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_4:__ "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 [3]:

```
%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 [4]:

```
project_data = pd.read_csv('train_data.csv',nrows=50000)
resource_data = pd.read_csv('resources.csv')
```

In [5]:

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

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

In [6]:

```
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[6]:

	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 [7]:

```
project_data["project_is_approved"].value_counts()
```

Out[7]:

```
1    42286
0     7714
Name: project_is_approved, dtype: int64
```

1.2 preprocessing of `project_subject_categories`

In [8]:

```
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())
```

In [9]:

```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

Out[9]:

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

1.3 preprocessing of `project_subject_subcategories`

In [10]:

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

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

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

In [11]:

```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(2)
```

Out[11]:

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

1.2.7 Univariate Analysis: Text features (Project Essay's)

In [12]:

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

1.2.8 Univariate Analysis: Cost per project

In [13]:

```
# we get the cost of the project using resource.csv file
resource_data.head(2)
```

Out[13]:

	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 [14]:

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

Out[14]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [15]:

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

print(project_data)
```

```
       Unnamed: 0       id                         teacher_id teacher_prefix  \
0          160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc            Mrs.
1          140945  p258326  897464ce9ddc600bced1151f324dd63a             Mr.
2           21895  p182444  3465aaf82da834c0582ebd0ef8040ca0             Ms.
3              45  p246581  f3cb9bffbba169bef1a77b243e620b60            Mrs.
4          172407  p104768  be1f7507a41f8479dc06f047086a39ec            Mrs.
5          141660  p154343  a50a390e8327a95b77b9e495b58b9a6e            Mrs.
6           21147  p099819  9b40170bfa65e399981717ee8731efc3            Mrs.
7           94142  p092424  5bfd3d12fae3d2fe88684bbac570c9d2             Ms.
8          112489  p045029  487448f5226005d08d36bdd75f095b31            Mrs.
9          158561  p001713  140eeac1885c820ad5592a409a3a8994             Ms.
10          43184  p040307  363788b51d40d978fe276bcb1f8a2b35            Mrs.
11         127083  p251806  4ba7c721133ef651ca54a03551746708             Ms.
12          19090  p051126  5e52c92b7e3c472aad247a239d345543            Mrs.
13          15126  p003874  178f6ae765cd4e0fb143a77c47fd65e2            Mrs.
14          62232  p233127  424819801de22a60bba7d0f4354d0258             Ms.
15          67303  p132832  bb6d6d054824fa01576ab38dfa2be160             Ms.
16         127215  p174627  4ad7e280fddff889e1355cc9f29c3b89            Mrs.
17         157771  p152491  e39abda057354c979c5b075cffbe5f88             Ms.
18         122186  p196421  fcd9b003fc1891383f340a89da02a1a6            Mrs.
19         146331  p058343  8e07a98deb1bc74c75b97521e05b1691             Ms.
20          75560  p052326  e0c1aad1f71badeff703fadc15f57680            Mrs.
21         132078  p187097  2d4a4d2d774e5c2fdd25b2ba0e7341f8            Mrs.
22          84810  p165540  30f08fbe02eba5453c4ce2e857e88eb4             Ms.
23           8636  p219330  258ef2e6ab5ce007ac6764ce15d261ba             Mr.
24          21478  p126524  74f8690562c44fc88f65f845b9fe61d0            Mrs.
25          20142  p009037  b8bf3507cee960d5fedcb27719df2d59            Mrs.
26          33903  p040091  7a0a5de5ed94e7036946b1ac3eaa99d0             Ms.
27           1156  p161033  efdc3cf14d136473c9f62becc00d4cec         Teacher
28          35430  p085706  22c8184c4660f1c589bea061d14b7f35            Mrs.
29          22088  p032018  45f16a103f1e00b7439861d4e0728a59            Mrs.
...           ...      ...                               ...             ...
49970       48139  p035589  03c50019548dd9ad9af9071fc76e5eeb             Ms.
49971      165303  p223730  0118a9857c874be87b315397f89e01d5            Mrs.
49972       63169  p104703  ba74528e836831eecac01773dcceddb1            Mrs.
49973       93353  p148480  fe2ad9b264d7a635834f36aa1b649ccd            Mrs.
49974      158902  p179531  6a4129e5310e29c21a6c50f9b6f808d3             Ms.
49975      121072  p086067  39a09b91c4c76ad631a61400f1ad47de             Ms.
49976        3059  p164918  78f09b1c41019e4f0455e3eb50d4dc03             Ms.
49977      164903  p214345  6b293f09676d0fe7d09f509e5cf0edec             Mr.
49978       15950  p258473  4c9a7219cf17ea5ded4819b3c23bd167             Ms.
49979       35813  p059990  a3a6de13f1e65fb1a6de7d0fd94ff9a7            Mrs.
49980        3524  p236931  a0655e02d03a5560f7ce9c627198ca4b            Mrs.
49981       97334  p078864  be29e53ae707eca7a35d0f9295e41691             Ms.
49982       11975  p039851  e46da6793a26b19ee5af40582230e29d            Mrs.
49983      156577  p216585  876fbb0add5e3ce09121bcde2553ed08            Mrs.
49984      127474  p224995  01e2ac2a6e6313d14f1e909e84f5987a            Mrs.
49985       78855  p175446  dc73ab17b5f5967cb282628bd7cd8f28             Ms.
49986       78097  p192812  e7a2e9a3312207fd60577f5edeaf64b9            Mrs.
49987      159360  p147171  49402e5295b1440a3eb361371e21e413             Ms.
49988       69407  p245054  a437264489c55252ff993bcb44f628f9            Mrs.
49989      107823  p049807  ef2b0681c4095ac55b0b39742a18fb2d             Ms.
49990      162953  p127477  72ea5e6bab3e3a509a0b1dba2a6df137            Mrs.
49991      153686  p183870  3a78d6aaa327aa63bbf71c75862fb17e            Mrs.
49992        2971  p236386  f87aba87d69fef2d72c617711e3371d3            Mrs.
49993       71389  p054472  fcd0839e05279f8478801dce254ba647             Ms.
49994       45277  p172774  dad8cf5bd23d36a93e6526737867192f             Ms.
49995       27461  p144673  88a8bdd51dca790df61b3cc2fafdae14            Mrs.
49996       89711  p138289  df7a55562859452b3aa897c3f3a53d19             Mr.
49997        5176  p159292  30f3dd18199ab24d10e6c8fdc1a877f8            Mrs.
```

```
49997        5176  p159292  5013dd18199ab24d10e6c81dc1a87716          Mrs.
49998       48461  p094764  bdf30a7b220e6b90218acbc57cf73440          Mrs.
49999       82189  p188201  56dbd8fbf3338c939a37f384eae0fd72          Mrs.

      school_state project_submitted_datetime project_grade_category  \
0               IN        2016-12-05 13:43:57          Grades PreK-2
1               FL        2016-10-25 09:22:10             Grades 6-8
2               AZ        2016-08-31 12:03:56             Grades 6-8
3               KY        2016-10-06 21:16:17          Grades PreK-2
4               TX        2016-07-11 01:10:09          Grades PreK-2
5               FL        2017-04-08 22:40:43             Grades 3-5
6               CT        2017-02-17 19:58:56             Grades 6-8
7               GA        2016-09-01 00:02:15             Grades 3-5
8               SC        2016-09-25 17:00:26          Grades PreK-2
9               NC        2016-11-17 18:18:56          Grades PreK-2
10              CA        2017-01-04 16:40:30             Grades 3-5
11              CA        2016-11-14 22:57:28          Grades PreK-2
12              NY        2016-05-23 15:46:02             Grades 6-8
13              OK        2016-10-17 09:49:27          Grades PreK-2
14              MA        2017-02-14 16:29:10          Grades PreK-2
15              TX        2016-10-05 21:05:38             Grades 3-5
16              FL        2017-01-18 10:59:05          Grades PreK-2
17              NV        2016-11-23 17:14:17             Grades 3-5
18              GA        2016-08-28 15:04:42          Grades PreK-2
19              OH        2016-08-06 13:05:20             Grades 3-5
20              PA        2016-10-07 18:27:02          Grades PreK-2
21              NC        2016-05-17 19:45:13             Grades 6-8
22              CA        2016-09-01 10:09:15            Grades 9-12
23              AL        2017-01-10 11:41:06             Grades 6-8
24              FL        2017-03-31 12:34:44          Grades PreK-2
25              AL        2017-03-09 15:36:20             Grades 3-5
26              TX        2016-09-18 22:10:40          Grades PreK-2
27              LA        2016-11-06 16:02:31             Grades 3-5
28              GA        2017-01-27 12:34:59            Grades 9-12
29              VA        2016-07-15 12:58:40          Grades PreK-2
...            ...                        ...                    ...
49970           NY        2016-06-06 15:09:33          Grades PreK-2
49971           IL        2016-12-12 22:41:36             Grades 6-8
49972           UT        2017-01-10 12:31:27             Grades 3-5
49973           NE        2016-09-30 14:17:39          Grades PreK-2
49974           IL        2016-10-14 21:04:42          Grades PreK-2
49975           MO        2017-04-04 12:27:00             Grades 6-8
49976           IA        2017-01-06 12:58:57          Grades PreK-2
49977           OR        2016-09-01 01:25:19             Grades 3-5
49978           LA        2016-09-01 07:57:14            Grades 9-12
49979           IN        2016-07-31 20:26:10             Grades 3-5
49980           KY        2017-02-26 18:19:52             Grades 3-5
49981           CA        2017-01-11 16:40:20             Grades 3-5
49982           CA        2016-11-23 16:40:05          Grades PreK-2
49983           CA        2016-12-29 22:50:04          Grades PreK-2
49984           MA        2017-03-03 15:45:06             Grades 6-8
49985           MI        2017-01-30 07:57:43          Grades PreK-2
49986           LA        2016-10-08 19:11:57          Grades PreK-2
49987           MO        2017-04-07 13:13:24          Grades PreK-2
49988           FL        2016-08-22 18:14:26            Grades 9-12
49989           OH        2016-08-03 17:25:07          Grades PreK-2
49990           AR        2017-02-01 10:34:52             Grades 3-5
49991           AL        2017-01-29 00:00:22            Grades 9-12
49992           GA        2016-12-06 11:43:44             Grades 6-8
49993           IA        2016-08-16 14:12:09          Grades PreK-2
49994           IL        2016-08-12 16:55:48             Grades 3-5
49995           IL        2016-09-05 21:25:39          Grades PreK-2
49996           NV        2017-04-20 01:29:24             Grades 3-5
49997           SD        2016-08-22 16:46:27             Grades 3-5
49998           CT        2017-01-29 12:56:04          Grades PreK-2
49999           KY        2016-08-13 08:47:34          Grades PreK-2

                                           project_title  \
0        Educational Support for English Learners at Home
1                   Wanted: Projector for Hungry Learners
2       Soccer Equipment for AWESOME Middle School Stu...
3                                  Techie Kindergarteners
4                                  Interactive Math Tools
5       Flexible Seating for Mrs. Jarvis' Terrific Thi...
6       Chromebooks for Special Education Reading Program
7                                   It's the 21st Century
8                          Targeting More Success in Class
9         Just For the Love of Reading--\r\nPure Pleasure
```

9	Just for the Love of Reading--\r\nPure Pleasure	
10	Reading Changes Lives	
11	Elevating Academics and Parent Rapports Throug...	
12	Building Life Science Experiences	
13	Everyone deserves to be heard!	
14	TABLETS CAN SHOW US THE WORLD	
15	Making Recess Active	
16	Making Great LEAP's With Leapfrog!	
17	Technology Teaches Tomorrow's Talents Today	
18	Test Time	
19	Wiggling Our Way to Success	
20	Magic Carpet Ride in Our Library	
21	From Sitting to Standing in the Classroom	
22	Books for Budding Intellectuals	
23	Instrumental Power: Conquering STEAM!	
24	S.T.E.A.M. Challenges(Science Technology Engin...	
25	Math Masters!	
26	Techy Teaching	
27	4th Grade French Immersion Class Ipads	
28	Hands-On Language and Literacy	
29	Basic Classroom Supplies Needed	
...	...	
49970	Art Paper: Making Creation a Team Effort	
49971	Improving Skills Through Game-Playing	
49972	STEAM supplies for art room centers!	
49973	Enhancing Math for Students	
49974	We Are Ready To Learn!	
49975	Crime Scene: Who Stole the Gum?	
49976	Headphones for First Grade Learners!	
49977	Research and Writing for All!	
49978	Shaping Tomorrow's Children, Through Art Today	
49979	Help Us Speak the Language of Art	
49980	21st Century Learners Need 21st Century Techno...	
49981	Chromebooks for Success!!!	
49982	For the Love of Art	
49983	STEAM Bins for Future Engineers	
49984	Helping Kids Have What They Need to Learn	
49985	We can code!!!	
49986	Flood Our Class With Technology	
49987	Our Social Skills Aren't Wobbly!	
49988	Math teacher in need of class set of graphing ...	
49989	We Like to Move it Move it While We Learn!	
49990	Flexible Seating for Dynamic Students	
49991	Renovate Roberson's Room	
49992	Exploring History With Chromebooks	
49993	Book Buddies for New Readers!	
49994	Keep Calm and Learn On!	
49995	iTeach: Using iPads in Instruction	
49996	A \"Starbucks\" Classroom Redesign	
49997	Active Bodies = Active Minds	
49998	Can You Read My Writing Now?	
49999	Inspiring Young Authors Through Reading	

	project_essay_1 \
0	My students are English learners that are work...
1	Our students arrive to our school eager to lea...
2	\r\n\"True champions aren't always the ones th...
3	I work at a unique school filled with both ESL...
4	Our second grade classroom next year will be m...
5	I will be moving from 2nd grade to 3rd grade a...
6	My students are a dynamic and very energetic g...
7	Not only do our students struggle with poverty...
8	My students are enthusiastic and inquisitive l...
9	Over 95% of my students are on free or reduced...
10	\"There are many little ways to enlarge your w...
11	All of our students receive free breakfast, lu...
12	My students are always working on new projects...
13	I teach in a small school district in central ...
14	My students are my babies...I want the world f...
15	Located in West Dallas, my students face sever...
16	My Preschool children, ages 3-5 years old with...
17	My students are special because they come from...
18	I teach at a Title I school in a low-income ar...
19	We are apart of an urban district and many of ...
20	The students in our school come from diverse b...
21	My students walk into school every day full of...
22	Every day in my English classroom, we work to ...
23	100% of our musical students get free breakfas...

```
23     100% of our musical students eat free breakfas...
24     This year, I am teaching in an EFL (Extended F...
25     My students are highly motivated to succeed. U...
26     I teach 22 bright 5 and 6 year olds. My studen...
27     My students spend most of their day learning f...
28     My students all have a primary diagnosis of au...
29     I have an awesome group of 24 students any tea...
...                                                  ...
49970  My school is a government funded Pre-Kindergar...
49971  I teach in a middle school on the south side o...
49972  My students are a phenomenal group of kids ran...
49973  I work with kids from first and second grade. ...
49974  Teaching in a high poverty/low-income school, ...
49975  Students are sometimes underwhelmed with the i...
49976  My students come from a variety of backgrounds...
49977  Buckman Arts Focus Elementary is a K-5 Arts in...
49978  My students come from various backgrounds, and...
49979  \"What are we doing today?\"  This is the firs...
49980  I teach an extremely talented and unique group...
49981  Yehey! Amazement as our class tried one of the...
49982  My first grade class is a diverse group of lea...
49983  The moment my second grade students walk in th...
49984  The students I work with come from a very poor...
49985  My students come from different economic backg...
49986  As a teacher at a Title I school, my students ...
49987  Welcome to my page! I'm the Counselor who work...
49988  Our school is considered \"High poverty\" and ...
49989  My classroom is a fully inclusive, high energy...
49990  I teach in a small neighborhood school which s...
49991  I teach at a very small and rural K-12 school....
49992  My students are being challenged in 6th grade ...
49993  My students come from various backgrounds and ...
49994  My classroom has 13 students with a variety of...
49995  I teach kindergarten in a Title I school in Ch...
49996  The students in our room are enrolled at an el...
49997  Welcome! My students and I are pleased to have...
49998  My school empowers 538 students in grades pre-...
49999  We have GRIT!  If you want to meet tenacious, ...

                                       project_essay_2 project_essay_3  \
0      \"The limits of your language are the limits o...             NaN
1      The projector we need for our school is very c...             NaN
2      The students on the campus come to school know...             NaN
3      My students live in high poverty conditions wi...             NaN
4      For many students, math is a subject that does...             NaN
5      These flexible seating options will allow my s...             NaN
6      My students are an engaging and active group o...             NaN
7      My students need 4 iPads, the latest technolog...             NaN
8      My second graders need extra activity time dur...             NaN
9      Reading is Fundamental! My students will read ...             NaN
10     I've had 8 sets of students enjoy the books in...             NaN
11     With three chromebooks, I can teach the Common...             NaN
12     My Spanish Dual Language students are always r...             NaN
13     My students are smart, creative, and also have...             NaN
14     Having this computer in the classroom would pr...             NaN
15     Due to the size of our school, and the tiny na...             NaN
16     Having a set of Leapfrog iPads and educational...             NaN
17     Classroom ChromebookCar\r\n\r\nMy name is Shan...             NaN
18     My 2nd grade students will benefit from having...             NaN
19     Many of my students struggle to sit still for ...             NaN
20     Each week our students love visiting the schoo...             NaN
21     I want to purchase desks in my classroom that ...             NaN
22     My students need books that interest them so t...             NaN
23     We need classroom instruments for our band pro...             NaN
24     I will use these items to create S.T.E.A.M. bi...             NaN
25     These math games will help reinforce the skill...             NaN
26     The iPads will be effectively used to improve ...             NaN
27     The iPads will also be used to enhance the stu...             NaN
28     Children with autism struggle in core deficit ...             NaN
29     My students need basic school supplies such as...             NaN
...                                                  ...             ...
49970  As a teacher, I can use some of this paper to ...             NaN
49971  The students at my  middle school are hard wor...             NaN
49972  These materials will focus on the creation pro...             NaN
49973  My students in first grade and math need these...             NaN
49974  I am asking for interactive phonics journals t...             NaN
49975  Students will be exploring the career of foren...             NaN
```

49976	First graders use Ipads and laptops daily. I u...	NaN	
49977	Why should students hold back their curiosity ...	NaN	
49978	In Fine Arts Survey, I find that my students l...	NaN	
49979	Students will be learning about art of other c...	NaN	
49980	"We need technology in every classroom and in ...	NaN	
49981	Chrome books will help my students be familiar...	NaN	
49982	I am requesting a variety of art supplies that...	NaN	
49983	My second graders love to learn and explore ev...	NaN	
49984	The resources that I selected address the lear...	NaN	
49985	Students will be able to navigate their way ar...	NaN	
49986	My students need these Dell laptops to be able...	NaN	
49987	Our students are the most resilient kids in KC...	NaN	
49988	Using graphing utilities is part of the curric...	NaN	
49989	Many of my students are frustrated by the amou...	NaN	
49990	The wobble cushions and bouncy bands will be a...	NaN	
49991	Collaboration is a daily focus in my English c...	NaN	
49992	My students are able to dig into social studie...	NaN	
49993	My students need leveled readers to read at ho...	NaN	
49994	This project will allow us to establish a \"ca...	NaN	
49995	Teaching kindergarten is all about differentia...	NaN	
49996	he research is clear. Students who engage in c...	NaN	
49997	Students in my class currently sit, bounce, wi...	NaN	
49998	A 7 year old girl in my class desperately year...	NaN	
49999	Receiving books written by the same author wil...	NaN	

	project_essay_4	project_resource_summary	\
0	NaN	My students need opportunities to practice beg...	
1	NaN	My students need a projector to help with view...	
2	NaN	My students need shine guards, athletic socks,...	
3	NaN	My students need to engage in Reading and Math...	
4	NaN	My students need hands on practice in mathemat...	
5	NaN	My students need movement to be successful. Be...	
6	NaN	My students need some dependable laptops for d...	
7	NaN	My students need ipads to help them access a w...	
8	NaN	My students need three devices and three manag...	
9	NaN	My students need great books to use during Ind...	
10	NaN	My students need books by their favorite autho...	
11	NaN	My students need paper, three chromebooks, and...	
12	NaN	My students need 3D and 4D life science activi...	
13	NaN	My students need access to technology that wil...	
14	NaN	My students need 5 tablets for our classroom t...	
15	NaN	My students need activities to play during rec...	
16	NaN	My students need 2 LeapPad that will engage th...	
17	NaN	My students need Chromebooks to publish writte...	
18	NaN	My students need privacy partitions to use whi...	
19	NaN	My students need 7 Hokki stools to encourage a...	
20	NaN	My students need carpet in our library to brig...	
21	NaN	My students need desks to stand at and be able...	
22	NaN	My students need books so that they can become...	
23	NaN	My students need these instruments to give the...	
24	NaN	My students need building materials, such as g...	
25	NaN	My students need the learning centers and mult...	
26	NaN	My students need 2 ipad minis to enhance learn...	
27	NaN	My students need Ipads to work in smaller grou...	
28	NaN	My students need to increase language and lite...	
29	NaN	My students need basic school supplies such as...	
...	...	...	
49970	NaN	My students need Duo-Finish Butcher Paper Roll...	
49971	NaN	My students need a variety of math games becau...	
49972	NaN	My students need hands-on materials that will ...	
49973	NaN	My students need will use money puzzles and ma...	
49974	NaN	My students need interactive phonics journals ...	
49975	NaN	My students need materials to discover the car...	
49976	NaN	My students need headphones to use with their ...	
49977	NaN	My students need 6 more Chromebooks to add to ...	
49978	NaN	My students need art-time dough and paper mach...	
49979	NaN	My students need printing inks, markers, paint...	
49980	NaN	My students need 2 Chromebooks and Google Chro...	
49981	NaN	My students need chrome books to help them kee...	
49982	NaN	My students need creative opportunities for ar...	
49983	NaN	My students need materials to help them fall i...	
49984	NaN	My students need basic curriculum and books to...	
49985	NaN	My students need the osmo coding system and ip...	
49986	NaN	My students need laptops to take AR tests, do ...	
49987	NaN	My students need a whiteboard table and wobble...	
49988	NaN	My students need access to graphing calculator...	
49989	NaN	My students need a way to move while being sea...	

```
49990            NaN  My students need Wobble cushions, bouncy bands...
49991            NaN  My students need 10 funtioning tables that wil...
49992            NaN  My students need Chromebooks for research and ...
49993            NaN  My students need grade level appropriate books...
49994            NaN  My students need classroom supplies like expo ...
49995            NaN  My students need iPads to help customize learn...
49996            NaN  My students need Hokki Stools to maximize enga...
49997            NaN  My students need 12 Learniture Active Learning...
49998            NaN  My students need Dimples hand strengthener, th...
49999            NaN  My students need copies of books by the same a...

       teacher_number_of_previously_posted_projects  project_is_approved  \
0                                                 0                    0
1                                                 7                    1
2                                                 1                    0
3                                                 4                    1
4                                                 1                    1
5                                                 1                    1
6                                                 1                    1
7                                                 7                    1
8                                                28                    1
9                                                36                    1
10                                               37                    1
11                                               32                    1
12                                                5                    0
13                                               30                    1
14                                               15                    0
15                                                3                    1
16                                                1                    1
17                                                0                    1
18                                                0                    1
19                                                9                    1
20                                               23                    1
21                                                0                    1
22                                                0                    0
23                                                2                    1
24                                                0                    1
25                                               11                    0
26                                                2                    1
27                                                2                    1
28                                                5                    0
29                                                0                    1
...                                             ...                  ...
49970                                             7                    1
49971                                             1                    1
49972                                            11                    1
49973                                             2                    1
49974                                            50                    1
49975                                             1                    0
49976                                             0                    1
49977                                             0                    1
49978                                             7                    1
49979                                            21                    0
49980                                            45                    1
49981                                             0                    1
49982                                             6                    1
49983                                             3                    1
49984                                             0                    1
49985                                             6                    0
49986                                             1                    1
49987                                             0                    1
49988                                             0                    1
49989                                             3                    1
49990                                             0                    1
49991                                             0                    1
49992                                             0                    1
49993                                             1                    1
49994                                             6                    0
49995                                             8                    1
49996                                             6                    1
49997                                             9                    1
49998                                            37                    1
49999                                             0                    1

                       clean_categories  \
0                     Literacy_Language
1          History_Civics Health_Sports
```

```
2                         Health_Sports
3          Literacy_Language Math_Science
4                          Math_Science
5          Literacy_Language SpecialNeeds
6          Literacy_Language SpecialNeeds
7                          Math_Science
8                         Health_Sports
9                     Literacy_Language
10                    Literacy_Language
11     Literacy_Language AppliedLearning
12                         Math_Science
13                          SpecialNeeds
14                    Literacy_Language
15                        Health_Sports
16         Literacy_Language SpecialNeeds
17         Math_Science Literacy_Language
18                       AppliedLearning
19                         Health_Sports
20                    Literacy_Language
21              Math_Science SpecialNeeds
22                    Literacy_Language
23                            Music_Arts
24                         Math_Science
25                         Math_Science
26         Literacy_Language Math_Science
27         Literacy_Language Math_Science
28         Literacy_Language SpecialNeeds
29     Literacy_Language AppliedLearning
...                                  ...
49970                         Music_Arts
49971                      Math_Science
49972            Math_Science Music_Arts
49973                      Math_Science
49974     Literacy_Language SpecialNeeds
49975                      Math_Science
49976                 Literacy_Language
49977   Literacy_Language History_Civics
49978                         Music_Arts
49979          History_Civics Music_Arts
49980     Literacy_Language Math_Science
49981     Literacy_Language Math_Science
49982                         Music_Arts
49983                      Math_Science
49984     Literacy_Language Math_Science
49985                      Math_Science
49986                 Literacy_Language
49987                   AppliedLearning
49988                      Math_Science
49989                     Health_Sports
49990     Literacy_Language Math_Science
49991                 Literacy_Language
49992                    History_Civics
49993                 Literacy_Language
49994                       SpecialNeeds
49995     Literacy_Language Math_Science
49996                     Health_Sports
49997                     Health_Sports
49998     Literacy_Language SpecialNeeds
49999                 Literacy_Language

                         clean_subcategories  \
0                                ESL Literacy
1                 Civics_Government TeamSports
2                   Health_Wellness TeamSports
3                         Literacy Mathematics
4                                  Mathematics
5               Literature_Writing SpecialNeeds
6                         Literacy SpecialNeeds
7                                  Mathematics
8                               Health_Wellness
9                   Literacy Literature_Writing
10                                     Literacy
11                  Literacy ParentInvolvement
12     EnvironmentalScience Health_LifeScience
13                                 SpecialNeeds
14                                     Literacy
15                              Health_Wellness
```

```
16                      Literacy SpecialNeeds
17          AppliedSciences Literature_Writing
18                             EarlyDevelopment
19                              Health_Wellness
20                                      Literacy
21             Health_LifeScience SpecialNeeds
22                                      Literacy
23                                         Music
24                 AppliedSciences Mathematics
25                                 Mathematics
26                         Literacy Mathematics
27                ForeignLanguages Mathematics
28                         Literacy SpecialNeeds
29                                Literacy Other
...                                         ...
49970                               VisualArts
49971                              Mathematics
49972          EnvironmentalScience VisualArts
49973                              Mathematics
49974                      Literacy SpecialNeeds
49975              AppliedSciences Mathematics
49976                             ESL Literacy
49977        Literature_Writing SocialSciences
49978                PerformingArts VisualArts
49979             History_Geography VisualArts
49980                      Literacy Mathematics
49981           Literature_Writing Mathematics
49982                               VisualArts
49983                           AppliedSciences
49984                      Literacy Mathematics
49985              AppliedSciences Mathematics
49986                        Literature_Writing
49987    CharacterEducation College_CareerPrep
49988                              Mathematics
49989              Gym_Fitness Health_Wellness
49990           Literature_Writing Mathematics
49991              Literacy Literature_Writing
49992         History_Geography SocialSciences
49993                             ESL Literacy
49994                              SpecialNeeds
49995                      Literacy Mathematics
49996                           Health_Wellness
49997                           Health_Wellness
49998          Literature_Writing SpecialNeeds
49999                        Literature_Writing
```

	essay	price	quantity
0	My students are English learners that are work...	154.60	23
1	Our students arrive to our school eager to lea...	299.00	1
2	\r\n\"True champions aren't always the ones th...	516.85	22
3	I work at a unique school filled with both ESL...	232.90	4
4	Our second grade classroom next year will be m...	67.98	4
5	I will be moving from 2nd grade to 3rd grade a...	113.22	11
6	My students are a dynamic and very energetic g...	159.99	3
7	Not only do our students struggle with poverty...	229.00	4
8	My students are enthusiastic and inquisitive l...	241.98	6
9	Over 95% of my students are on free or reduced...	125.36	14
10	\"There are many little ways to enlarge your w...	100.21	10
11	All of our students receive free breakfast, lu...	431.77	8
12	My students are always working on new projects...	219.46	22
13	I teach in a small school district in central ...	399.99	1
14	My students are my babies...I want the world f...	91.94	10
15	Located in West Dallas, my students face sever...	435.84	24
16	My Preschool children, ages 3-5 years old with...	298.43	7
17	My students are special because they come from...	158.63	12
18	I teach at a Title I school in a low-income ar...	59.98	4
19	We are apart of an urban district and many of ...	749.42	7
20	The students in our school come from diverse b...	213.85	1
21	My students walk into school every day full of...	250.91	4
22	Every day in my English classroom, we work to ...	278.09	21
23	100% of our musical students eat free breakfas...	299.98	2
24	This year, I am teaching in an EFL (Extended F...	250.00	6
25	My students are highly motivated to succeed. U...	268.99	2
26	I teach 22 bright 5 and 6 year olds. My studen...	280.83	4
27	My students spend most of their day learning f...	660.84	7
28	My students all have a primary diagnosis of au...	129.98	3
29	I have an awesome group of 24 students any tea...	86.74	53

```
...                                                   ...      ...        ...
49970  My school is a government funded Pre-Kindergar...  159.98         2
49971  I teach in a middle school on the south side o...  158.14        18
49972  My students are a phenomenal group of kids ran...  102.95         6
49973  I work with kids from first and second grade. ...  287.86        28
49974  Teaching in a high poverty/low-income school, ...  117.98         2
49975  Students are sometimes underwhelmed with the i...  167.05         7
49976  My students come from a variety of backgrounds...   12.44        25
49977  Buckman Arts Focus Elementary is a K-5 Arts in...  149.99         6
49978  My students come from various backgrounds, and...  100.99        16
49979  \"What are we doing today?\"  This is the firs...  215.09       486
49980  I teach an extremely talented and unique group...  165.95         4
49981  Yehey! Amazement as our class tried one of the...  157.00         2
49982  My first grade class is a diverse group of lea...  153.30        20
49983  The moment my second grade students walk in th...  100.91        10
49984  The students I work with come from a very poor...  324.87        13
49985  My students come from different economic backg...  719.77         7
49986  As a teacher at a Title I school, my students ...  310.74         1
49987  Welcome to my page! I'm the Counselor who work...  484.36         7
49988  Our school is considered \"High poverty\" and ...  189.62         8
49989  My classroom is a fully inclusive, high energy...   13.95        24
49990  I teach in a small neighborhood school which s...   60.04        19
49991  I teach at a very small and rural K-12 school....  159.57        50
49992  My students are being challenged in 6th grade ...  175.42         5
49993  My students come from various backgrounds and ...  381.00        14
49994  My classroom has 13 students with a variety of...  210.92        22
49995  I teach kindergarten in a Title I school in Ch...  539.98         2
49996  The students in our room are enrolled at an el...  214.12         6
49997  Welcome! My students and I are pleased to have...   52.05        14
49998  My school empowers 538 students in grades pre-...  102.25         6
49999  We have GRIT!  If you want to meet tenacious, ...  505.43        41

[50000 rows x 20 columns]
```

In [16]:

```
approved_price = project_data[project_data['project_is_approved']==1]['price'].values
print
rejected_price = project_data[project_data['project_is_approved']==0]['price'].values
```

1.3 Text preprocessing

1.3.1 Essay Text

In [17]:

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

Out[17]:

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

In [18]:

```
# printing some random essays.
print(project_data['essay'].values[0])
```

```
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves
to get together and celebrate. Around Halloween there is a whole school parade to show off the bea
utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by
the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t
he hard work put in during the school year, with a dunk tank being the most popular activity.My st
udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged
chairs. As I will only have a total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During independent reading time they
will be used as special chairs students will each use on occasion. I will utilize them in place of
chairs at my small group tables during math and reading times. The rest of the day they will be us
ed by the students who need the highest amount of movement in their life in order to stay focused
on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki
Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i
n group with me on the Hokki Stools, they are always moving, but at the same time doing their
work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are
disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours
a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th
e same time. These stools will help students to meet their 60 minutes a day of movement by
allowing them to activate their core muscles for balance while they sit. For many of my students,
these chairs will take away the barrier that exists in schools for a child who can't sit
still.nannan
==================================================
```

In [19]:

```
# 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 [20]:

```
sent = decontracted(project_data['essay'].values[4000])
print(sent)
print("="*50)
```

```
I teach language arts and social studies to about 50 students each day.  I teach two groups of ama
zing kids each day!\r\n\r\nThe students in my classroom range from advanced or gifted learners to
students with various learning disabilities. My school is located in an urban environment in
Maryland. The school is a Title I (low-income) school, and 99% of the students in the school recei
ve free and reduced price lunch. All students at my school receive free breakfast which is the mos
t important meal of the day!High interest reading supports comprehension and learning. I want to e
ncourage a love of reading by choosing books that interest my third grade students. Many of my
students are classified as \"struggling readers\". There is extensive research to support the
premise that the best way to become a better reader is to read more. In order for my students to b
ecome better or more fluent readers I need to increase both the quantity and quality of their read
ing.  They need reading materials that they can read and will want to read. \r\n\r\nI want to send
my students into summer vacation with a high interest book. If they find success and interest with
one book, research shows that learning will generate more learning! The book I have chosen is read
able, has a convincing plot, and has realistic characters.nannan
==================================================
```

In [21]:

```
# \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)
```

```
I teach language arts and social studies to about 50 students each day.  I teach two groups of ama
zing kids each day!    The students in my classroom range from advanced or gifted learners to stud
ents with various learning disabilities. My school is located in an urban environment in Maryland.
The school is a Title I (low-income) school, and 99% of the students in the school receive free an
d reduced price lunch. All students at my school receive free breakfast which is the most
important meal of the day!High interest reading supports comprehension and learning. I want to enc
ourage a love of reading by choosing books that interest my third grade students. Many of my
students are classified as  struggling readers . There is extensive research to support the
premise that the best way to become a better reader is to read more. In order for my students to b
ecome better or more fluent readers I need to increase both the quantity and quality of their read
ing.  They need reading materials that they can read and will want to read.     I want to send my
students into summer vacation with a high interest book. If they find success and interest with on
e book, research shows that learning will generate more learning! The book I have chosen is readab
le, has a convincing plot, and has realistic characters.nannan
```

In [22]:

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

```
I teach language arts and social studies to about 50 students each day I teach two groups of amazi
ng kids each day The students in my classroom range from advanced or gifted learners to students w
ith various learning disabilities My school is located in an urban environment in Maryland The sch
ool is a Title I low income school and 99 of the students in the school receive free and reduced p
rice lunch All students at my school receive free breakfast which is the most important meal of th
e day High interest reading supports comprehension and learning I want to encourage a love of read
ing by choosing books that interest my third grade students Many of my students are classified as
struggling readers There is extensive research to support the premise that the best way to become
a better reader is to read more In order for my students to become better or more fluent readers I
need to increase both the quantity and quality of their reading They need reading materials that t
hey can read and will want to read I want to send my students into summer vacation with a high int
erest book If they find success and interest with one book research shows that learning will gener
ate more learning The book I have chosen is readable has a convincing plot and has realistic chara
cters nannan
```

In [23]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
```

```
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [24]:

```
# Combining all the above statemennts
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%|██████████████████████████████████████████████████████████████████████████| 50000/50000 [01:
08<00:00, 726.12it/s]
```

In [25]:

```
# after preprocesing
preprocessed_essays[2000]

project_data['essay']=pd.DataFrame(preprocessed_essays)
```

1.3.2 Project title Text

In [26]:

```
# similarly you can preprocess the titles also

# Combining all the above statemennts
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].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_titles.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000
[00:03<00:00, 13753.45it/s]
```

In [27]:

```
preprocessed_titles[2000]

project_data['project_title']=pd.DataFrame(preprocessed_titles)
```

1. 4 Preparing data for models

In [28]:

```
project_data.columns
```

Out[28]:

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

we are going to consider

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

       - project_title : text data
       - text : text data
       - project_resource_summary: text data

       - quantity : numerical
       - teacher_number_of_previously_posted_projects : numerical
       - price : numerical
```

In [29]:

```
grades = list(project_data['project_grade_category'].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
grades_list = []
for i in grades:
    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"]
        j = j.replace(' ','_') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Scien
ce"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('-','_') # we are replacing the & value into
        temp = temp.replace('Grades','grades') # we are replacing the & value into
        temp = temp.replace('PreK','prek') # we are replacing the & value into
    grades_list.append(temp.strip())

project_data['project_grade_category'] = grades_list
```

In [30]:

```
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
```

```
project_data.head(1)
```

Out[30]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_categ
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	grades_pre

Assignment 3: Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**
   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)
   - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
   - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
   - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)
2. **Hyper paramter tuning to find best K**
   - Find the best hyper parameter which results in the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation (or) simple cross validation data
   - Use gridsearch-cv or randomsearch-cv or write your own for loops to do this task
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
   - Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points
4. **[Task-2]**
   - Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features
     - ```
       from sklearn.datasets import load_digits
       from sklearn.feature_selection import SelectKBest, chi2
       X, y = load_digits(return_X_y=True)
       X.shape
       X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
       X_new.shape
       ========
       output:
       (1797, 64)
       (1797, 20)
       ```
   - Repeat the steps 2 and 3 on the data matrix after feature selection
5. **Conclusion**
   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it
       ```

2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

2. K Nearest Neighbor

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

In [31]:

```
X=project_data
```

In [32]:

```
#train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [33]:

```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)
print("="*100)
```

```
(22445, 19) (22445,)
(11055, 19) (11055,)
(16500, 19) (16500,)
====================================================================================================
```

2.2 Make Data Model Ready: encoding numerical, categorical features

Normalizing the numerical features: Price

In [34]:

```
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))
X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))
print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

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

Normalizing the numerical features: Previously posted projects

In [35]:

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

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

Normalizing the numerical features : Quantity

In [36]:

```
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['quantity'].values.reshape(-1,1))
X_train_qty_norm = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
X_cv_qty_norm = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_qty_norm = normalizer.transform(X_test['quantity'].values.reshape(-1,1))
print("After vectorizations")

print(X_train_qty_norm.shape, y_train.shape)
print(X_cv_qty_norm.shape, y_cv.shape)
print(X_test_qty_norm.shape, y_test.shape)

print("="*100)
```

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

One hot encoding the catogorical features: State

In [37]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
```

```
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)
print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 51) (22445,)
(11055, 51) (11055,)
(16500, 51) (16500,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm',
'nv', 'ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv
', 'wy']
====================================================================================================
```

One hot encoding the catogorical features: Project Grade

In [38]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)
print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
====================================================================================================
```

One hot encoding the catogorical features: Teacher Prefix

In [39]:

```
#replacing nan with empty string
X_train.teacher_prefix=X_train.teacher_prefix.fillna('')
X_cv.teacher_prefix=X_cv.teacher_prefix.fillna('')
X_test.teacher_prefix=X_test.teacher_prefix.fillna('')
uniqueData=X_train['teacher_prefix'].unique()
print(uniqueData)

vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].values)
print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
['Ms.' 'Mrs.' 'Mr.' 'Teacher' 'Dr.' '']
```

```
[ Ms.   Mrs.   Mr.   Teacher   Dr.    ]
After vectorizations
(22445, 5) (22445,)
(11055, 5) (11055,)
(16500, 5) (16500,)
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
====================================================================================================
```

One hot encoding the catogorical features: Clean categories

In [40]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_ccat_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_ccat_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_ccat_ohe = vectorizer.transform(X_test['clean_categories'].values)
print("After vectorizations")
print(X_train_ccat_ohe.shape, y_train.shape)
print(X_cv_ccat_ohe.shape, y_cv.shape)
print(X_test_ccat_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 9) (22445,)
(11055, 9) (11055,)
(16500, 9) (16500,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language',
'math_science', 'music_arts', 'specialneeds', 'warmth']
====================================================================================================
```

One hot encoding the catogorical features: Cleab subcategories

In [41]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_csub_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_csub_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_csub_ohe = vectorizer.transform(X_test['clean_subcategories'].values)
print("After vectorizations")
print(X_train_csub_ohe.shape, y_train.shape)
print(X_cv_csub_ohe.shape, y_cv.shape)
print(X_test_csub_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(22445, 30) (22445,)
(11055, 30) (11055,)
(16500, 30) (16500,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience',
'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness',
'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'm
athematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socia
lsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
====================================================================================================
```

2.3 Make Data Model Ready: encoding essay, and project_title

Bag of Words

Bag of Words

In [42]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4))
vectorizer.fit(X_train['project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['project_title'].values)
X_cv_title_bow = vectorizer.transform(X_cv['project_title'].values)
X_test_title_bow = vectorizer.transform(X_test['project_title'].values)
print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1983) (22445,)
(11055, 1983) (11055,)
(16500, 1983) (16500,)
====================================================================================================
```

In [43]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4))
vectorizer.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer.transform(X_test['essay'].values)
print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 71753) (22445,)
(11055, 71753) (11055,)
(16500, 71753) (16500,)
====================================================================================================
```

TFIDF vectorizer

In [44]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['project_title'].values)
X_cv_title_tfidf = vectorizer.transform(X_cv['project_title'].values)
X_test_title_tfidf = vectorizer.transform(X_test['project_title'].values)
print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_test_title_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1229) (22445,)
(11055, 1229) (11055,)
(16500, 1229) (16500,)
====================================================================================================
```

In [45]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer.transform(X_train['essay'].values)
X_cv_essay_tfidf = vectorizer.transform(X_cv['essay'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['essay'].values)
print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 8870) (22445,)
(11055, 8870) (11055,)
(16500, 8870) (16500,)
====================================================================================================
```

2.4.1 Applying KNN brute force on BOW, SET 1

In [ ]:

```
#merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_bow = hstack((X_train_qty_norm, X_train_ppp_norm, X_train_price_norm, X_train_state_ohe, X_tra
in_grade_ohe,X_train_teacher_ohe,
X_train_ccat_ohe,X_train_csub_ohe,X_train_title_bow,X_train_essay_bow)).tocsr()

X_cr_bow = hstack((X_cv_qty_norm, X_cv_ppp_norm, X_cv_price_norm, X_cv_state_ohe, X_cv_grade_ohe,X_
cv_teacher_ohe,
X_cv_ccat_ohe,X_cv_csub_ohe,X_cv_title_bow,X_cv_essay_bow)).tocsr()

X_te_bow = hstack((X_test_qty_norm, X_test_ppp_norm, X_test_price_norm, X_test_state_ohe,
X_test_grade_ohe,X_test_teacher_ohe,
X_test_ccat_ohe,X_test_csub_ohe,X_test_title_bow,X_test_essay_bow)).tocsr()
print("Final Data matrix")
print(X_tr_bow.shape, y_train.shape)
print(X_cr_bow.shape, y_cv.shape)
print(X_te_bow.shape, y_test.shape)
print("="*100)
```

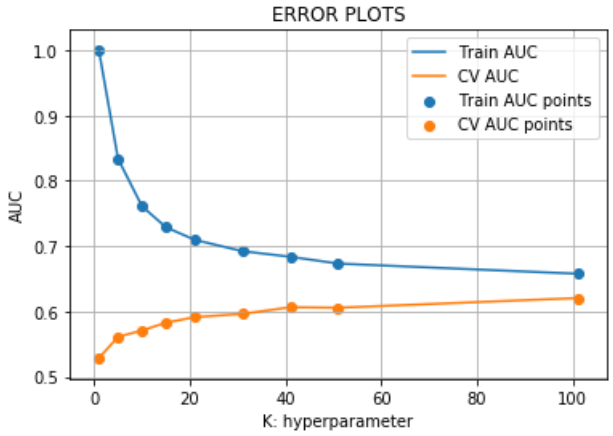
```
Final Data matrix
(22445, 73919) (22445,)
(11055, 73919) (11055,)
(16500, 73919) (16500,)
====================================================================================================
```

In [ ]:

```
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 [ ]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 101]
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_bow, y_train)
    y_train_pred = batch_predict(neigh, X_tr_bow)
    y_cv_pred = batch_predict(neigh, X_cr_bow)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



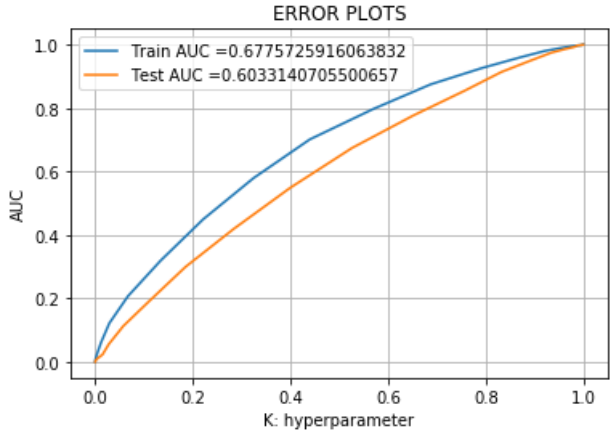
In [ ]:

```
best_k=47
```

In [ ]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.r
rve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k)
neigh.fit(X_tr_bow, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr_bow)
y_test_pred = batch_predict(neigh, X_te_bow)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [ ]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [ ]:

```
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_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.39298959851716603 for threshold 0.787
[[ 1940  1523]
 [ 5666 13316]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.329497627768312 for threshold 0.809
[[1529 1017]
 [6298 7656]]
```

2.4.2 Applying KNN brute force on TFIDF, SET 2

In [46]:

```
#merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf = hstack((X_train_qty_norm, X_train_ppp_norm, X_train_price_norm, X_train_state_ohe, X_t
rain_grade_ohe,X_train_teacher_ohe,
X_train_ccat_ohe,X_train_csub_ohe,X_train_title_tfidf,X_train_essay_tfidf)).tocsr()

X_cr_tfidf = hstack((X_cv_qty_norm, X_cv_ppp_norm, X_cv_price_norm, X_cv_state_ohe, X_cv_grade_ohe,
```

```
X_cv_teacher_ohe,
X_cv_ccat_ohe,X_cv_csub_ohe,X_cv_title_tfidf,X_cv_essay_tfidf)).tocsr()

X_te_tfidf = hstack((X_test_qty_norm, X_test_ppp_norm, X_test_price_norm, X_test_state_ohe,
X_test_grade_ohe,X_test_teacher_ohe,
X_test_ccat_ohe,X_test_csub_ohe,X_test_title_tfidf,X_test_essay_tfidf)).tocsr()
print("Final Data matrix")
print(X_tr_tfidf.shape, y_train.shape)
print(X_cr_tfidf.shape, y_cv.shape)
print(X_te_tfidf.shape, y_test.shape)
print("="*100)
```

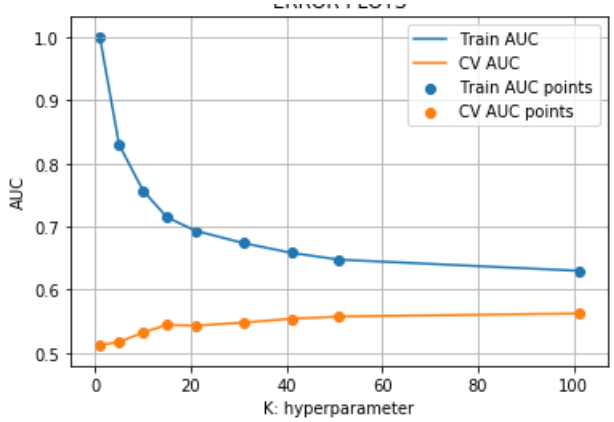
```
Final Data matrix
(22445, 10201) (22445,)
(11055, 10201) (11055,)
(16500, 10201) (16500,)
====================================================================================================
```

In [47]:

```
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 [48]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 101]
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_tfidf, y_train)
    y_train_pred = batch_predict(neigh, X_tr_tfidf)
    y_cv_pred = batch_predict(neigh, X_cr_tfidf)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

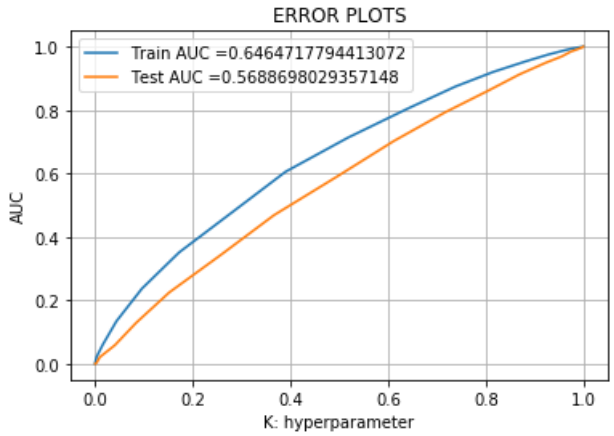


In [49]:

```
best_k=53
```

In [50]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k)
neigh.fit(X_tr_tfidf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr_tfidf)
y_test_pred = batch_predict(neigh, X_te_tfidf)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [51]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
```

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

In [52]:

```
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_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.3695175388888414 for threshold 0.849
[[ 2112  1351]
 [ 7481 11501]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2979155728940371 for threshold 0.849
[[1284 1262]
 [5711 8243]]
```

Average-w2v

In [51]:

```
# 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 X_train['project_title']:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

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

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

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

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

```
Loading Glove Model
```

```
1917495it [09:00, 3545.15it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 97595
the unique words in the coupus 8056
The number of words that are present in both glove vectors and our coupus 7794 ( 96.748 %)
word 2 vec length 7794
```

In [52]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-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())
```

In [53]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_train_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title']): # 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_train_title.append(vector)

print(len(avg_w2v_train_title))
print(len(avg_w2v_train_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 22445/22445
[00:01<00:00, 17627.19it/s]
```

```
22445
300
```

In [54]:

```
# 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 X_cv['project_title']:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

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

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


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

```
Loading Glove Model
```

```
1917495it [08:44, 3657.59it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 48150
the unique words in the coupus 5671
The number of words that are present in both glove vectors and our coupus 5561 ( 98.06 %)
word 2 vec length 5561
```

In [55]:

```
# 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())
```

In [56]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_cv_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title']): # 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_cv_title.append(vector)

print(len(avg_w2v_cv_title))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 11055/11055
```

```
[00:00<00:00, 14119.14it/s]
```

```
11055
```

In [57]:

```
# 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 X_test['project_title']:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

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

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


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

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

```
Loading Glove Model
```

```
1917495it [09:27, 3379.20it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 71344
the unique words in the coupus 6945
The number of words that are present in both glove vectors and our coupus 6750 ( 97.192 %)
word 2 vec length 6750
```

In [58]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove vectors file
```

```
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [59]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_test_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title']): # 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_test_title.append(vector)

print(len(avg_w2v_test_title))
print(len(avg_w2v_test_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 16500/16500
[00:01<00:00, 16364.18it/s]
```

```
16500
300
```

In [60]:

```
# Similarly you can vectorize for title also

# 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 X_train['essay']:
    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-save-and-load-variables-in-python/

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

```
Loading Glove Model
```

```
1917495it [08:50, 3614.51it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 3394625
the unique words in the coupus 30337
The number of words that are present in both glove vectors and our coupus 28663 ( 94.482 %)
word 2 vec length 28663
```

In [61]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-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())
```

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_train_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay']): # 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_train_essay.append(vector)

print(len(avg_w2v_train_essay))
print(len(avg_w2v_train_essay[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 22445/22445 [00:20<00:00, 1119.31it/s]
```

```
22445
300
```

In [63]:

```
# Similarly you can vectorize for title also

# 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 X_cv['essay']:
    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)
```

```
Loading Glove Model
```

```
1917495it [09:10, 3482.50it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 1671220
the unique words in the coupus 23500
The number of words that are present in both glove vectors and our coupus 22534 ( 95.889 %)
word 2 vec length 22534
```

In [64]:

```
# 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())
```

In [65]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_cv_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay']): # 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_cv_essay.append(vector)

print(len(avg_w2v_cv_essay))
print(len(avg_w2v_cv_essay[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055
[00:09<00:00, 1130.42it/s]
```

```
11055
300
```

In [66]:

```
# Similarly you can vectorize for title also

# 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 X_test['essay']:
    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)
```

```
Loading Glove Model
```

```
1917495it [09:04, 3519.65it/s]
```

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

```
Done. 1917495  words loaded!
all the words in the coupus 2495617
the unique words in the coupus 27235
The number of words that are present in both glove vectors and our coupus 25955 ( 95.3 %)
word 2 vec length 25955
```

In [67]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-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())
```

In [68]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_test_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay']): # 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_test_essay.append(vector)

print(len(avg_w2v_test_essay))
print(len(avg_w2v_test_essay[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 16500/16500 [00:15<00:00, 1067.90it/s]
```

```
16500
300
```

2.4.3 Applying KNN brute force on AVG W2V, SET 3

In [69]:

```
#merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_avg_w2v = hstack((X_train_qty_norm, X_train_ppp_norm, X_train_price_norm, X_train_state_ohe, X_train_grade_ohe,X_train_teacher_ohe,
X_train_ccat_ohe,X_train_csub_ohe,avg_w2v_train_title,avg_w2v_train_essay)).tocsr()

X_cv_avg_w2v = hstack((X_cv_qty_norm, X_cv_ppp_norm, X_cv_price_norm, X_cv_state_ohe, X_cv_grade_ohe,X_cv_teacher_ohe,
X_cv_ccat_ohe,X_cv_csub_ohe,avg_w2v_cv_title,avg_w2v_cv_essay)).tocsr()

X_te_avg_w2v = hstack((X_test_qty_norm, X_test_ppp_norm, X_test_price_norm, X_test_state_ohe,
X_test_grade_ohe,X_test_teacher_ohe,
X_test_ccat_ohe,X_test_csub_ohe,avg_w2v_test_title,avg_w2v_test_essay)).tocsr()
print("Final Data matrix")
print(X_tr_avg_w2v.shape, y_train.shape)
print(X_cv_avg_w2v.shape, y_cv.shape)
print(X_te_avg_w2v.shape, y_test.shape)
print("="*100)
```

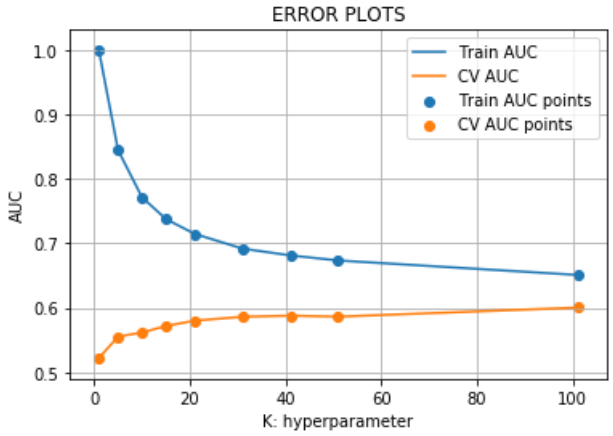
```
Final Data matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
====================================================================================================
```

In [70]:

```
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 [71]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 101]
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_avg_w2v, y_train)
    y_train_pred = batch_predict(neigh, X_tr_avg_w2v)
    y_cv_pred = batch_predict(neigh, X_cv_avg_w2v)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

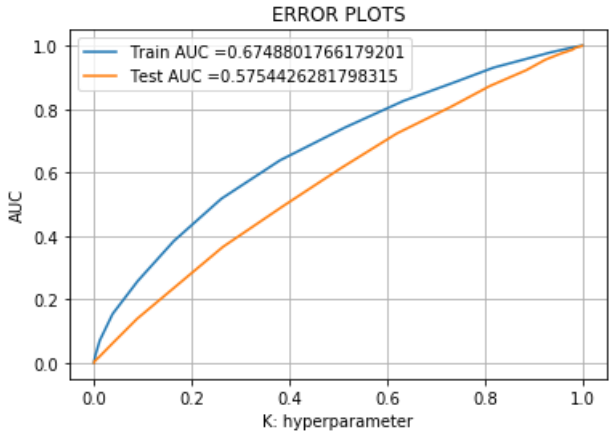


In [72]:

```
best_k=49
```

In [73]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
rve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k)
neigh.fit(X_tr_avg_w2v, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr_avg_w2v)
y_test_pred = batch_predict(neigh, X_te_avg_w2v)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [74]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [75]:

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

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24978734393513075 for threshold 0.837
[[ 1681  1782]
 [ 4884 14098]]
Test confusion matrix
```

```
the maximum value of tpr*(1-fpr) 0.24997778503192475 for threshold 0.857
[[1261 1285]
 [5398 8556]]
```

TFIDF Word2Vec

In [76]:

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

In [77]:

```
# average Word2Vec
# compute average word2vec for each review.
X_train_tfidf_w2v_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title']): # 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
    X_train_tfidf_w2v_title.append(vector)

print(len(X_train_tfidf_w2v_title))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 22445/22445 [00:
51<00:00, 433.40it/s]
```

```
22445
```

In [78]:

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

In [79]:

```
# average Word2Vec
# compute average word2vec for each review.
X_cv_tfidf_w2v_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title']): # 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
    X_cv_tfidf_w2v_title.append(vector)

print(len(X_cv_tfidf_w2v_title))
```

```
100%|██████████| 11055/11055 [00:06<00:00, 1598.19it/s]
```

```
11055
```

In [80]:

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

In [81]:

```
# average Word2Vec
# compute average word2vec for each review.
X_test_tfidf_w2v_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title']): # 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
    X_test_tfidf_w2v_title.append(vector)

print(len(X_test_tfidf_w2v_title))
```

```
100%|██████████| 16500/16500 [00:12<00:00, 1374.63it/s]
```

```
16500
```

In [82]:

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

In [83]:

```
# average Word2Vec
# compute average word2vec for each review.
X_train_tfidf_w2v_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay']): # 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
    X_train_tfidf_w2v_essay.append(vector)

print(len(X_train_tfidf_w2v_essay))
```

```
100%|████████████████████████████████████████████████████████████| 22445/22445 [02:
23<00:00, 156.67it/s]
```

```
22445
```

In [84]:

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

In [85]:

```
# average Word2Vec
# compute average word2vec for each review.
X_cv_tfidf_w2v_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay']): # 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
    X_cv_tfidf_w2v_essay.append(vector)

print(len(X_cv_tfidf_w2v_essay))
```

```
100%|████████████████████████████████████████████████████████████| 11055/11055 [01:
04<00:00, 171.78it/s]
```

```
11055
```

In [86]:

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

In [87]:

```
# average Word2Vec
# compute average word2vec for each review.
X_test_tfidf_w2v_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay']): # 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
    X_test_tfidf_w2v_essay.append(vector)

print(len(X_test_tfidf_w2v_essay))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 16500/16500 [01:
45<00:00, 157.00it/s]
```

```
16500
```

2.4.4 Applying KNN brute force on TFIDF W2V, SET 4

In [88]:

```
#merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf_w2v = hstack((X_train_qty_norm, X_train_ppp_norm, X_train_price_norm, X_train_state_ohe,
X_train_grade_ohe,X_train_teacher_ohe,
X_train_ccat_ohe,X_train_csub_ohe,X_train_tfidf_w2v_essay,X_train_tfidf_w2v_title)).tocsr()

X_cv_tfidf_w2v = hstack((X_cv_qty_norm, X_cv_ppp_norm, X_cv_price_norm, X_cv_state_ohe, X_cv_grade_
ohe,X_cv_teacher_ohe,
X_cv_ccat_ohe,X_cv_csub_ohe,X_cv_tfidf_w2v_title,X_cv_tfidf_w2v_essay)).tocsr()

X_te_tfidf_w2v = hstack((X_test_qty_norm, X_test_ppp_norm, X_test_price_norm, X_test_state_ohe, X_t
est_grade_ohe,X_test_teacher_ohe,
X_test_ccat_ohe,X_test_csub_ohe,X_test_tfidf_w2v_essay,X_test_tfidf_w2v_title)).tocsr()
print("Final Data matrix")
print(X_tr_avg_w2v.shape, y_train.shape)
print(X_cv_avg_w2v.shape, y_cv.shape)
print(X_te_avg_w2v.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
====================================================================================================
```

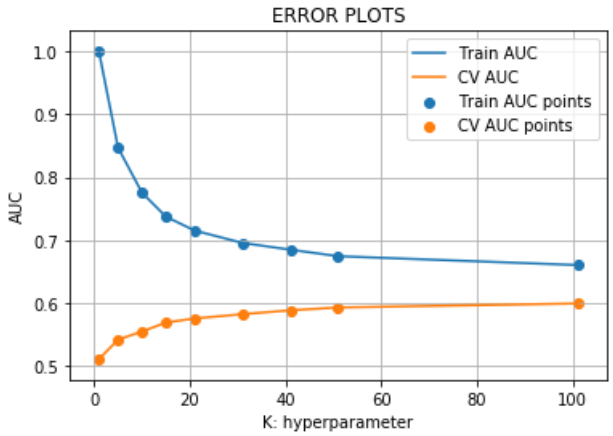
In [89]:

```
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 [90]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y true : array, shape = [n samples] or [n samples, n classes]
```

```
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 101]
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_tfidf_w2v, y_train)
    y_train_pred = batch_predict(neigh, X_tr_tfidf_w2v)
    y_cv_pred = batch_predict(neigh, X_cv_tfidf_w2v)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

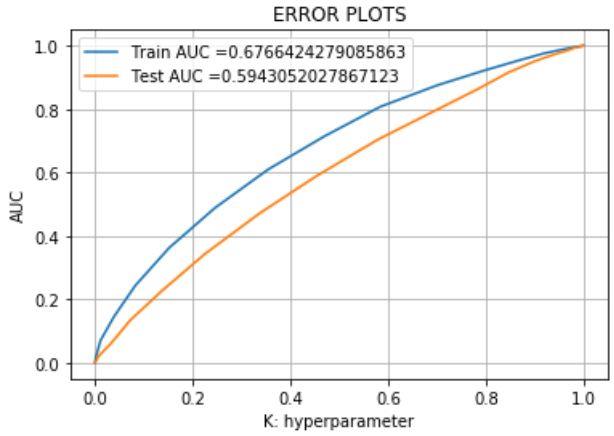


In [91]:

```
best_k=49
```

In [92]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.r
rve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k)
neigh.fit(X_tr_tfidf_w2v, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr_tfidf_w2v)
y_test_pred = batch_predict(neigh, X_te_tfidf_w2v)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [93]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [94]:

```
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_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.39376386273872604 for threshold 0.857
[[ 2236  1227]
 [ 7406 11576]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.32188953019352895 for threshold 0.857
[[1388 1158]
 [5715 8239]]
```

2.5 Feature selection with `SelectKBest`

In [45]:

```
from sklearn.datasets import load_digits
from sklearn.feature_selection import SelectKBest, chi2
import scipy.sparse as sp


X_new = SelectKBest(chi2, k=20).fit(X_tr_tfidf, y_train)

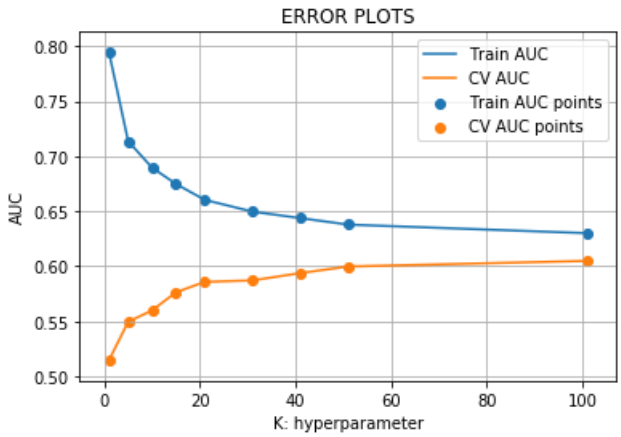

X_train=X_new.transform(X_tr_tfidf)
X_cv=X_new.transform(X_cr_tfidf)
X_test=X_new.transform(X_te_tfidf)
```

In [46]:

```
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 [47]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 101]
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_train, y_train)
    y_train_pred = batch_predict(neigh, X_train)
    y_cv_pred = batch_predict(neigh, X_cv)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

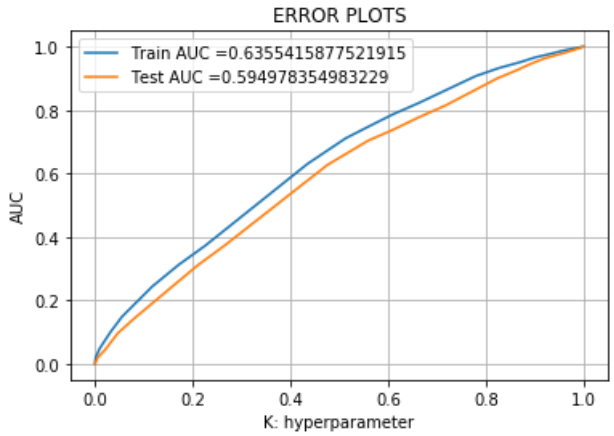


In [48]:

```
best_k=61
```

In [49]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.r
rve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k)
neigh.fit(X_train, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_train)
y_test_pred = batch_predict(neigh, X_test)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [50]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [51]:

```
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_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

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

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.3562684565857534 for threshold 0.852
[[ 1956  1507]
 [ 7009 11973]]
```

```
 [ 7009 11973]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3288002966992546 for threshold 0.852
[[1335 1211]
 [5204 8750]]
```

Summary

In [53]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyperparamter", "AUC"]

x.add_row(["BOW", "BRUTE", 47, 0.603])
x.add_row(["TFIDF", "BRUTE", 53, 0.568])
x.add_row(["AVG W2V", "BRUTE", 49, 0.575])
x.add_row(["TFIDF W2V", "BRUTE", 49, 0.594])

print(x)
```

```
+------------+-------+---------------+-------+
| Vectorizer | Model | Hyperparamter |  AUC  |
+------------+-------+---------------+-------+
|    BOW     | BRUTE |       47      | 0.603 |
|   TFIDF    | BRUTE |       53      | 0.568 |
|  AVG W2V   | BRUTE |       49      | 0.575 |
| TFIDF W2V  | BRUTE |       49      | 0.594 |
+------------+-------+---------------+-------+
```

In [ ]:

```

```

In [ ]:

```

```