0.56043441, 0.9401793 , 0.93676212, 0.99623801, 0.65211496,
       0.71726926, 0.9995209 , 0.99440639, 0.99953489, 0.99627564]
```

In [119]:

```
x2= [0.55326183, 0.55455891, 0.54620284, 0.52583947, 0.61262427,
```

```
       0.60659608, 0.52236008, 0.51025936, 0.52221339, 0.52787058]
```

In [120]:

```
z1 = pd.Series([1,5,10,10,50,50,100,100,500,500],index = x1)
```

In [121]:

```
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10], index = x1)
```

In [122]:

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

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

In [124]:

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

In [125]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- TFIDF_w2v Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
```

```
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [126]:

```
import plotly.plotly as py

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

py.iplot(fig, filename='Decision-trees-d', height=900)
```

Out[126]:

B) Train the model using the best hyper parameter value

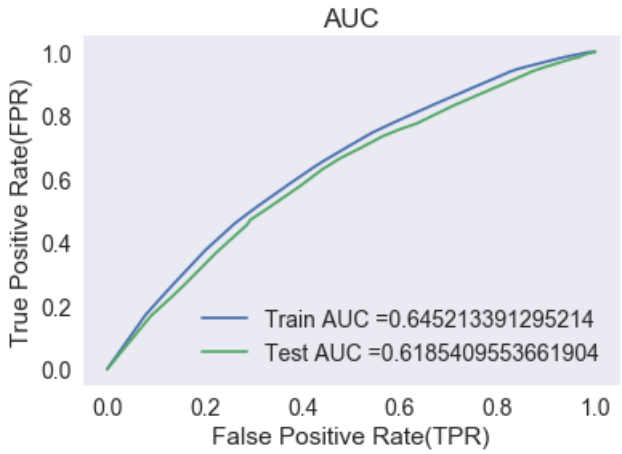
In [0]:

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

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

    return y_data_pred
```

In [0]:

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

model = DecisionTreeClassifier(max_depth = 5, min_samples_split = 10)

model.fit(X_tr_new, y_train)

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

y_train_pred = batch_predict(model, X_tr_new)
y_test_pred = batch_predict(model, X_te_new)

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

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



C) Confusion Matrix

In [0]:

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

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

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

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

```
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

Train Data

In [0]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24996801188188134 for threshold 0.835
[[ 3755  3671]
 [12391 29224]]
```

In [0]:

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

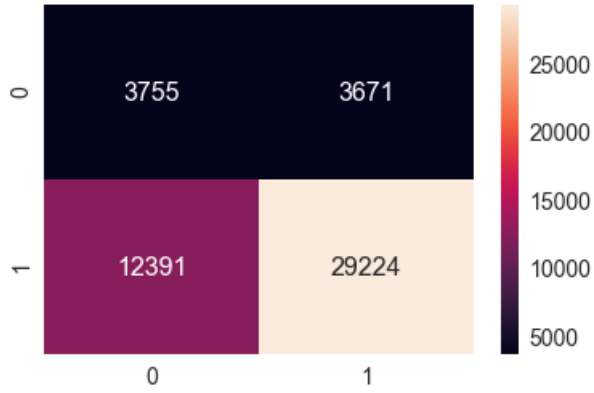
```
the maximum value of tpr*(1-fpr) 0.24996801188188134 for threshold 0.835
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc4871e48>
```



Test Data

In [0]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24966778443754356 for threshold 0.835
[[ 2630  2829]
 [ 9288 21305]]
```

In [0]:

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

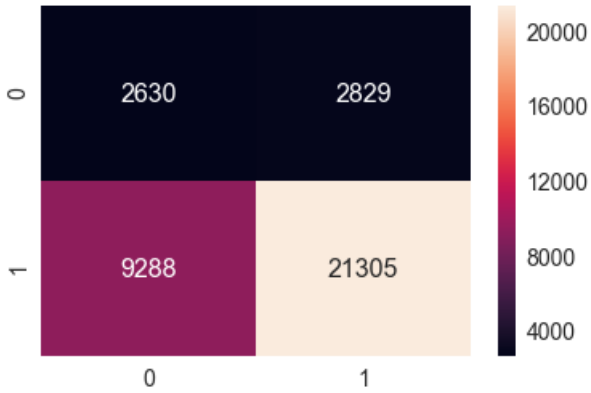
```
the maximum value of tpr*(1-fpr) 0.24966778443754356 for threshold 0.835
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdb3f56860>
```



Summary:

1. When data(n) is large and dimension(d) is small , Decision Tree is your choice
2. As depth increases --> OVERFITTING As depth decreases --> UNDERFITTING

[Task 2] Select best 5k features from Set 2

In [107]:

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

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

In [108]:

```
from sklearn.feature_selection import SelectKBest, chi2

X_tr_new = SelectKBest(chi2, k=5000).fit_transform(X_tr, y_train)
X_te_new = SelectKBest(chi2, k=5000).fit_transform(X_te, y_test)
X_cr_new = SelectKBest(chi2, k=5000).fit_transform(X_cr, y_cv)
```

In [109]:

```
print("Final Data matrix")
print(X_tr_new.shape, y_train.shape)
print(X_cr_new.shape, y_cv.shape)
print(X_te_new.shape, y_test.shape)
```

```
Final Data matrix
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
```

In [110]:

```
import scipy.stats as sc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
params = {   "min_samples_split":[5,10,100,500],
             "max_depth":[1, 5, 10, 50, 100, 500, 100],
         }

grid = RandomizedSearchCV(DecisionTreeClassifier(), params, cv = 3, scoring = 'roc_auc', verbose =
1, random_state = 0,n_jobs = -1)
grid.fit(X_tr_new,y_train)
print(grid.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed:  6.3min finished
```

```
{'min_samples_split': 500, 'max_depth': 10}
```

- Decision Tree with maximum depth 10, performs decently on both Train as well as Cross Validation Data.
- Minimum samples per split is 500.

3D Scatter Plots

In [111]:

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

In [112]:

```
train_auc
```

Out[112]:

```
array([0.55052892, 0.97384492, 0.82055896, 0.93249374, 0.61772317,
       0.65418001, 0.9417974 , 0.8537404 , 0.9989926 , 0.93321118])
```

In [113]:

```
cv_auc
```

Out[113]:

```
array([0.54838288, 0.55591558, 0.54806407, 0.51175939, 0.59945291,
       0.61035643, 0.50457983, 0.52339071, 0.53903286, 0.51007976])
```

In [127]:

```
x1=[0.56043441, 0.9401793 , 0.93676212, 0.99623801, 0.65211496,
       0.71726926, 0.9995209 , 0.99440639, 0.99953489, 0.99627564]
```

In [128]:

```
x2= [0.54838288, 0.55591558, 0.54806407, 0.51175939, 0.59945291,
       0.61035643, 0.50457983, 0.52339071, 0.53903286, 0.51007976]
```

In [129]:

```
z1 = pd.Series([1,5,10,10,50,50,100,100,500,500],index = x1)
```

In [130]:

```
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10], index = x1)
```

In [131]:

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

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

In [132]:

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

In [133]:

```
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- Train Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
```

```
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [134]:

```
import plotly.plotly as py

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

py.iplot(fig, filename='Decision-trees-d', height=900)
```

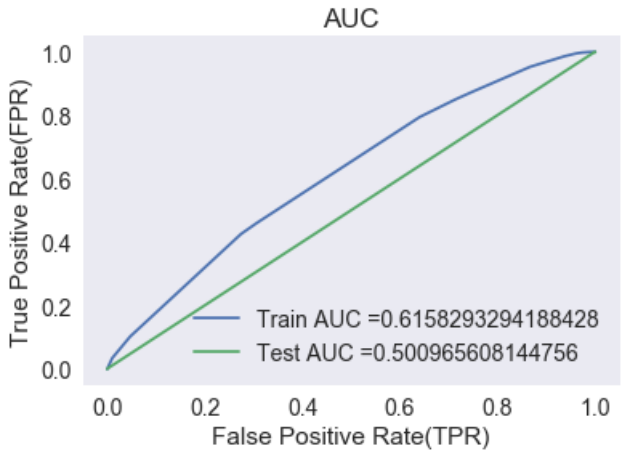
Out[134]:

C) Train the model using the best hyper parameter value

In [0]:

```
# https://scikit-
```

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

model = DecisionTreeClassifier(max_depth = 5, min_samples_split = 10)

model.fit(X_tr_new, y_train)

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

y_train_pred = batch_predict(model, X_tr_new)
y_test_pred = batch_predict(model, X_te_new)

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

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



Confusion Matrix

Train Data

In [0]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.23034868717063933 for threshold 0.849
[[ 2672  4754]
 [ 8550 33065]]
```

In [0]:

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

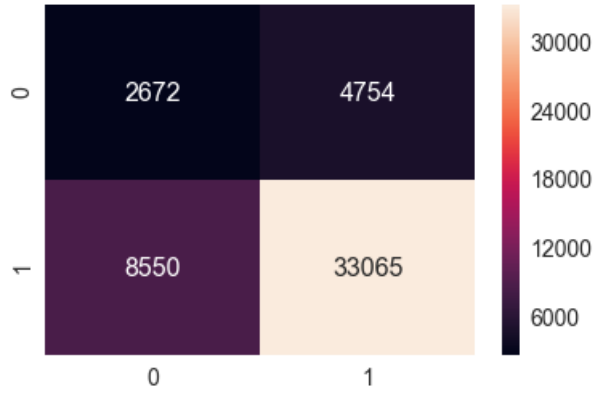
```
the maximum value of tpr*(1-fpr) 0.23034868717063933 for threshold 0.849
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdeaf31710>
```



Test Data

In [0]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.0029223493248359124 for threshold 0.912
[[ 5458     1]
 [30572    21]]
```

In [0]:

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

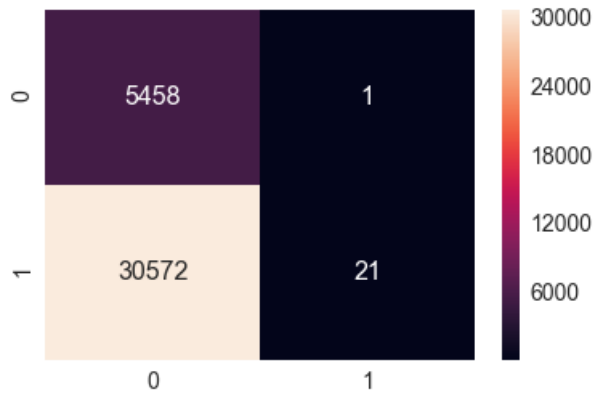
```
the maximum value of tpr*(1-fpr) 0.0029223493248359124 for threshold 0.912
```

In [0]:

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

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xcdc238bf28>
```



Utility Functions for Confusion Matrix, Precision Matrix, Recall Matrix

In [0]:

```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are predicted class j

    A =(((C.T)/(C.sum(axis=1))).T)
    #divid each element of the confusion matrix with the sum of elements in that column

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #         [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to columns and axis=1 corresponds to rows in two
diamensional array
    # C.sum(axix =1) = [[3, 7]]
    # ((C.T)/(C.sum(axis=1))) = [[1/3, 3/7]
    #                            [2/3, 4/7]]

    # ((C.T)/(C.sum(axis=1))).T = [[1/3, 2/3]
    #                            [3/7, 4/7]]
    # sum of row elements = 1

    B =(C/C.sum(axis=0))
    #divid each element of the confusion matrix with the sum of elements in that row
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to rows in two
diamensional array
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                      [3/4, 4/6]]
    plt.figure(figsize=(20,4))

    labels = [1,2]
    # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

    plt.subplot(1, 3, 2)
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Precision matrix")

    plt.subplot(1, 3, 3)
    # representing B in heatmap format
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

Distribution of Yi's

In [0]:

```
print("-"*10, "Distribution of output variable in train data", "-"*10)
train_distr = Counter(y_train)
train_len = len(y_train)
print("Class 0: ",int(train_distr[0])/train_len,"Class 1: ", int(train_distr[1])/train_len)
print("-"*10, "Distribution of output variable in train data", "-"*10)
test_distr = Counter(y_test)
```

```
test_len = len(y_test)
print("Class 0: ",int(test_distr[1])/test_len, "Class 1: ",int(test_distr[1])/test_len)
```

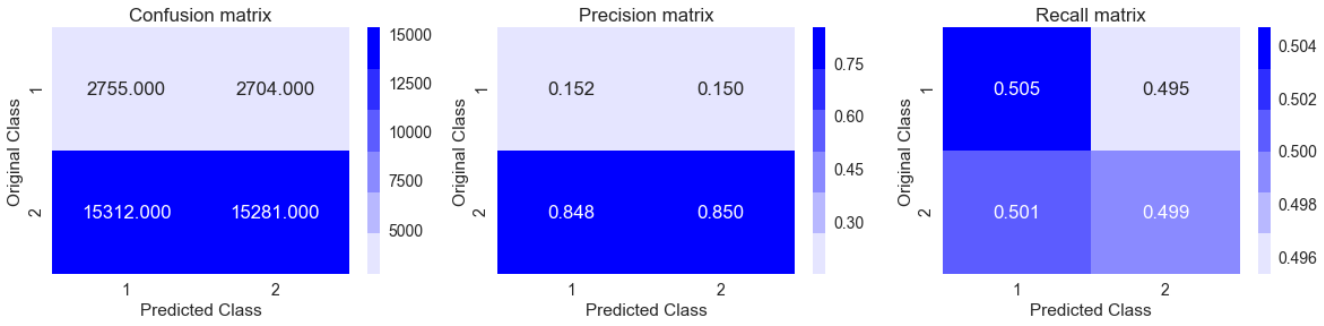
```
---------- Distribution of output variable in train data ----------
Class 0:  0.15142431842743825 Class 1:  0.8485756815725617
---------- Distribution of output variable in train data ----------
Class 0:  0.8485798291356929 Class 1:  0.8485798291356929
```

Building a Random Model

In [0]:

```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same size as the CV data
predicted_y = np.zeros((test_len,2))
for i in range(test_len):
    rand_probs = np.random.rand(1,2)
    predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test, predicted_y, eps=1e-15))

predicted_y =np.argmax(predicted_y, axis=1)
plot_confusion_matrix(y_test, predicted_y)
```

```
Log loss on Test Data using Random Model 0.8879068011160692
```



So, we got Test Log-Loss of a Random Model to be 0.887. Any sensible model we build further should have Test Log-Loss considerably less than this.

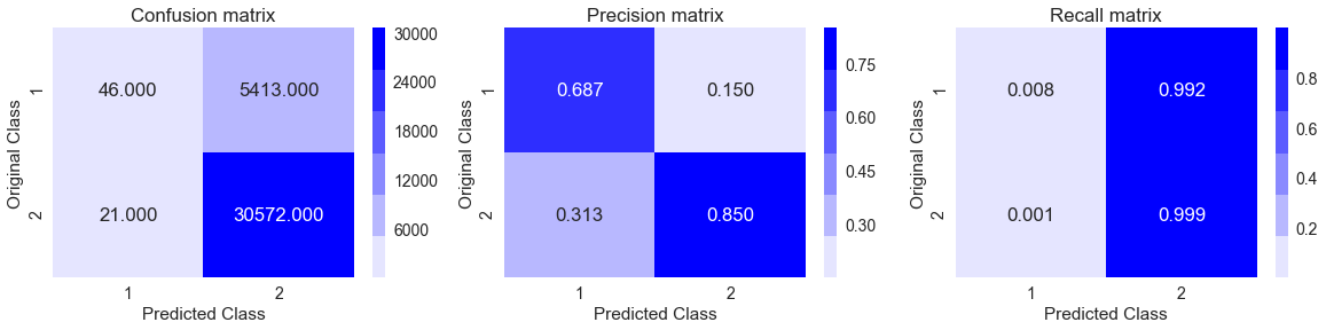
Logistic Regression with hyperparameter tuning

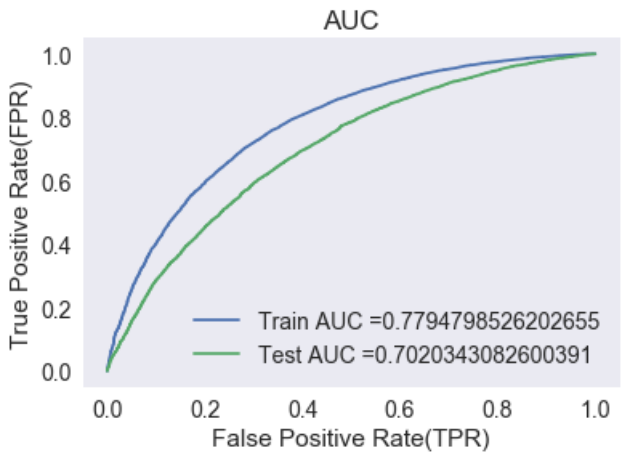
In [0]:

```
from sklearn.linear_model import SGDClassifier
from sklearn.calibration import CalibratedClassifierCV
from sklearn.metrics.classification import accuracy_score, log_loss
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42)
    clf.fit(X_tr_new, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_tr_new, y_train)
    predict_y = sig_clf.predict_proba(X_te_new)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.cl
asses_, eps=1e-15))


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_state=42)
clf.fit(X_tr_new, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
```

```
sig_clf.fit(X_tr_new, y_train)

predict_y = sig_clf.predict_proba(X_tr_new)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train,
predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_te_new)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, p
redict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)


y_train_pred = batch_predict(sig_clf, X_tr_new)
y_test_pred = batch_predict(sig_clf, X_te_new)

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

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

```
For values of alpha =  1e-05 The log loss is: 0.3986213731090486
For values of alpha =  0.0001 The log loss is: 0.3913573981929031
For values of alpha =  0.001 The log loss is: 0.40168122827572167
For values of alpha =  0.01 The log loss is: 0.41813517242567577
For values of alpha =  0.1 The log loss is: 0.4223732438548344
For values of alpha =  1 The log loss is: 0.4233032564826483
For values of alpha =  10 The log loss is: 0.4234428006674644
For values of best alpha =  0.0001 The train log loss is: 0.36711916365446967
For values of best alpha =  0.0001 The test log loss is: 0.3913573981929031
Total number of data points : 36052
```





Pretty Table

In [0]:

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

from prettytable import PrettyTable

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

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

x.add_row(["BOW", "Decision Trees","(10, 500)", 0.654, 0.625])
x.add_row(["TFIDF", "Decision Trees", "(10, 500)", 0.655, 0.626])
x.add_row(["AVG W2V", "Decision Trees", "(5, 10)", 0.640, 0.60])
x.add_row(["TFIDF W2V", "Decision Trees", "(5, 10)", 0.645, 0.618])
x.add_row(["TFIDF-5k Features", "Decision Trees","(10,500)", 0.615, 0.592])
x.add_row(["TFIDF-5k Features", "Logistic Regression", "[L1 penalty, alpha = 0.0001]", 0.779, 0.70
2])

print(x)
```

```
+------------------+---------------------+-----------------------------------------------+---------
+----------+
|     Vectorizer   |        Model        | Hyperparameters(max depth,min samples split) | Train AU
C | Test AUC |
+------------------+---------------------+-----------------------------------------------+---------
+----------+
|        BOW       |    Decision Trees   |                  (10, 500)                    |   0.654
|  0.625   |
|       TFIDF      |    Decision Trees   |                  (10, 500)                    |   0.655
|  0.626   |
|      AVG W2V     |    Decision Trees   |                   (5, 10)                     |    0.64
|   0.6    |
|     TFIDF W2V    |    Decision Trees   |                   (5, 10)                     |   0.645
|  0.618   |
| TFIDF-5k Features |    Decision Trees   |                   (10,500)                    |   0.615
|  0.592   |
| TFIDF-5k Features | Logistic Regression |         [L1 penalty, alpha = 0.0001]          |   0.779
|  0.702   |
+------------------+---------------------+-----------------------------------------------+---------
+----------+
```