DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

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

In [3]:

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

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['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

In [5]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039

cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]

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

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

1.2 preprocessing of `project_subject_categories`

In [6]:

```
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 [7]:

```
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]))
```

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

In [63]:

```
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['projec
is_approved'])
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [9]:

```
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)
```

preprocessing of project_grade_category

In [64]:

```
X_train["clean_essays"].values
```

Out[64]:

```
array(['i teach title i school south carolina 100 students receive free breakfast lunch around 30
students come non english speaking homes puts disadvantage learning read write most students famil
ies also lack resources provide books educational supplies children use home despite economic disa
dvantages students eager learn read write they love experiencing new texts read school take home s
hare families my students enjoy reading i want ensure continue read learn throughout lives i teach
kindergarten first second grade students qualified reading assistance based upon reading readiness
scores most students live homes no books academic tools use leave school nor parents help read com
plete homework my students need engaging books filled stunning artwork original stories like prize
winning toon books fall love develop lifelong passion reading with books students opportunity read
books independent reading levels well read high quality children literature through books students
learn love reading nannan',
       'my students active group first graders come school lots excitement desire learn they come
variety backgrounds our school first year stem magnet school means trying many new things support
student learning as try new things students engaged keeping 6 7 year olds engaged learning vital e
mbark upon path learning flexible seating options balance balls stability cushions greatly support
learning classroom students get choose type seat sit throughout day this choice helps young learne
rs learn early age self reflect able decide type seating best suits learning needs six seven year
olds active flexible seating options also allows students get wiggles move around focus task hand
when students comfortable learning improves students focused happy nannan',
       'hi welcome kindergarten class i lucky enough work group 5 6 year olds many possibilies
future our children come middle class families diverse backgrounds variety needs i advanced learne
rs struggling students non english speakers i want help engage all students use technology educati
onal apps my goal kindergarten class become excited school work performing my kindergarten
students need 2 ipads cases use instructional time they utilize ipads content areas i excited
expore science videos curriculum taught life science space plants animal come life help technology
i eager students communicate writing making books share my struggling readers able use ipads
i eager students communicate writing making books share my struggling readers able use ipads
literacy center read books practice thier literacy skills i want help foster self confident studen
ts want create share work others everything today explored technology ipads great way incorporate
technology curriculum early age they make learning fun engaging little learners nannan',
       ...,
       'out steam club meets school design robots gadgets we also like incorporating arts stem stuc
ents enjoy playing music well working engineering projects students come plan various activities h
elp hands experience science technology music great way students incorporate arts science we also
charge recycling school we want make school green reduce reuse let part environment my students ch
arge school wide recycling we noticed students not pay attention put recyclables trash wrong cans
stickers used label recycle cans trash cans we need larger cans collect classrooms we also need
gloves keep students pathogens students also help reduce use plastic using water bottles there wat
er dispensers campus let encourage students stop using plastic bottles drink reusable water
containers if using disposable water bottles students recycle let help environment reduce reuse re
cycle nannan',
       'i teach fifth grade reading one best rural schools oklahoma my students diverse group varie
d levels learning our classroom space students enjoy coming learn we title i school majority stude
nts receiving free lunches these kids huge hearts love learn non traditional ways room
transformations integrating arts lessons project based learning my students curiosity creativity c
ompassion positive attitudes they truly amazing people my school wonderfully supportive active han
ds learning classroom i could not ask better environment students we truly community my students t
hrilled enter classroom transformed world harry potter we read along harry potter audio cd conduct
project with owls birdcage fluffy dog black lights life size stand ups backdrops paint materials r
oom become replica classroom hogwarts the sorting hat broom used costumes project we use measuring
spoons mixing spoons electric kettle create pumpkin pasties butterbeer polyjuice potion punch hogw
arts kitchen we use classroom tablets computers research various owls go owl shopping choose owl h
ogwarts house then students write rough draft owl story using research part fact part fiction
after peer editing stories make owls print final product create owl cages chinese lanterns next cr
eate wands bamboo skewers after learning quidditch write pamphlet including instructions using bro
om competition next attend potions class the students practice following written directions create
exploding filibusters elephant toothpaste mandrake restorative drought basic vinegar eruption snap
es slime slime then students visit herbology class without told end product students arrive find v
arious herbs supplies team tables they follow recipes earn team points successful batches they end
product herb play dough take home enjoy nannan',
       'would choose go read interesting book piece cold concrete would comfortable reading
another person inches away or would rather sit comfy chair my students must sit hard plastic chair
s close together day my 29 students attend public school southern california high poverty area mos
t students complain hard focus work home loud chaotic not space in classroom try best concentrate
desks chairs not comfortable several children sitting close proximity i would like create flexible
seating classroom space i would tables students stand sit stools tables low ground students would
sit stability cushions balls bean bag chairs several cushions students could choose spot class wor
k lap desks each student would experiment find space makes comfortable best able work students
would able spread find space not distracted bothered others some seating options also allow
movement helps fidgety kids by stability balls cushions bean bag chairs lap desks i rid classroom
one desk chair fits approach actually make student feel comfortable research shown students allowe
d choose learning environment comfortable concentration improves leads effective learning'],
      dtype=object)
```

In [11]:

```
project_data["project_grade_category"]=project_data["project_grade_category"].str.replace(" ","")
project_data["project_grade_category"]=project_data["project_grade_category"].str.replace("-","_")
```

In [12]:

```
project_data["project_grade_category"].values
```

Out[12]:

```
array(['GradesPreK_2', 'Grades3_5', 'GradesPreK_2', ..., 'Grades3_5',
       'Grades9_12', 'GradesPreK_2'], dtype=object)
```

cleaning text(Text preprocessing)

Text preprocessing of essay

In [13]:

```
# 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_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [14]:

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

Out[14]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_t
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	GradesPreK_2	Enginee STEAM the Prim Classro
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades3_5	Sens Tools Fo

In [15]:

```
# 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', 'each', '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', "doesn't", 'ha
dn',\
"hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
"mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
'won', "won't", 'wouldn', "wouldn't"]
```

In [16]:

```
# 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 [17]:

```
def getProcessedData(txt_type, working_data):
    preprocessed_data = []
    # tqdm is for printing the status bar

    for sentance in tqdm(working_data[txt_type].values):
        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\"', ' ')
        sent = sent.replace('\\n', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
        # https://gist.github.com/sebleier/554280
        sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
        preprocessed_data.append(sent.lower().strip())

    return preprocessed_data
```

In [18]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

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)
```

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as the STEM j
ournals, which my students really enjoyed.  I would love to implement more of the Lakeshore STEM k
its in my classroom for the next school year as they provide excellent and engaging STEM
lessons.My students come from a variety of backgrounds, including language and socioeconomic statu
s.  Many of them don't have a lot of experience in science and engineering and these kits give me
the materials to provide these exciting opportunities for my students.Each month I try to do
several science or STEM/STEAM projects.  I would use the kits and robot to help guide my science i
nstruction in engaging and meaningful ways.  I can adapt the kits to my current language arts paci
ng guide where we already teach some of the material in the kits like tall tales (Paul Bunyan) or
Johnny Appleseed.  The following units will be taught in the next school year where I will
implement these kits: magnets, motion, sink vs. float, robots.  I often get to these units and don
't know If I am teaching the right way or using the right materials.    The kits will give me
additional ideas, strategies, and lessons to prepare my students in science.It is challenging to d
evelop high quality science activities.  These kits give me the materials I need to provide my
students with science activities that will go along with the curriculum in my classroom.  Although
I have some things (like magnets) in my classroom, I don't know how to use them effectively.  The
kits will provide me with the right amount of materials and show me how to use them in an
appropriate way.
==================================================
I teach high school English to students with learning and behavioral disabilities. My students all
vary in their ability level. However, the ultimate goal is to increase all students literacy level
s. This includes their reading, writing, and communication levels.I teach a really dynamic group o
f students. However, my students face a lot of challenges. My students all live in poverty and in
a dangerous neighborhood. Despite these challenges, I have students who have the the desire to def
eat these challenges. My students all have learning disabilities and currently all are performing
below grade level. My students are visual learners and will benefit from a classroom that fulfills
their preferred learning style.The materials I am requesting will allow my students to be prepared
for the classroom with the necessary supplies.  Too often I am challenged with students who come t
o school unprepared for class due to economic challenges.  I want my students to be able to focus
on learning and not how they will be able to get school supplies.  The supplies will last all year
.  Students will be able to complete written assignments and maintain a classroom journal.  The ch
art paper will be used to make learning more visual in class and to create posters to aid students
in their learning.  The students have access to a classroom printer.  The toner will be used to pr
int student work that is completed on the classroom Chromebooks I want to try and remove all barri
```

int student work that is completed on the classroom Chromebooks.I want to try and remove all barriers for the students learning and create opportunities for learning. One of the biggest barriers is the students not having the resources to get pens, paper, and folders. My students will be able to increase their literacy skills because of this project.

==

\"Life moves pretty fast. If you don't stop and look around once in awhile, you could miss it.\" from the movie, Ferris Bueller's Day Off. Think back...what do you remember about your grandparents? How amazing would it be to be able to flip through a book to see a day in their lives?My second graders are voracious readers! They love to read both fiction and nonfiction books. Their favorite characters include Pete the Cat, Fly Guy, Piggie and Elephant, and Mercy Watson. They also love to read about insects, space and plants. My students are hungry bookworms! My students are eager to learn and read about the world around them. My kids love to be at school and are like little sponges absorbing everything around them. Their parents work long hours and usually do not see their children. My students are usually cared for by their grandparents or a family friend. Most of my students do not have someone who speaks English at home. Thus it is difficult for my students to acquire language.Now think forward... wouldn't it mean a lot to your kids, nieces or nephews or grandchildren, to be able to see a day in your life today 30 years from now? Memories are so precious to us and being able to share these memories with future generations will be a rewarding experience. As part of our social studies curriculum, students will be learning about changes over time. Students will be studying photos to learn about how their community has changed over time. In particular, we will look at photos to study how the land, buildings, clothing, and schools have changed over time. As a culminating activity, my students will capture a slice of their history and preserve it through scrap booking. Key important events in their young lives will be documented with the date, location, and names.   Students will be using photos from home and from school to create their second grade memories.   Their scrap books will preserve their unique stories for future generations to enjoy.Your donation to this project will provide my second graders with an opportunity to learn about social studies in a fun and creative manner. Through their scrapbooks, children will share their story with others and have a historical document for the rest of their lives.

==

\"A person's a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the biggest enthusiasm for learning. My students learn in many different ways using all of our senses and multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nStudents in my class come from a variety of different backgrounds which makes for wonderful sharing of experiences and cultures, including Native Americans.\r\nOur school is a caring community of successful learners which can be seen through collaborative student project based learning in and out of the classroom. Kindergarteners in my class love to work with hands-on materials and have many different opportunities to practice a skill before it is mastered. Having the social skills to work cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the perfect place to learn about agriculture and nutrition. My students love to role play in our pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try cooking with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we learn important math and writing concepts while cooking delicious healthy food for snack time. My students will have a grounded appreciation for the work that went into making the food and knowledge of where the ingredients came from as well as how it's healthy for their bodies. This project would expand our learning of nutrition and agricultural cooking recipes by having us peel our own apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classroom garden in the spring. We will also create our own cookbooks to be printed and shared with families. \r\nStudents will gain math and literature skills as well as a life long enjoyment for healthy cooking.nannan

==

My classroom consists of twenty-two amazing sixth graders from different cultures and backgrounds. They are a social bunch who enjoy working in partners and working with groups. They are hard-working and eager to head to middle school next year. My job is to get them ready to make this transition and make it as smooth as possible. In order to do this, my students need to come to school every day and feel safe and ready to learn. Because they are getting ready to head to middle school, I give them lots of choice- choice on where to sit and work, the order to complete assignments, choice of projects, etc. Part of the students feeling safe is the ability for them to come into a welcoming, encouraging environment. My room is colorful and the atmosphere is casual. I want them to take ownership of the classroom because we ALL share it together. Because my time with them is limited, I want to ensure they get the most of this time and enjoy it to the best of their abilities.Currently, we have twenty-two desks of differing sizes, yet the desks are similar to the ones the students will use in middle school. We also have a kidney table with crates for seating. I allow my students to choose their own spots while they are working independently or in groups. More often than not, most of them move out of their desks and onto the crates. Believe it or not, this has proven to be more successful than making them stay at their desks! It is because of this that I am looking toward the “Flexible Seating” option for my classroom.\r\n The students look forward to their work time so they can move around the room. I would like to get rid of the constricting desks and move toward more “fun” seating options. I am requesting various seating so my students have more options to sit. Currently, I have a stool and a papasan chair I inherited from the previous sixth-grade teacher as well as five milk crate seats I made, but I would like to give them more options and reduce the competition for the “good seats”. I am also requesting two rugs as not only more seating options but to make the classroom more welcoming and appealing. In order for my students to be able to write and complete work without desks, I am requesting a class set of clipboards. Finally, due to curriculum that requires groups to work together, I am requesting tables that we can fold up when we are not using them to leave more room for our flexible seating options.\r\nI know that with more seating options, they will be that much more excited about coming to school! Thank you for your support in making my classroom one students will remember

```
to school! Thank you for your support in making my classroom one students will remember
forever!nannan
==================================================
```

In [20]:

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

```
\"A person is a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the b
iggest enthusiasm for learning. My students learn in many different ways using all of our senses a
nd multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nS
tudents in my class come from a variety of different backgrounds which makes for wonderful sharing
of experiences and cultures, including Native Americans.\r\nOur school is a caring community of su
ccessful learners which can be seen through collaborative student project based learning in and ou
t of the classroom. Kindergarteners in my class love to work with hands-on materials and have many
different opportunities to practice a skill before it is mastered. Having the social skills to wor
k cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the
perfect place to learn about agriculture and nutrition. My students love to role play in our
pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try coo
king with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we
learn important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies. This project
would expand our learning of nutrition and agricultural cooking recipes by having us peel our own
apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro
om garden in the spring. We will also create our own cookbooks to be printed and shared with famil
ies. \r\nStudents will gain math and literature skills as well as a life long enjoyment for health
y cooking.nannan
==================================================
```

In [21]:

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

```
 A person is a person, no matter how small.  (Dr.Seuss) I teach the smallest students with the big
gest enthusiasm for learning. My students learn in many different ways using all of our senses and
multiple intelligences. I use a wide range of techniques to help all my students succeed.
Students in my class come from a variety of different backgrounds which makes for wonderful
sharing of experiences and cultures, including Native Americans.  Our school is a caring community
of successful learners which can be seen through collaborative student project based learning in a
nd out of the classroom. Kindergarteners in my class love to work with hands-on materials and have
many different opportunities to practice a skill before it is mastered. Having the social skills t
o work cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is
the perfect place to learn about agriculture and nutrition. My students love to role play in our p
retend kitchen in the early childhood classroom. I have had several kids ask me,  Can we try cooki
ng with REAL food?  I will take their idea and create  Common Core Cooking Lessons  where we learn
important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies. This project
would expand our learning of nutrition and agricultural cooking recipes by having us peel our own
apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro
om garden in the spring. We will also create our own cookbooks to be printed and shared with famil
ies.   Students will gain math and literature skills as well as a life long enjoyment for healthy
cooking.nannan
```

In [22]:

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

```
 A person is a person no matter how small Dr Seuss I teach the smallest students with the biggest
enthusiasm for learning My students learn in many different ways using all of our senses and multi
ple intelligences I use a wide range of techniques to help all my students succeed Students in my
class come from a variety of different backgrounds which makes for wonderful sharing of
experiences and cultures including Native Americans Our school is a caring community of successful
learners which can be seen through collaborative student project based learning in and out of the
learners which can be seen through collaborative student project based learning in and out of the
classroom Kindergarteners in my class love to work with hands on materials and have many different
opportunities to practice a skill before it is mastered Having the social skills to work
cooperatively with friends is a crucial aspect of the kindergarten curriculum Montana is the
perfect place to learn about agriculture and nutrition My students love to role play in our
pretend kitchen in the early childhood classroom I have had several kids ask me Can we try cooking
with REAL food I will take their idea and create Common Core Cooking Lessons where we learn
important math and writing concepts while cooking delicious healthy food for snack time My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies This project w
ould expand our learning of nutrition and agricultural cooking recipes by having us peel our own a
pples to make homemade applesauce make our own bread and mix up healthy plants from our classroom
garden in the spring We will also create our own cookbooks to be printed and shared with families
Students will gain math and literature skills as well as a life long enjoyment for healthy cooking
nannan
```

In [23]:

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

```
100%|████████████████████████████████████████████████████████████████████████| 109248/109248
[12:33<00:00, 145.03it/s]
```

In [24]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[24]:

```
'a person person no matter small dr seuss i teach smallest students biggest enthusiasm learning my
students learn many different ways using senses multiple intelligences i use wide range techniques
help students succeed students class come variety different backgrounds makes wonderful sharing ex
periences cultures including native americans our school caring community successful learners seen
collaborative student project based learning classroom kindergarteners class love work hands
materials many different opportunities practice skill mastered having social skills work
cooperatively friends crucial aspect kindergarten curriculum montana perfect place learn
agriculture nutrition my students love role play pretend kitchen early childhood classroom i
several kids ask can try cooking real food i take idea create common core cooking lessons learn im
portant math writing concepts cooking delicious healthy food snack time my students grounded appre
ciation work went making food knowledge ingredients came well healthy bodies this project would ex
pand learning nutrition agricultural cooking recipes us peel apples make homemade applesauce make
bread mix healthy plants classroom garden spring we also create cookbooks printed shared families
students gain math literature skills well life long enjoyment healthy cooking nannan'
```

In [25]:

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

```
100%|████████████████████████████████████████████████████████████████████████| 109248/109248
[09:45<00:00, 186.61it/s]
```

In [26]:

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

In [27]:

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

In [59]:

```
project_data["clean_essays"].values
```

Out[59]:

```
array(['i fortunate enough use fairy tale stem kits classroom well stem journals students really e
njoyed i would love implement lakeshore stem kits classroom next school year provide excellent eng
aging stem lessons my students come variety backgrounds including language socioeconomic status ma
ny not lot experience science engineering kits give materials provide exciting opportunities stude
nts each month i try several science stem steam projects i would use kits robot help guide science
instruction engaging meaningful ways i adapt kits current language arts pacing guide already teach
material kits like tall tales paul bunyan johnny appleseed the following units taught next school
year i implement kits magnets motion sink vs float robots i often get units not know if i teaching
right way using right materials the kits give additional ideas strategies lessons prepare students
science it challenging develop high quality science activities these kits give materials i need pr
ovide students science activities go along curriculum classroom although i things like magnets cla
ssroom i not know use effectively the kits provide right amount materials show use appropriate way
',
       'imagine 8 9 years old you third grade classroom you see bright lights kid next chewing gum
birds making noise street outside buzzing cars hot teacher asking focus learning ack you need brea
k so students most students autism anxiety another disability it tough focus school due sensory ov
erload emotions my students lot deal school i think makes incredible kids planet they kind caring
sympathetic they know like overwhelmed understand someone else struggling they open minded
compassionate they kids someday change world it tough one thing time when sensory overload gets wa
y hardest thing world focus learning my students need many breaks throughout day one best items us
ed boogie board if classroom students could take break exactly need one regardless rooms school oc
cupied many students need something hands order focus task hand putty give sensory input need
order focus calm overloaded help improve motor skills make school fun when students able calm read
y learn when able focus learn retain they get sensory input need prevent meltdowns scary everyone
room this lead better happier classroom community able learn best way possible',
       'having class 24 students comes diverse learners some students learn best auditory means i
class twenty four kindergarten students my students attend title 1 school great majority english l
anguage learners most students come low income homes students receive free breakfast lunch my stud
ents enthusiastic learners often faced many types hardships home school often safe by mobile
listening storage center students able reinforce enhance learning they able listen stories using m
obile listening center help reinforce high frequency words introduced in addition able listen stor
ies reinforce reading comprehension skills strategies amongst auditory experiences a mobile
listening center help keep equipment neat organized ready use help reinforce enhance literacy skil
ls numerous students able use center help increase student learning',
       ...,
       'we title 1 school 650 total students our elementary school students third fifth grade
beginning formal training technology computing many theses children come rural farm backgrounds se
en agriculture action lives connect agriculture sustainability in elementary school students acces
s single computer technology laboratory all 650 students rotate lab learn science mathematics comp
uter programming web design reading computer processing using computers our students rely computin
g technology currently access chromebooks due state budget issues students would greatly benefit c
urrent computers could use access programs activities google earth geographic information systems
software software could used teach relationship agriculture sustainability these computers
populate computer lab currently no computers the old systems 11 years old removed network safety i
ssues could no longer updated repaired we would like teach children taking responsibility
environment early life there several effective ways three computer video games blockhood game
students building homes responsible way it teaches must take account resources water land energy a
lso cityrain teaches building sustainable cities lastly stopdisasters org teaches planning anticip
ated potential disasters building accordingly nannan',
       'i teach many different types students my classes full students want change world they uniqu
e way i teach clinical health students grades 9th 12th our school loyal support one another studen
ts take class learn health medical field opportunities available they want learn body systems help
others they motivated ready learn they hardworking strive excellence this cricket cutting machine
used making display boards health fair students put together community each group students chooses
different topic want inform community some topics include cancer fitness nutrition skeletal system
mental health blood pressure cpr first aid many each group conducts research creates display board
the cricket machine help enhance presentations community see learn important health care topics th
e health fair free anyone attend provides valuable information attends nannan',
       'my first graders eager learn world around they come school day full enthusiasm genuinely lo
ve learning our diverse class includes students variety cultural economic backgrounds many come ho
mes parents not afford simply not know importance books important provide environment rich
mes parents not afford simply not know importance books important provide environment rich
literature students learn love reading i want students lifelong learners reading best way i used m
agazines past kids absolutely love the topics high interest children always correspond real world
issues important kids learn the subscription also includes online resources videos printable works
heets skill based games these materials expose students rigorous interesting nonfiction text spark
curiosity world around the topics allow teach nonfiction text standards using interesting
materials they always lead engaging discussions inspire students find additional information vario
us topics nannan'],
      dtype=object)
```

Introducing new feature "Number of Words in Essay"

In [28]:

```
essay_word_count = []
```

In [29]:

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

In [30]:

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

Preprocessing of `project_title`

In [31]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:27<00:00, 3913.62it/s]
```

In [32]:

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

In [33]:

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

Introducing new feature "Number of Words in Title"

In [34]:

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

In [35]:

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

In [36]:

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

Out[36]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	GradesPreK_2	I ha fortunate to use t
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades3_5	Imagine 9 y You'r

In [37]:

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

In [38]:

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

```
100%|████████████████████████████████████████████████████████████| 109248/109248
[2:29:50<00:00, 12.15it/s]
```

In [39]:

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

1.5 Preparing data for models

In [40]:

```
project_data.columns
```

Out[40]:

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

we are going to consider

we are going to consider

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

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

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

1.5.1 Vectorizing Categorical data

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

One hot encoding of clean_categotories

In [175]:

```
X_train['clean_categories'].values
```

Out[175]:

```
array(['Health_Sports', 'SpecialNeeds', 'Math_Science', ...,
       'Math_Science', 'AppliedLearning Music_Arts', 'Math_Science'],
      dtype=object)
```

In [41]:

```
# 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 of clean_subcategotories

In [42]:

```
#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)
```

In [ ]:

```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
```

One hot encoding of clean_categories

In [43]:

```
# 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 of clean_subcategotories

In [44]:

```
# 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)
```

In [45]:

```
#one hot encoding on school_states

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

In [46]:

```
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 [47]:

```
## 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)
```

In [48]:

```
#one hot encoding of project_grade_category
my_counter = Counter()
for project_grade in project_data['project_grade_category'].values:
    my_counter.update(project_grade.split())
```

In [49]:

```
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 [50]:

```
## 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)
```

```
['Grades9_12', 'Grades6_8', 'Grades3_5', 'GradesPreK_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)
```

In [55]:

```
#one hot encoding of teacher_prefix

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

In [56]:

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

In [57]:

```
vectorizer_teacher = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase
=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)
```

```
['nan', 'Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
Shape of matrix after one hot encoding  (49041, 6)
Shape of matrix after one hot encoding  (36052, 6)
Shape of matrix after one hot encoding  (24155, 6)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

Bag of words on essays with train data

In [65]:

```
vectorizer_bow_essay = CountVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_bow_essay.fit(X_train["clean_essays"])
text_bow_train = vectorizer_bow_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 5000)
```

Bag of words on essays with test data

In [66]:

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

```
Shape of matrix after one hot encoding  (36052, 5000)
```

Bag of words on essays with cross_validation data

In [67]:

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

```
Shape of matrix after one hot encoding  (24155, 5000)
```

In [ ]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

Bag of words on titles with train data

In [68]:

```
vectorizer_bow_title = CountVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_bow_title.fit(X_train["clean_titles"])
title_bow_train = vectorizer_bow_title.transform(X_train["clean_titles"])
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 1706)
```

Bag of words on titles with test data

In [69]:

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

```
Shape of matrix after one hot encoding  (36052, 1706)
```

Bag of words on titles with cross_validation data

In [70]:

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

```
Shape of matrix after one hot encoding  (24155, 1706)
```

1.5.2.2 TFIDF vectorizer

Tf-idf on essays with train data

In [71]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essay = TfidfVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_tfidf_essay.fit(X_train["clean_essays"])
text_tfidf_train = vectorizer_tfidf_essay.transform(X_train["clean_essays"])
print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 5000)
```

Tf-idf on essays with test data

In [72]:

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

```
Shape of matrix after one hot encoding  (36052, 5000)
```

Tf-idf on essays with cross_validation data

In [73]:

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

```
Shape of matrix after one hot encoding  (24155, 5000)
```

Tf-idf on titles with train data

In [74]:

```
vectorizer_tfidf_titles = TfidfVectorizer(ngram_range=(2,2), min_df=10, max_features = 5000)
vectorizer_tfidf_titles.fit(X_train["clean_titles"])
title_tfidf_train = vectorizer_tfidf_titles.transform(X_train["clean_titles"])
print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (49041, 1706)
```

Tf-idf on titles with test data

In [75]:

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

```
Shape of matrix after one hot encoding  (36052, 1706)
```

Tf-idf on titles with cross_validation data

In [76]:

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

```
Shape of matrix after one hot encoding  (24155, 1706)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [77]:

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

In [78]:

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

```
Loading Glove Model
```

```
1917495it [48:58, 721.66it/s]
```

```
Done. 1917495  words loaded!
```

In [ ]:

```
'''
# 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)


'''
```

In [79]:

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

In [80]:

```
## Find the total number of words in the Train data of Essays.
print("All the words in the corpus", len(words_train_essays))
```

```
All the words in the corpus 7429066
```

In [81]:

```
## Find the unique words in this set of words
words_train_essay = set(words_train_essays)
print("the unique words in the corpus", len(words_train_essay))
```

```
the unique words in the corpus 41381
```

In [82]:

```
## Find the words present in both Glove Vectors as well as our corpus.
inter_words = set(model.keys()).intersection(words_train_essay)
print("The number of words that are present in both glove vectors and our corpus are {} which \ is
nearly{}% ".format(len(inter_words), np.round((float(len(inter_words))/len(words_train_essay)) *100
)))
```

```
The number of words that are present in both glove vectors and our corpus are 37997 which \ is nea
rly92.0%
```

In [83]:

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

```
word 2 vec length 37997
```

In [84]:

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

In [85]:

```
# 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())
```

2.3 Make Data Model Ready: encoding eassay, and project_title

Train data on Essays

In [86]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_train = [];
for sentence in tqdm(X_train["clean_essays"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)
print(len(avg_w2v_vectors_train))
print(len(avg_w2v_vectors_train[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 49041/49041 [02:
45<00:00, 296.94it/s]
```

```
49041
300
```

Test data on Essays

In [87]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_test = [];
for sentence in tqdm(X_test["clean_essays"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)
print(len(avg_w2v_vectors_test))
print(len(avg_w2v_vectors_test[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 36052/36052 [02:
10<00:00, 276.58it/s]
```

```
36052
300
```

Cross_validation data on Essays

In [88]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_cv = [];
for sentence in tqdm(X_cv["clean_essays"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)
print(len(avg_w2v_vectors_cv))
print(len(avg_w2v_vectors_cv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 24155/24155 [01:
31<00:00, 263.47it/s]
```

```
24155
300
```

Train data on Titles

In [89]:

```
# Similarly you can vectorize for title also
avg_w2v_vectors_titles_train = [];
# the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_titles"]):
    # for each title
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_train.append(vector)
print(len(avg_w2v_vectors_titles_train))
print(len(avg_w2v_vectors_titles_train[0]))
```

```
100%|███████████████████████████████████████████████████████████████████████████| 49041/49041
[00:14<00:00, 3366.27it/s]
```

```
49041
300
```

Test data on Titles

In [90]:

```
# Similarly you can vectorize for title also
avg_w2v_vectors_titles_test = [];
# the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["clean_titles"]):
    # for each title
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_test.append(vector)
print(len(avg_w2v_vectors_titles_test))
print(len(avg_w2v_vectors_titles_test[0]))
```

```
100%|███████████████████████████████████████████████████████████████████████████| 36052/36052
[00:11<00:00, 3075.83it/s]
```

```
36052
300
```

Cross_validation data on Titles

In [91]:

```
# Similarly you can vectorize for title also
avg_w2v_vectors_titles_cv = [];
# the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["clean_titles"]):
    # for each title
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_cv.append(vector)
print(len(avg_w2v_vectors_titles_cv))
print(len(avg_w2v_vectors_titles_cv[0]))
```

```
100%|███████████████████████████████████████████████████████████████████████████| 24155/24155
[00:06<00:00, 3613.81it/s]
```

```
24155
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [92]:

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

In [93]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248
[48:17<00:00, 37.71it/s]
```

```
109248
300
```

Train data on Essays

In [94]:

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

In [95]:

```
# average Word2Vec # compute average word2vec for each review.
tfidf_w2v_vectors_train = [];
# the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_essays"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((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 [25
:26<00:00, 32.13it/s]
```

```
49041
300
```

Test data on Essays

In [96]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 36052/36052 [17
:25<00:00, 34.49it/s]
```

```
36052
300
```

Cross_validation data on Essays

In [97]:

```
# 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(X_cv["clean_essays"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((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 [17
:11<00:00, 23.41it/s]
```

```
24155
300
```

Train data on Titles

In [98]:

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

In [99]:

```
# Similarly you can vectorize for title also
tfidf_w2v_vectors_titles_train = [];
# the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["clean_titles"]):
    # for each title
    vector = np.zeros(300)
    # as word vectors are of zero length
    cnt_words =0;
    # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    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
[00:19<00:00, 2466.04it/s]
```

```
49041
300
```

Test data on Titles

In [100]:

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

```
100%|████████████████████████████████████████████████████████████████████████| 36052/36052
[00:26<00:00, 1337.22it/s]
```

```
36052
300
```

Cross_validation data on Titles

In [101]:

```
# 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(X_cv["clean_titles"]):
    # for each review/sentence
    vector = np.zeros(300)
    # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split():
        # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((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
[00:14<00:00, 1615.32it/s]
```

```
24155
300
```

1.5.3 Vectorizing Numerical features

In [102]:

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

In [103]:

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

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

In [104]:

```
# join two dataframes in python:
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

1)Price

In [105]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer() # normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(-1,1))
price_train = normalizer.transform(X_train['price'].values.reshape(-1,1))
price_cv = normalizer.transform(X_cv['price'].values.reshape(-1,1))
price_test = normalizer.transform(X_test['price'].values.reshape(-1,1))
print("After vectorizations")
print(price_train.shape, y_train.shape)
print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
print("="*100)
```

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

2)Quantity

In [106]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer() # normalizer.fit(X_train['quantity'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['quantity'].values.reshape(-1,1))
quantity_train = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
quantity_cv = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
quantity_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))
print("After vectorizations")
print(quantity_train.shape, y_train.shape)
print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
print("="*100)
```

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

3)teacher_number_of_previously_posted_projects

In [107]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer() #
normalizer.fit(X_train["teacher_number_of_previously_posted_projects"].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train["teacher_number_of_previously_posted_projects"].values.reshape(-1,1))
prev_projects_train = normalizer.transform(X_train["teacher_number_of_previously_posted_projects"]
.values.reshape(-1,1))
prev_projects_cv =
normalizer.transform(X_cv["teacher_number_of_previously_posted_projects"].values.reshape(-1,1))
prev_projects_test = normalizer.transform(X_test["teacher_number_of_previously_posted_projects"].v
alues.reshape(-1,1))
print("After vectorizations")
print(prev_projects_train.shape, y_train.shape)
print(prev_projects_cv.shape, y_cv.shape)
print(prev_projects_test.shape, y_test.shape)
print("="*100)
```

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

4)Title_word_count

In [108]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['title_word_count'].values.reshape(-1,1))
title_word_count_train = normalizer.transform(X_train['title_word_count'].values.reshape(-1,1))
title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape(-1,1))
print("After vectorizations")
print(title_word_count_train.shape, y_train.shape)
print(title_word_count_cv.shape, y_cv.shape)
print(title_word_count_test.shape, y_test.shape)
print("="*100)
```

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

5)Essay_word_count

In [109]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['essay_word_count'].values.reshape(-1,1))
essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.reshape(-1,1))
essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape(-1,1))
print("After vectorizations")
print(essay_word_count_train.shape, y_train.shape)
print(essay_word_count_cv.shape, y_cv.shape)
print(essay_word_count_test.shape, y_test.shape)
print("="*100)
```

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

6)Essay sentiments-Pos

In [110]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['pos'].values.reshape(-1,1))
essay_sent_pos_train = normalizer.transform(X_train['pos'].values.reshape(-1,1))
essay_sent_pos_cv = normalizer.transform(X_cv['pos'].values.reshape(-1,1))
essay_sent_pos_test = normalizer.transform(X_test['pos'].values.reshape(-1,1))
print("After vectorizations")
print(essay_sent_pos_train.shape, y_train.shape)
print(essay_sent_pos_cv.shape, y_cv.shape)
print(essay_sent_pos_test.shape, y_test.shape)
print("="*100)
```

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

7)Essay sentiments-neg

In [111]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['neg'].values.reshape(-1,1))
essay_sent_neg_train = normalizer.transform(X_train['neg'].values.reshape(-1,1))
essay_sent_neg_cv = normalizer.transform(X_cv['neg'].values.reshape(-1,1))
essay_sent_neg_test = normalizer.transform(X_test['neg'].values.reshape(-1,1))
print("After vectorizations")
print(essay_sent_neg_train.shape, y_train.shape)
print(essay_sent_neg_cv.shape, y_cv.shape)
print(essay_sent_neg_test.shape, y_test.shape)
print("="*100)
```

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

8)Essay sentiments-neu

In [112]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['neu'].values.reshape(-1,1))
essay_sent_neu_train = normalizer.transform(X_train['neu'].values.reshape(-1,1))
essay_sent_neu_cv = normalizer.transform(X_cv['neu'].values.reshape(-1,1))
essay_sent_neu_test = normalizer.transform(X_test['neu'].values.reshape(-1,1))
print("After vectorizations")
print(essay_sent_neu_train.shape, y_train.shape)
print(essay_sent_neu_cv.shape, y_cv.shape)
print(essay_sent_neu_test.shape, y_test.shape)
print("="*100)
```

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

9)Essay sentiment-compound

In [113]:

```
from sklearn.preprocessing import Normalizer
normalizer.fit(X_train['compound'].values.reshape(-1,1))
essay_sent_compound_train = normalizer.transform(X_train['compound'].values.reshape(-1,1))
essay_sent_compound_cv = normalizer.transform(X_cv['compound'].values.reshape(-1,1))
essay_sent_compound_test = normalizer.transform(X_test['compound'].values.reshape(-1,1))
print("After vectorizations")
print(essay_sent_compound_train.shape, y_train.shape)
print(essay_sent_compound_cv.shape, y_cv.shape)
print(essay_sent_compound_test.shape, y_test.shape)
print("="*100)
```

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

Computing Sentiment Scores

In [114]:

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

# import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students w
ith the biggest enthusiasm \
for learning my students learn in many different ways using all of our senses and multiple intelli
gences i use a wide range\
of techniques to help all my students succeed students in my class come from a variety of differen
t backgrounds which makes\
for wonderful sharing of experiences and cultures including native americans our school is a carin
g community of successful \
learners which can be seen through collaborative student project based learning in and out of the
classroom kindergarteners \
in my class love to work with hands on materials and have many different opportunities to practice
a skill before it is\
mastered having the social skills to work cooperatively with friends is a crucial aspect of the ki
ndergarten curriculum\
montana is the perfect place to learn about agriculture and nutrition my students love to role pla
y in our pretend kitchen\
in the early childhood classroom i have had several kids ask me can we try cooking with real food
i will take their idea \
and create common core cooking lessons where we learn important math and writing concepts while co
oking delicious healthy \
food for snack time my students will have a grounded appreciation for the work that went into maki
ng the food and knowledge \
of where the ingredients came from as well as how it is healthy for their bodies this project woul
d expand our learning of \
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade apple
sauce make our own bread \
and mix up healthy plants from our classroom garden in the spring we will also create our own cook
books to be printed and \
shared with families students will gain math and literature skills as well as a life long enjoymen
t for healthy cooking \
nannan'
```

```
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
neg: 0.01, neu: 0.745, pos: 0.245, compound: 0.9975,
```

Assignment 5: Logistic Regression

1. **[Task-1] Logistic Regression(either SGDClassifier with log loss, or LogisticRegression) on these feature sets**

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (`BOW with bi-grams` with `min_df=10` and `max_features=5000`)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (`TFIDF with bi-grams` with `min_df=10` and `max_features=5000`)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning (find best hyper parameters corresponding the algorithm that you choose)**

    - 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. **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. Please visualize your confusion matrices using seaborn heatmaps.

4. **[Task-2] Apply Logistic Regression on the below feature set Set 5 by finding the best hyper parameter as suggested in step 2 and step 3.**
5. Consider these set of features Set 5 :

    - **school_state** : categorical data
    - **clean_categories** : categorical data
    - **clean_subcategories** : categorical data
    - **project_grade_category** :categorical data
    - **teacher_prefix** : categorical data
    - **quantity** : numerical data
    - **teacher_number_of_previously_posted_projects** : numerical data
    - **price** : numerical data
    - **sentiment score's of each of the essay** : numerical data
    - **number of words in the title** : numerical data
    - **number of words in the combine essays** : numerical data

    And apply the Logistic regression on these features by finding the best hyper paramter as suggested 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

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakage, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.

4. For more details please go through this [link.]

2. Logistic Regression

2.5 Logistic Regression with added Features `Set 5`

Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay

In [115]:

```
# 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_word_count_train, essay_word_count_train, title_bow_train, text_bow_train)).tc
csr()
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, tit
le_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 [116]:

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

```
Final Data matrix
(49041, 6811) (49041,)
(24155, 6811) (24155,)
(36052, 6811) (36052,)
====================================================================================================
```

Gridsearch_cv

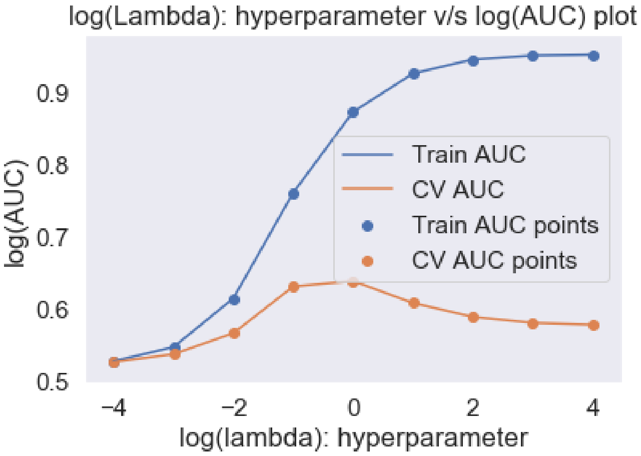
In [117]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression
```

In [194]:

```
lr = LogisticRegression()
parameters = {'C':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

```
cv_auc_std= clf.cv_results_['std_test_score']
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

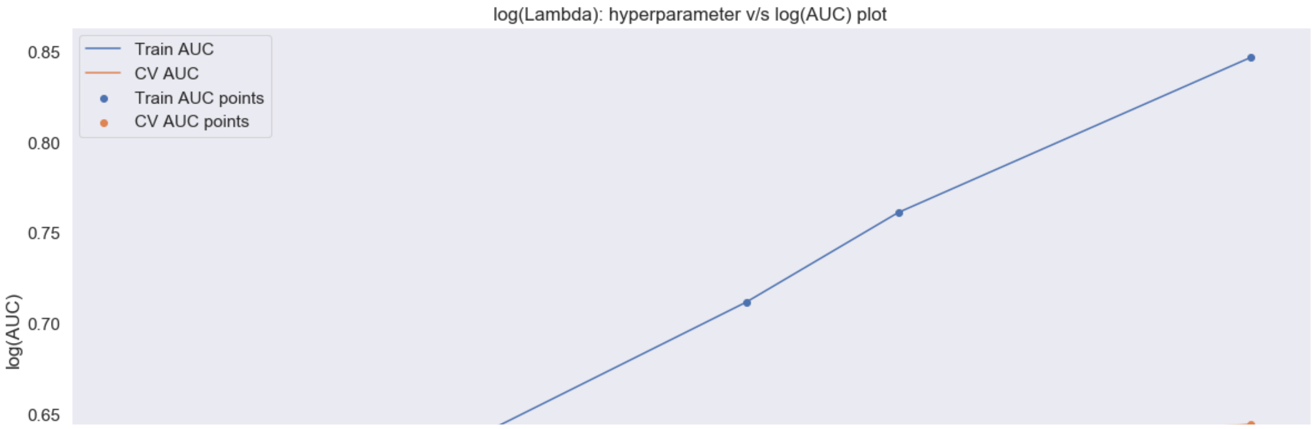


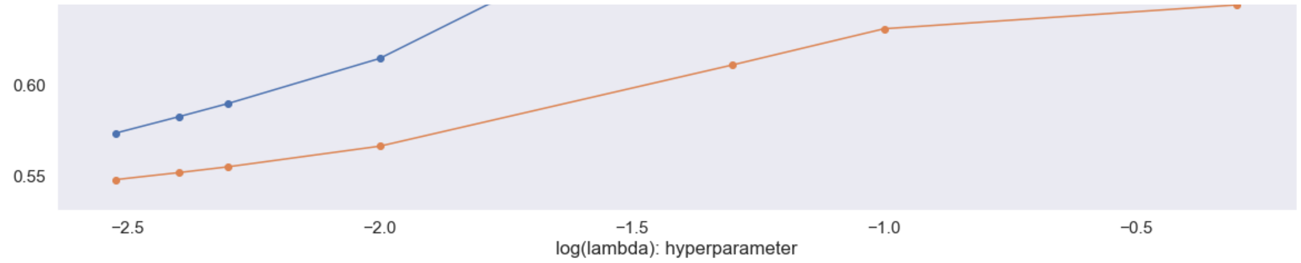
Inference:

Determining appropriate value for my parameter was not possible. Then i re-ran the GridSearchCV on parameters of small set of values.

In [195]:

```
lr = LogisticRegression()
parameters = {'C':[0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.figure(figsize=(20,10))
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```





Inference:0.005 is chosen as the best hyperparameter value.

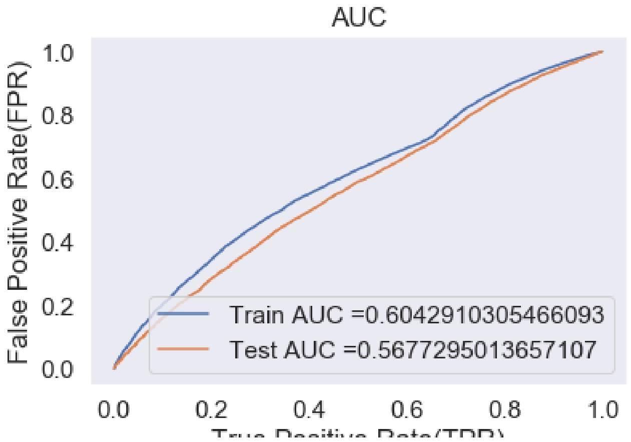
B) Train the model using the best hyper parameter value

In [196]:

```
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 [197]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
model = LogisticRegression(C = 0.005)
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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



True Positive Rate(TPR)

C)Confusion Matrix

In [198]:

```
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 [199]:

```
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) 0.25 for threshold 0.85
[[ 3713  3713]
 [15443 26172]]
```

In [200]:

```
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))
```

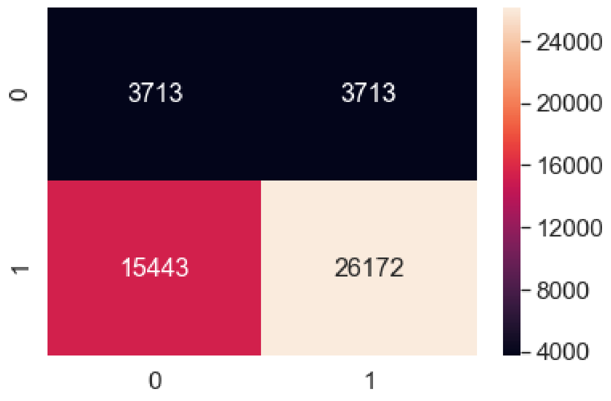
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.85
```

In [201]:

```
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[201]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbec69198>
```



Test Data

In [202]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.855
[[ 3161  2298]
 [14812 15781]]
```

In [203]:

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

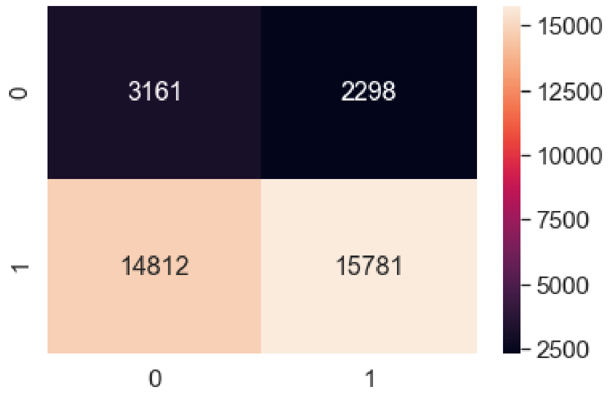
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.855
```

In [204]:

```
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[204]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edc31b1438>
```



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

In [205]:

```
# 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, pri
ce_train,
               quantity_train, prev_projects_train, title_word_count_train, essay_word_count_train,
text_tfidf_train,
               title_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test,
               project_grade_categories_one_hot_test,teacher_prefix_categories_one_hot_test, price_
test, quantity_test,
                prev_projects_test, title_word_count_test, essay_word_count_test, text_tfidf_test, t
itle_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 [206]:

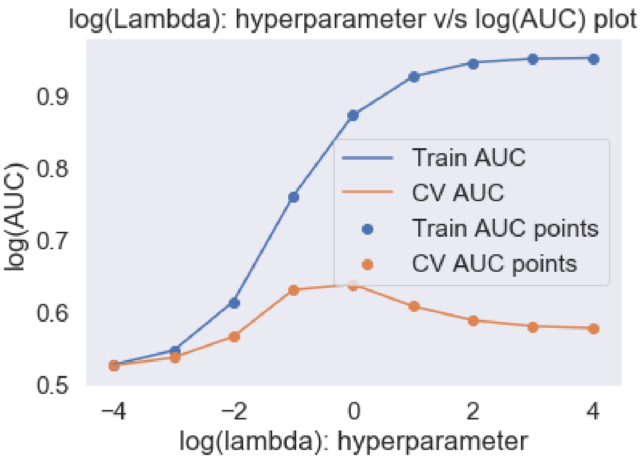
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 6811) (49041,)
(24155, 6811) (24155,)
(36052, 6811) (36052,)
====================================================================================================
```

A) GridSearchCV

In [207]:

```
lr = LogisticRegression()
parameters = {'C':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

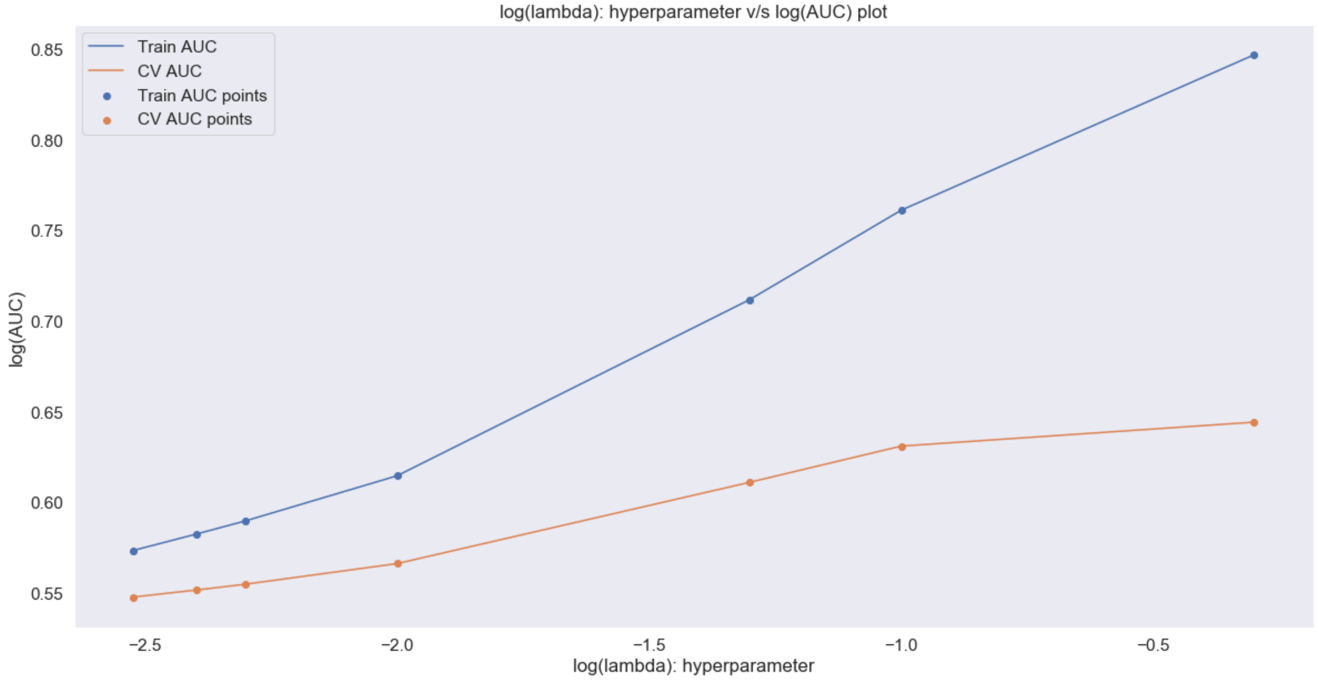


Inference:

Determining appropriate value for my parameter was not possible. Then i re-ran the GridSearchCV on parameters of small set of values.

In [208]:

```
lr = LogisticRegression()
parameters = {'C':[0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003]}
clf = GridSearchCV(lr, parameters, cv=2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.figure(figsize=(20,10))
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```



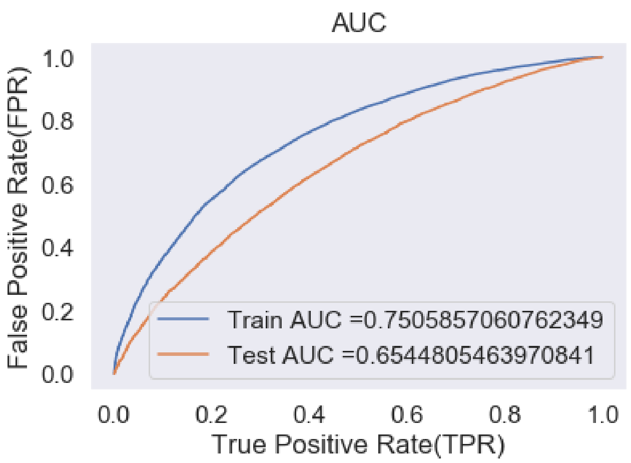
Inference:

The AUC values for the points before and after 0.5 seems to be lower.While for 0.5 there seems to be a majordifference between the Train and the Test model.So, 0.1 is taken as best hyper parameter value.

B) Train the model using the best hyper parameter value

In [209]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
model = LogisticRegression(C = 0.1)
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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C)Confusion Matrix

In [210]:

```
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 [211]:

```
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) 0.25 for threshold 0.817
[[ 3713  3713]
 [ 6991 34624]]
```

In [212]:

```
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) 0.25 for threshold 0.817
```

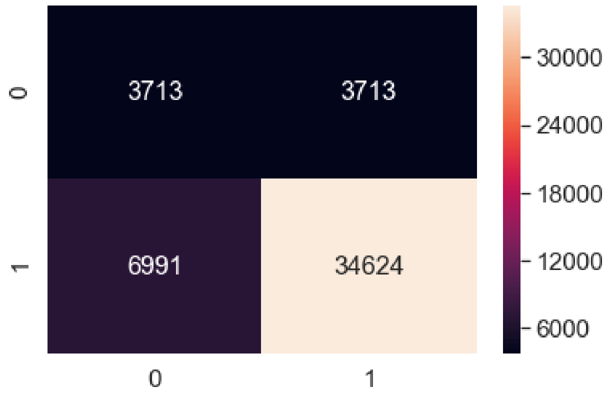
In [213]:

In [213]:

```
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[213]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbe60bc88>
```



Test Data

In [214]:

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

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.835
[[ 2803  2656]
 [ 9044 21549]]
```

In [215]:

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

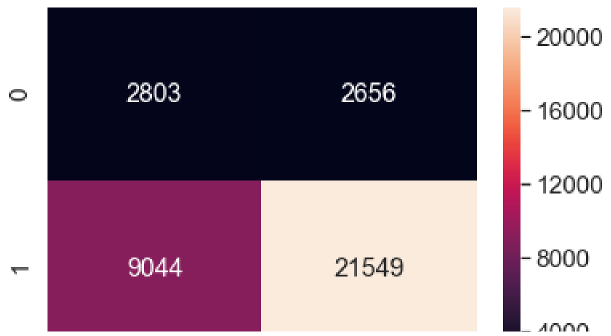
```
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.835
```

In [216]:

```
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[216]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbfefd6a0>
```



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

In [217]:

```
#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_word_count_train,
essay_word_count_train, avg_w2v_vectors_train,avg_w2v_vectors_titles_train)).tocsr()

X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, avg_w2v_vectors_test, avg_w2v_vectors_titles_test)).
tocsr()

X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, avg_w2v_vectors_cv, avg_w2v_vectors_titles_cv)).tocsr()
```

In [218]:

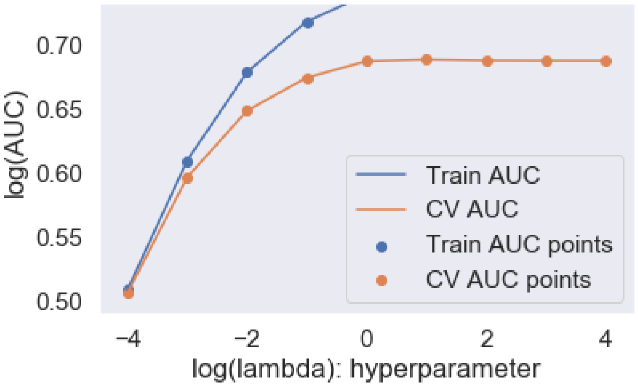
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 705) (49041,)
(24155, 705) (24155,)
(36052, 705) (36052,)
====================================================================================================
```

A) GridSearchCV

In [219]:

```
lr = LogisticRegression()
parameters = {'C':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

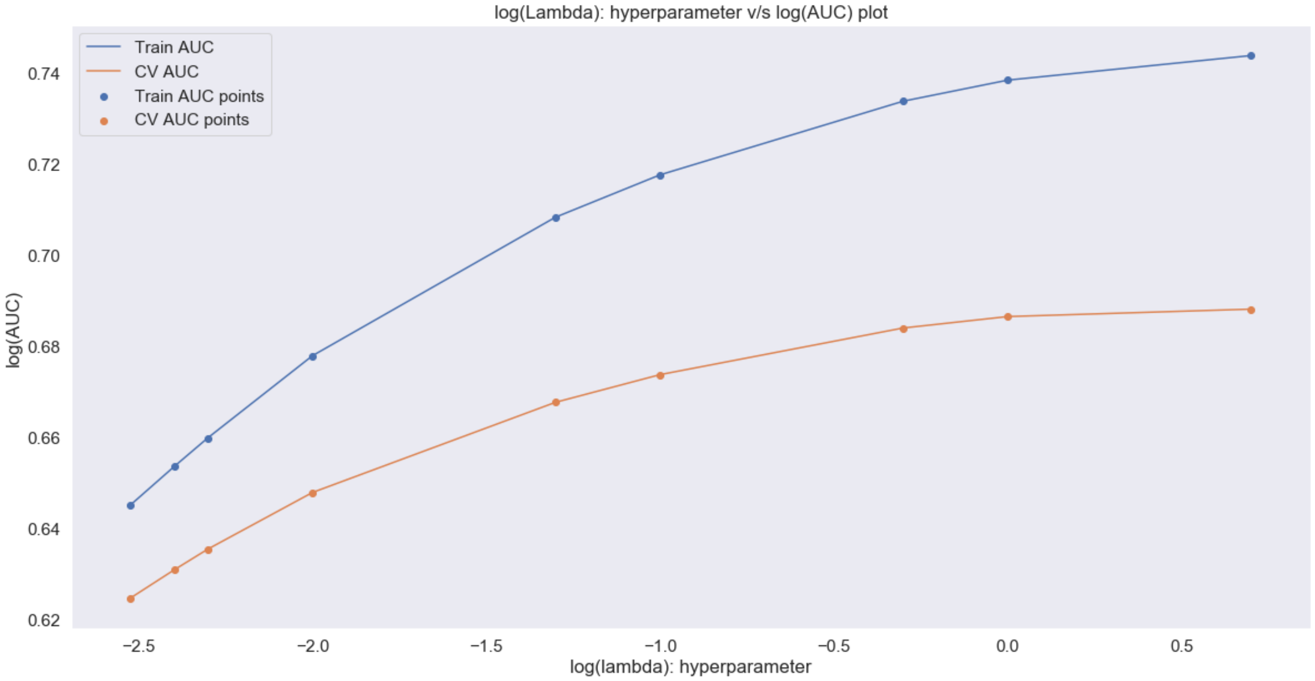


Inference:

1. points ranging 100 and above seems like fruitless as the AUC is almost constant after a certain point.
2. Very low values ranging between 10^-4 and 10^-3 do not have a very appreciatable AUC score.
3. So we will consider the points in between for a better understanding and to obtain a better model.

In [220]:

```
lr = LogisticRegression()
parameters = {'C':[5, 1, 0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.figure(figsize=(20,10))
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
#It took 4hrs
```

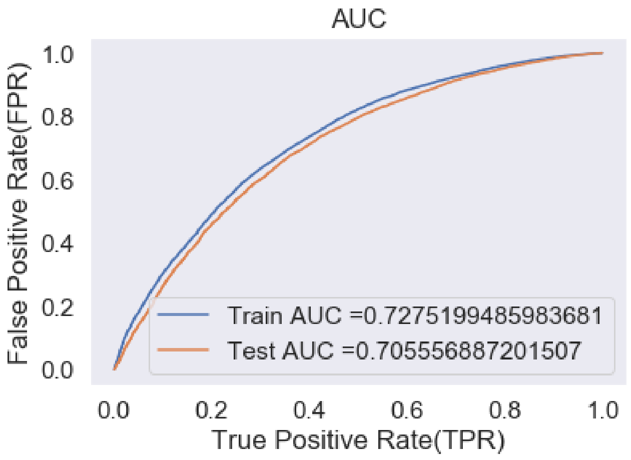


Inference:1.0 is chosen as the best hyper parameter value.

B) Train the model using the best hyper parameter value

In [221]:

```
model = LogisticRegression(C = 1.0)
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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C)Confusion Matrix

Train Data

In [222]:

```
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) 0.25 for threshold 0.787
[[ 3713  3713]
 [ 7377 34238]]
```

In [223]:

```
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))
```

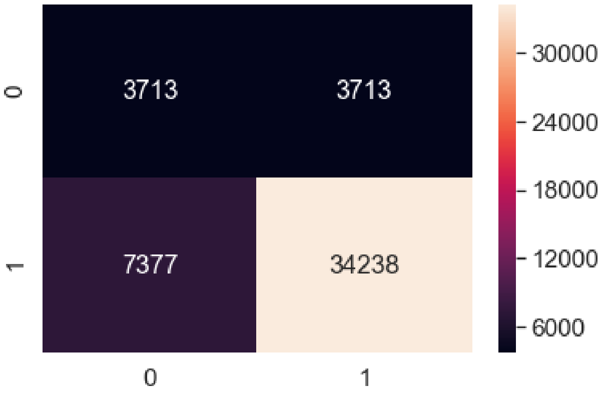
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.787
```

In [224]:

```
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[224]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbff51048>
```



Test Data

In [225]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.834
[[ 3365  2094]
 [ 9368 21225]]
```

In [226]:

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

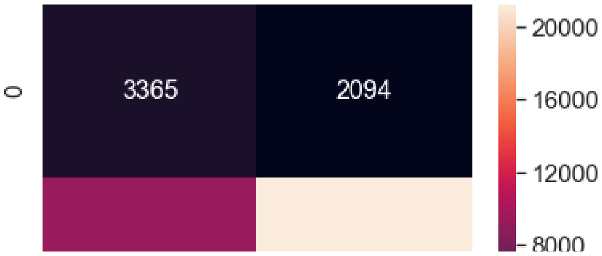
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.834
```

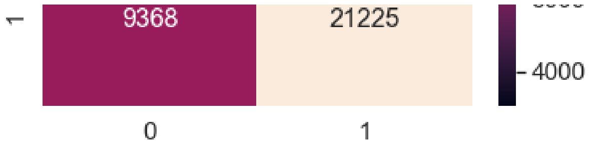
In [227]:

```
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[227]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edc30736a0>
```





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

In [228]:

```
#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_word_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 [229]:

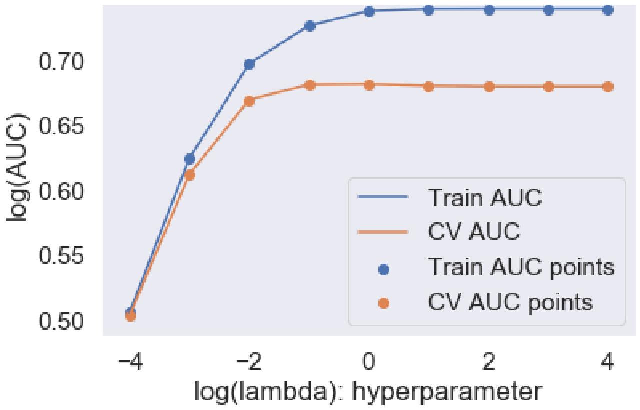
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 705) (49041,)
(24155, 705) (24155,)
(36052, 705) (36052,)
====================================================================================================
```

A) GridSearchCV

In [230]:

```
lr = LogisticRegression()
parameters = {'C':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

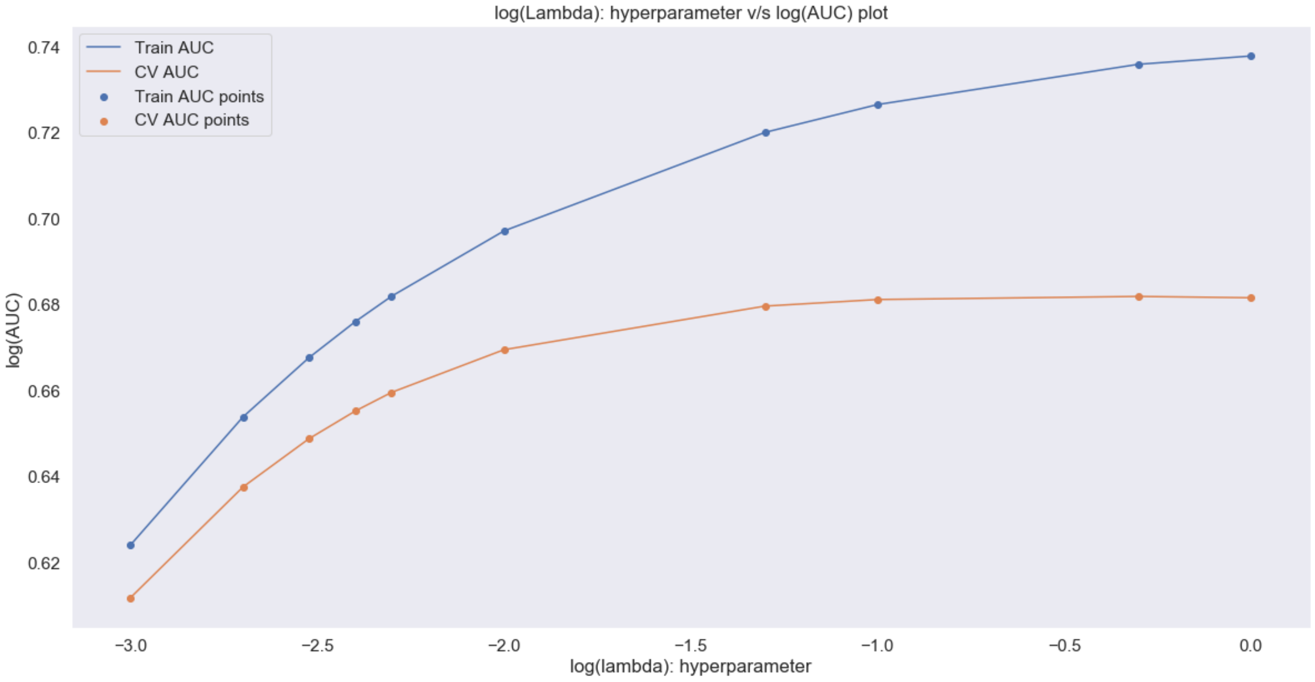


Inference

1. points ranging 100 and above seem to be futile as the AUC is almost constant after a certain point.
2. very low values ranging between 10^-4 and 10^-3 do not have a very appreciatable AUC score.
3. Lets consider the points in between for a better understanding and to obtain a better model.

In [231]:

```
lr = LogisticRegression()
parameters = {'C':[1, 0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003, 0.002, 0.001]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.figure(figsize=(20,10))
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

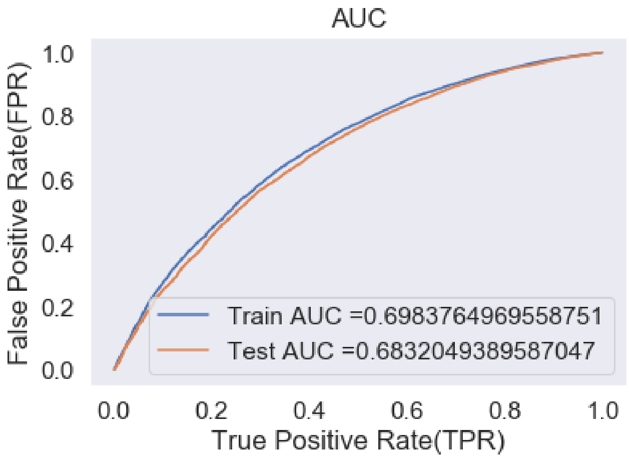


Inference:0.01 is chosen as the best hyper parameter value.

B) Train the model using the best hyper parameter value

In [232]:

```
model = LogisticRegression(C = 0.01)
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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C)Confusion Matrix

Train Data

In [233]:

```
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) 0.25 for threshold 0.812
[[ 3713  3713]
 [ 9263 32352]]
```

In [234]:

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

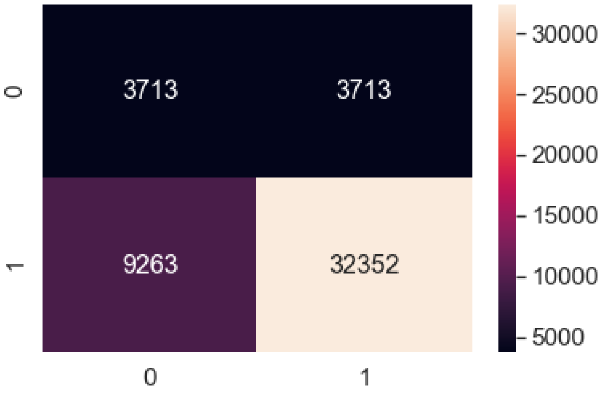
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.812
```

In [235]:

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

Out[235]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbec218d0>
```



Test Data

In [236]:

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

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

Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.837
[[ 3377  2082]
 [10694 19899]]
```

In [237]:

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

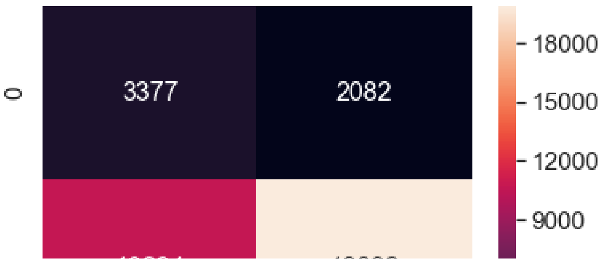
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.837
```

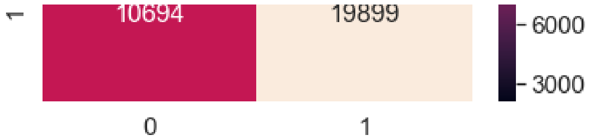
In [238]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[238]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edc31b4cc0>
```





Set 5 : Categorical features, Numerical features & Essay Sentiments

In [239]:

```
# 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_word_count_train, essay_word_count_train, essay_sent_pos_train, essay_sent_neg_train,
essay_sent_neu_train, essay_sent_compound_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, essay_sent_pos_test, essay_sent_neg_test, essay_sent_
neu_test,
essay_sent_compound_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, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv,
essay_sent_compound_cv)).tocsr()
```

In [240]:

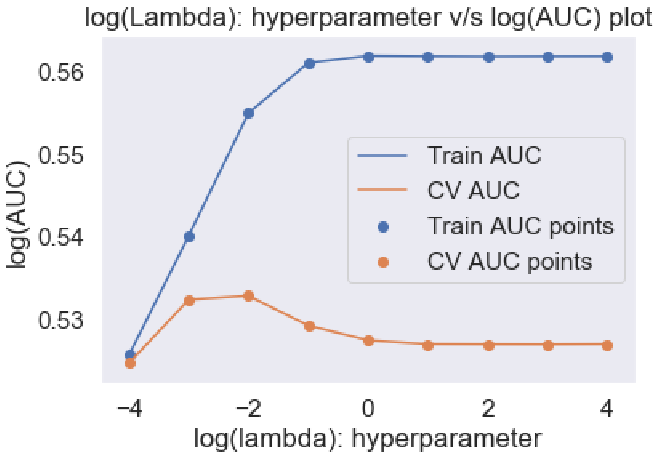
```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 109) (49041,)
(24155, 109) (24155,)
(36052, 109) (36052,)
====================================================================================================
```

A) GridSearchCV

In [241]:

```
lr = LogisticRegression()
parameters = {'C':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

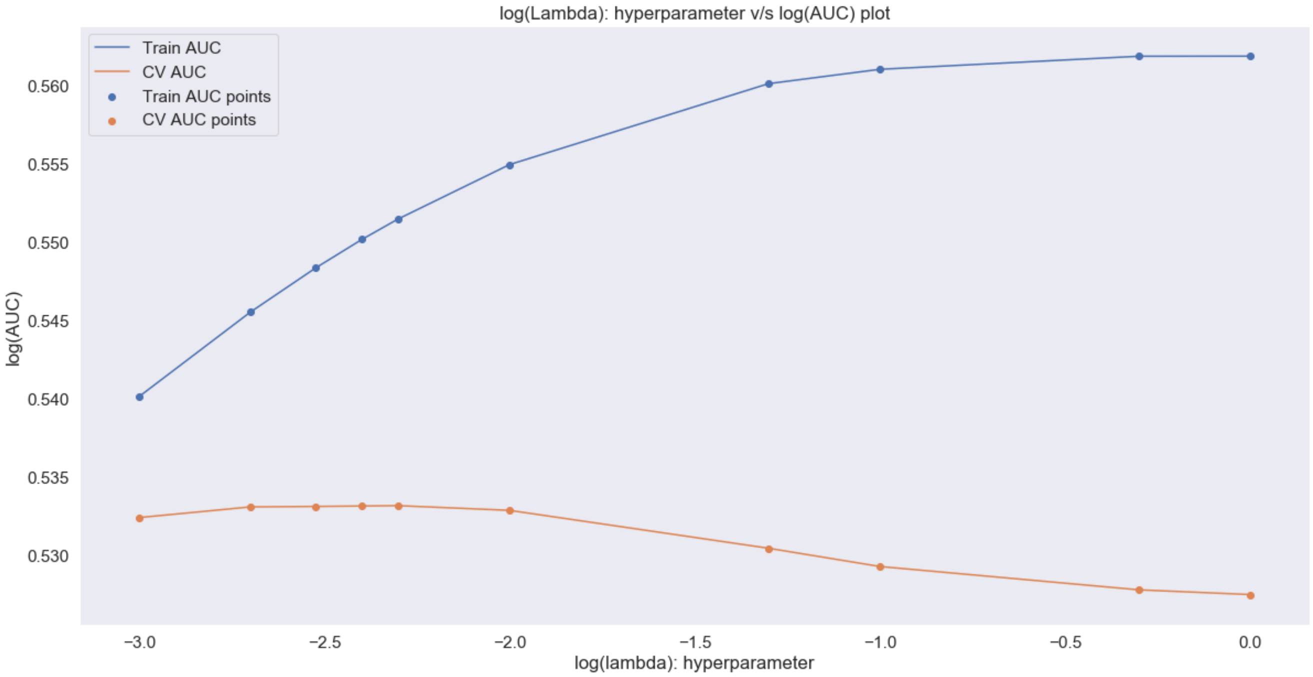


Inference

1. points ranging 100 and above seem to be futile as the AUC is almost constant after a certain point.
2. very low values ranging between 10^-4 and 10^-3 do not have a very appreciatiable AUC score.
3. Lets consider the points in between for a better understanding and to obtain a better model.

In [242]:

```
lr = LogisticRegression()
parameters = {'C':[1, 0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003, 0.002, 0.001]}
clf = GridSearchCV(lr, parameters, cv= 2, scoring='roc_auc')
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
plt.figure(figsize=(20,10))
plt.plot(np.log10(parameters['C']), train_auc, label='Train AUC')
plt.plot(np.log10(parameters['C']), cv_auc, label='CV AUC')
plt.scatter(np.log10(parameters['C']), train_auc, label='Train AUC points')
plt.scatter(np.log10(parameters['C']), cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(lambda): hyperparameter")
plt.ylabel("log(AUC)")
plt.title("log(Lambda): hyperparameter v/s log(AUC) plot")
plt.grid()
plt.show()
```

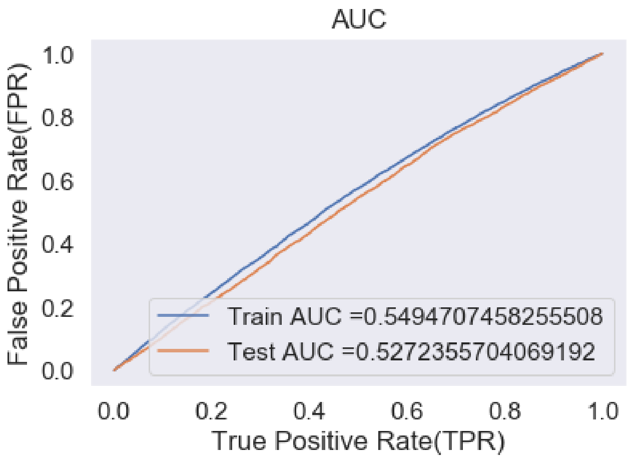


Inference:0.01 is chosen as the best hyper parameter value.

B) Train the model using the best hyper parameter value

In [243]:

```
model = LogisticRegression(C = 0.01)
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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



C) Confusion Matrix

Train Data

In [244]:

```
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) 0.2499999274645848 for threshold 0.853
[[ 3715  3711]
 [17721 23894]]
```

In [245]:

```
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))
```

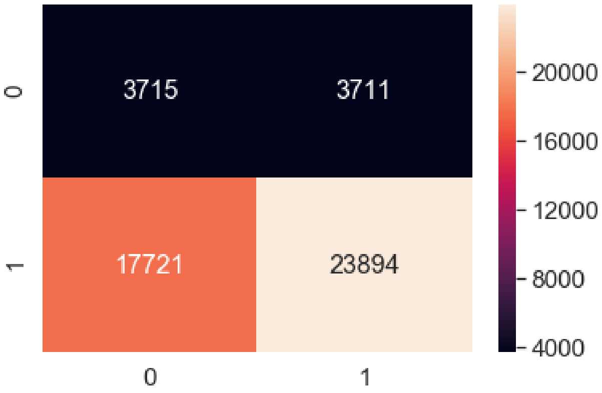
```
the maximum value of tpr*(1-fpr) 0.2499999274645848 for threshold 0.853
the maximum value of tpr*(1-fpr) 0.24999992746045848 for threshold 0.855
```

In [246]:

```
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[246]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edc31daa20>
```



Test Data

In [247]:

```
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) 0.24999979027324915 for threshold 0.857
[[ 3145  2314]
 [16481 14112]]
```

In [248]:

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

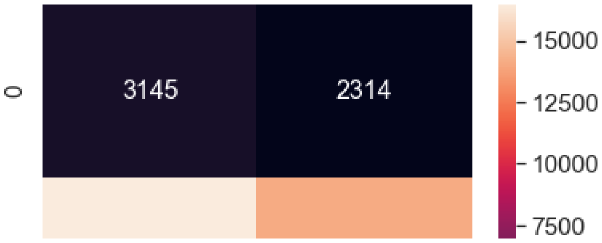
```
the maximum value of tpr*(1-fpr) 0.24999979027324915 for threshold 0.857
```

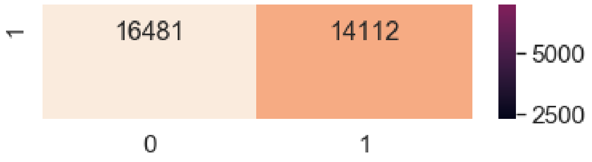
In [249]:

```
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[249]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edbe62a6a0>
```





4. Conclusion

In [250]:

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Alpha:Hyper Parameter", "AUC"]
x.add_row(["BOW", "Logistic Regression", 0.005, 0.67])
x.add_row(["TFIDF", "Logistic Regression", 0.1, 0.66])
x.add_row(["AVG W2V", "Logistic Regression", 1.0, 0.7])
x.add_row(["TFIDF W2V", "Logistic Regression", 0.01, 0.57])
x.add_row(["WITHOUT TEXT", "Logistic Regression", 0.01, 0.57])
print(x)
```

```
+--------------+---------------------+-----------------------+------+
|  Vectorizer  |        Model        | Alpha:Hyper Parameter | AUC  |
+--------------+---------------------+-----------------------+------+
|     BOW      | Logistic Regression |         0.005         | 0.67 |
|    TFIDF     | Logistic Regression |          0.1          | 0.66 |
|   AVG W2V    | Logistic Regression |          1.0          | 0.7  |
|  TFIDF W2V   | Logistic Regression |          0.01         | 0.57 |
| WITHOUT TEXT | Logistic Regression |          0.01         | 0.57 |
+--------------+---------------------+-----------------------+------+
```

SUMMARY:

1. Here we can confirm that Text data contained in the Essays and Essay Titles also play a major role in predicting the outcome of the project.
2. Hence, it can't be neglected as most of the models containing them proved to have a better AUC score.