# 1. Importing Packages

In [1]:

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

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

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer
import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

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

from tqdm import tqdm
import os

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

# 2. Loading Data

In [2]:

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

In [3]:

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

```
Number of data points in train data (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 [4]:

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

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

In [5]:

```
resource_data.head()
```

Out[5]:

| | 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 |
| **2** | p069063 | Cory Stories: A Kid's Book About Living With Adhd | 1 | 8.45 |
| **3** | p069063 | Dixon Ticonderoga Wood-Cased #2 HB Pencils, Bo... | 2 | 13.59 |
| **4** | p069063 | EDUCATIONAL INSIGHTS FLUORESCENT LIGHT FILTERS... | 3 | 24.95 |

In [6]:

```
project_data.head()
```

Out[6]:

| | 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 |
| **2** | 21895 | p182444 | 3465aaf82da834c0582ebd0ef8040ca0 | Ms. | AZ | 2016-08-31 12:03:56 | Grade |
| **3** | 45 | p246581 | f3cb9bffbba169bef1a77b243e620b60 | Mrs. | KY | 2016-10-06 21:16:17 | Grades P |
| **4** | 172407 | p104768 | be1f7507a41f8479dc06f047086a39ec | Mrs. | TX | 2016-07-11 01:10:09 | Grades P |

In [7]:

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

Out[7]:

| | 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 [8]:

```
# 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[8]:

| | id | price | quantity |
|---|---|---|---|
| 0 | p000001 | 459.56 | 7 |
| 1 | p000002 | 515.89 | 21 |

In [9]:

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

In [10]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].replace(np.NaN,'Mrs.')
```

# 3. Text Preprocessing

## 3.1. Concatenating all essay text

In [11]:

```
# 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)
```

## 3.2. Preprocessing Essay text

In [12]:

```
# printing some random essays.
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[49999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
```

ucational dvd's for the years to come for other EL students.\r\nnannan
==========
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together and celebrate. Around Halloween there is a whole school parade to show off the bea utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t he hard work put in during the school year, with a dunk tank being the most popular activity.My st udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in the classroom and not enough for each student to hav e an individual one, they will be used in a variety of ways. During independent reading time they will be used as special chairs students will each use on occasion. I will utilize them in place of chairs at my small group tables during math and reading times. The rest of the day they will be us ed by the students who need the highest amount of movement in their life in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i n group with me on the Hokki Stools, they are always moving, but at the same time doing their work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta ken. There are always students who head over to the kidney table to get one of the stools who are disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th e same time. These stools will help students to meet their 60 minutes a day of movement by allowing them to activate their core muscles for balance while they sit. For many of my students, these chairs will take away the barrier that exists in schools for a child who can't sit still.nannan
==========
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n \r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage r learners; they are like sponges, absorbing all the information and experiences and keep on wanti ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to be one of a themed nautical environment. Creating a classroom environment is very important in the success in each and every child's education. The nautical photo props will be used with each child as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic tures of each child with them, have them developed, and then hung in our classroom ready for their first day of 4th grade.  This kind gesture will set the tone before even the first day of school! The nautical thank you cards will be used throughout the year by the students as they create thank you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on resources to get our classroom ready. Please consider helping with this project t o make our new school year a very successful one. Thank you!nannan
==========
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I teach in a Title I school where most of the students receive free or reduced pr ice lunch.  Despite their disabilities and limitations, my students love coming to school and come eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju mping and playing. Physical engagement is the key to our success. The number toss and color and sh ape mats can make that happen. My students will forget they are doing work and just have the fun a 6 year old deserves.nannan
==========
We have GRIT!  If you want to meet tenacious, respectful seven year olds with growth mindsets, you need to come to our classroom.  We give hugs, high-fives, and compliments! We Begin with the End i n Mind and work hard everyday to reach our goals.\r\n\r\nWe don't believe in making excuses, but t here are times in life when you just need to ask for help.  As a classroom teacher in a low-income /high poverty school district, my 2nd grade students face real-life struggles both in and out of t he classroom.  Even though, as a visitor to my classroom, you wouldn't know the daily struggle for some of them.  I ask you. How can you learn with your belly growling?  How can I provide the absol ute best learning environment when we do not have the money to buy research-based materials?  \r\n \r\n“Education is not the filling of a pail, but the lighting of a fire,\" William Butler Yeats. We are not asking you to fill our pail with \"things,\"but to help provide resources to light the fire in young minds.Receiving books written by the same author will teach students how to develop their own Writer's Craft.  It will inspire them to think about different ways established authors have developed successful text that appeal to various audiences.  \r\n\r\nWe never forget our first love.  My mother read the Berenstain Bears series to me when I was five and I fell in love w ith the Berenstain family.  She took me to the public library every week and I would hunt for book

s written by Stan and Jan Berenstain.  Next, was the curious monkey and the man in the yellow hat, Curious George!  Thank you Margaret and H.A. Rey for creating a series that captured my heart and attention.  \r\n\r\nAs a teacher, it is my hope and dream to inspire the students in my classroom to find their first love in reading.  Help me help them to discover writer's craft, go on adventures in their minds, and develop a tenacious love for reading for the sake of reading.nannan
==================================================

In [13]:

```
# 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 [14]:

```
sent = decontracted(project_data['essay'].values[16499])
print(sent)
print("="*50)
```

I teach an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav e limited time to spend with their wonderfully talented children. My students work hard in class g iving 110% with everything that they do. They persevere through difficult topics, enjoy being engaged in their hands-on activities, and they love to laugh while learning. I set high expectation for my students. They understand that true, authentic learning takes hard work, dedication, and requires them to take ownership over their education. My goal for my students is t o leave my class as life long learners. The students work hard to overcome all obstacles in their path to meet and grow past my expectations.My students love being active while they are learning a nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa dly, one is not enough to reach all my students. My students love to use the Hokki stools while th ey learn and want more! One of my students suggested that I write a project since I \"only have on e, and we need more.\" These stools help my amazing kiddos get focused while engaging their core t o keep them happy and healthy.\r\n\r\nMy students love to wiggle so they can not only focus on the ir work, but engage in a healthy lifestyle.\r\n\r\n\r\nThe Hokki stools would allow my students to continue to be active throughout the day whether they are in small groups or working at their own seat.\r\nnannan
==================================================

In [15]:

```
# \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 an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav e limited time to spend with their wonderfully talented children. My students work hard in class g iving 110% with everything that they do. They persevere through difficult topics, enjoy being engaged in their hands-on activities, and they love to laugh while learning. I set high expectation for my students. They understand that true, authentic learning takes hard work, dedication, and requires them to take ownership over their education. My goal for my students is t o leave my class as life long learners. The students work hard to overcome all obstacles in their path to meet and grow past my expectations.My students love being active while they are learning a nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa dly, one is not enough to reach all my students. My students love to use the Hokki stools while th

```
ey learn and want more! One of my students suggested that I write a project since I  only have one
, and we need more.  These stools help my amazing kiddos get focused while engaging their core to
keep them happy and healthy.    My students love to wiggle so they can not only focus on their wor
k, but engage in a healthy lifestyle.      The Hokki stools would allow my students to continue to
be active throughout the day whether they are in small groups or working at their own seat.
nannan
```

In [16]:

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

```
I teach an amazing energetic engaged and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis Many of my students have parents who work odd hours and have
limited time to spend with their wonderfully talented children My students work hard in class givi
ng 110 with everything that they do They persevere through difficult topics enjoy being engaged in
their hands on activities and they love to laugh while learning I set high expectation for my stud
ents They understand that true authentic learning takes hard work dedication and requires them to
take ownership over their education My goal for my students is to leave my class as life long
learners The students work hard to overcome all obstacles in their path to meet and grow past my e
xpectations My students love being active while they are learning and wiggling while they are work
ing I am lucky enough to have one Hokki stools in my classroom Sadly one is not enough to reach al
l my students My students love to use the Hokki stools while they learn and want more One of my st
udents suggested that I write a project since I only have one and we need more These stools help m
y amazing kiddos get focused while engaging their core to keep them happy and healthy My students
love to wiggle so they can not only focus on their work but engage in a healthy lifestyle The Hokk
i stools would allow my students to continue to be active throughout the day whether they are in s
mall groups or working at their own seat nannan
```

In [17]:

```
# 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 [18]:

```
# 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 = sent.lower()
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.strip())
```

```
100%|████████████████████████████████████████████████████████████████| 50000/50000
[00:44<00:00, 1117.11it/s]
```

In [19]:

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

Out[19]:

```
'kindergarten students varied disabilities ranging speech language delays cognitive delays gross f
ine motor delays autism eager beavers always strive work hardest working past limitations
materials ones seek students teach title school students receive free reduced price lunch despite
disabilities limitations students love coming school come eager learn explore ever felt like ants
pants needed groove move meeting kids feel time want able move learn say wobble chairs answer love
develop core enhances gross motor turn fine motor skills also want learn games kids not want sit w
orksheets want learn count jumping playing physical engagement key success number toss color shape
mats make happen students forget work fun 6 year old deserves nannan'
```

In [20]:

```
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
project_data.head(2)
```

Out[20]:

| | 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 |

# 3.3. Preprocessing Title text

In [21]:

```
# printing some random titles.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[49999])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
We Need To Move It While We Input It!
==================================================
```

```
Inspiring Young Authors Through Reading
==================================================
```

In [22]:

```
# 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 [23]:

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

```
We Need To Move It While We Input It!
==================================================
```

In [24]:

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

```
We Need To Move It While We Input It!
```

In [25]:

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

```
We Need To Move It While We Input It
```

In [26]:

```
# 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 [27]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50000
[00:02<00:00, 24404.17it/s]
```

In [28]:

```
# after preprocesing
preprocessed_titles[20000]
```

Out[28]:

```
'need move input'
```

In [29]:

```
project_data['preprocessed_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(2)
```

Out[29]:

| | 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 [30]:

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

Out[30]:

| | 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 |

| | 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 |

# 3.4. Preprocessing project_grade_category

In [31]:

```
project_grade_clean_category = []

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

In [32]:

```
project_grade_clean_category[0:5]
```

Out[32]:

```
['Grades_PreK_2', 'Grades_6_8', 'Grades_6_8', 'Grades_PreK_2', 'Grades_PreK_2']
```

In [33]:

```
project_data['project_grade_clean_category'] = project_grade_clean_category
project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data.head(2)
```

Out[33]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | project_submitted_datetime | project_subject_ca |
|---|---|---|---|---|---|---|---|
| 0 | 160221 | p253737 | c90749f5d961ff158d4b4d1e7dc665fc | Mrs. | IN | 2016-12-05 13:43:57 | Literacy & L |
| 1 | 140945 | p258326 | 897464ce9ddc600bced1151f324dd63a | Mr. | FL | 2016-10-25 09:22:10 | History & Civics, |

# 3.5. Preprocessing project_subject_categories

In [34]:

```
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 [35]:

```
cat_list[0:5]
```

Out[35]:

```
['Literacy_Language',
 'History_Civics Health_Sports',
 'Health_Sports',
 'Literacy_Language Math_Science',
 'Math_Science']
```

In [36]:

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

Out[36]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | project_submitted_datetime | project_subject_su |
|---|---|---|---|---|---|---|---|
| 0 | 160221 | p253737 | c90749f5d961ff158d4b4d1e7dc665fc | Mrs. | IN | 2016-12-05 13:43:57 | |
| 1 | 140945 | p258326 | 897464ce9ddc600bced1151f324dd63a | Mr. | FL | 2016-10-25 09:22:10 | Civics & Gover |

# 3.5. Preprocessing project_subject_subcategories

In [37]:

```
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 [38]:

```
sub_cat_list[0:5]
```

Out[38]:

```
['ESL Literacy',
 'Civics_Government TeamSports',
 'Health_Wellness TeamSports',
```

```
 'Literacy Mathematics',
 'Mathematics']
```

In [39]:

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

Out[39]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | project_submitted_datetime | project_essay_1 |
|---|---|---|---|---|---|---|---|
| 0 | 160221 | p253737 | c90749f5d961ff158d4b4d1e7dc665fc | Mrs. | IN | 2016-12-05 13:43:57 | My students are English learners that are work... |
| 1 | 140945 | p258326 | 897464ce9ddc600bced1151f324dd63a | Mr. | FL | 2016-10-25 09:22:10 | Our students arrive to our school eager to lea... |

In [ ]:

In [ ]:

In [ ]:

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

In [40]:

```
from sklearn.model_selection import train_test_split

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

# 5. Dropping Target values from Train, Test and CV set

In [41]:

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

In [42]:

```
print(X_train.shape)
print(X_test.shape)
print(X_cv.shape)
```

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

In [43]:

```
X_train.head()
```

Out[43]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | project_submitted_datetime | project_essay |
|---|---|---|---|---|---|---|---|
| **28410** | 125185 | p064937 | fc645aa5ab5d027240470d73990fd342 | Ms. | NY | 2016-12-12 18:51:20 | Our school is t hub of our urb community |
| **47890** | 137201 | p174257 | e8de8eeacaf1917f459e3fdde2280195 | Ms. | NY | 2017-02-26 11:28:17 | My students a kindergartene who are learn |
| **23626** | 177892 | p013052 | 202339c54a2f63bbb1f039a0576a4c43 | Mrs. | HI | 2017-03-02 15:24:16 | We attend small K-6 scho in Hawaii.O thi |
| **28728** | 107880 | p024674 | b4ab661c368aec8b51068192dfca072a | Ms. | TX | 2016-08-31 16:01:50 | My students a as diverse you can get. I h |
| **47884** | 72338 | p245028 | 0d8202ddd7cf14d6eb0985a8af05b594 | Mr. | MI | 2017-01-04 21:25:31 | Have you ev interacted with group of kids |

In [44]:

```
y_train.head()
```

Out[44]:

```
28410    1
47890    1
23626    1
28728    1
47884    1
Name: project_is_approved, dtype: int64
```

# 6. Encoding Categorical Data

## 6.1. One Hot Encoding of clean_categories

In [45]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# cat_dict = dict(my_counter)
# sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

In [46]:

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer1 = CountVectorizer(lowercase=False, binary=True)
vectorizer1.fit(X_train['clean_categories'].values)
print(vectorizer1.get_feature_names())


categories_one_hot_Xtrain = vectorizer1.transform(X_train['clean_categories'].values)
categories_one_hot_Xtest = vectorizer1.transform(X_test['clean_categories'].values)
categories_one_hot_Xcv = vectorizer1.transform(X_cv['clean_categories'].values)
print("Shape of matrix after one hot encodig ",categories_one_hot_Xtrain.shape)
```

```
print("Shape of matrix after one hot encodig ",categories_one_hot_Xtest.shape)
print("Shape of matrix after one hot encodig ",categories_one_hot_Xcv.shape)
```

```
['AppliedLearning', 'Care_Hunger', 'Health_Sports', 'History_Civics', 'Literacy_Language',
'Math_Science', 'Music_Arts', 'SpecialNeeds', 'Warmth']
Shape of matrix after one hot encodig  (22445, 9)
Shape of matrix after one hot encodig  (16500, 9)
Shape of matrix after one hot encodig  (11055, 9)
```

## 6.2. One Hot Encoding of clean_subcategories

In [47]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# sub_cat_dict = dict(my_counter)
# sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [48]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer2 = CountVectorizer(lowercase=False, binary=True)
vectorizer2.fit(project_data['clean_subcategories'].values)
print(vectorizer2.get_feature_names())


sub_categories_one_hot_Xtrain = vectorizer2.transform(X_train['clean_subcategories'].values)
sub_categories_one_hot_Xtest = vectorizer2.transform(X_test['clean_subcategories'].values)
sub_categories_one_hot_Xcv = vectorizer2.transform(X_cv['clean_subcategories'].values)

print("Shape of matrix after one hot encoding ",sub_categories_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encodig ",sub_categories_one_hot_Xtest.shape)
print("Shape of matrix after one hot encodig ",sub_categories_one_hot_Xcv.shape)
```

```
['AppliedSciences', 'Care_Hunger', 'CharacterEducation', 'Civics_Government',
'College_CareerPrep', 'CommunityService', 'ESL', 'EarlyDevelopment', 'Economics',
'EnvironmentalScience', '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']
Shape of matrix after one hot encoding  (22445, 30)
Shape of matrix after one hot encodig  (16500, 30)
Shape of matrix after one hot encodig  (11055, 30)
```

## 6.3. One Hot Encoding of school_state

In [49]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# school_state_dict = dict(my_counter)
# sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1]))
```

In [50]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer3 = CountVectorizer(lowercase=False, binary=True)
vectorizer3.fit(project_data['school_state'].values)
```

```
print(vectorizer3.get_feature_names())


school_state_one_hot_Xtrain = vectorizer3.transform(X_train['school_state'].values)
school_state_one_hot_Xtest = vectorizer3.transform(X_test['school_state'].values)
school_state_one_hot_Xcv = vectorizer3.transform(X_cv['school_state'].values)

print("Shape of matrix after one hot encoding ",school_state_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",school_state_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",school_state_one_hot_Xcv.shape)
```

```
['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']
Shape of matrix after one hot encoding  (22445, 51)
Shape of matrix after one hot encoding  (16500, 51)
Shape of matrix after one hot encoding  (11055, 51)
```

## 6.4. One Hot Encoding of teacher_prefix

In [51]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# teacher_prefix_dict = dict(my_counter)
# sorted_teacher_prefix_dict = dict(sorted(teacher_prefix_dict.items(), key=lambda kv: kv[1]))
```

In [52]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer4 = CountVectorizer(lowercase=False, binary=True)
vectorizer4.fit(project_data['teacher_prefix'].values)
print(vectorizer4.get_feature_names())


teacher_prefix_one_hot_Xtrain = vectorizer4.transform(X_train['teacher_prefix'].values)
teacher_prefix_one_hot_Xtest = vectorizer4.transform(X_test['teacher_prefix'].values)
teacher_prefix_one_hot_Xcv = vectorizer4.transform(X_cv['teacher_prefix'].values)

print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xcv.shape)
```

```
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
Shape of matrix after one hot encoding  (22445, 5)
Shape of matrix after one hot encoding  (16500, 5)
Shape of matrix after one hot encoding  (11055, 5)
```

## 6.5. One Hot Encoding of project_grade_clean_category

In [53]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# grade_dict = dict(my_counter)
# sorted_grade_dict = dict(sorted(grade_dict.items(), key=lambda kv: kv[1]))
```

In [54]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer5 = CountVectorizer(lowercase=False, binary=True)
vectorizer5.fit(project_data['project_grade_clean_category'].values)
print(vectorizer5.get_feature_names())


grade_one_hot_Xtrain = vectorizer5.transform(X_train['project_grade_clean_category'].values)
grade_one_hot_Xtest = vectorizer5.transform(X_test['project_grade_clean_category'].values)
grade_one_hot_Xcv = vectorizer5.transform(X_cv['project_grade_clean_category'].values)

print("Shape of matrix after one hot encoding ",grade_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",grade_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",grade_one_hot_Xcv.shape)
```

```
['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2']
Shape of matrix after one hot encoding  (22445, 4)
Shape of matrix after one hot encoding  (16500, 4)
Shape of matrix after one hot encoding  (11055, 4)
```

# 7. Encoding of Text Data

## 7.1. BOW encoding of preprocessed_essays

In [55]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer6 = CountVectorizer(min_df=5)
text_bow_Xtrain = vectorizer6.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtrain.shape)
text_bow_Xtest = vectorizer6.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtest.shape)
text_bow_Xcv = vectorizer6.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 11969)
Shape of matrix after one hot encodig  (16500, 11969)
Shape of matrix after one hot encodig  (11055, 11969)
```

## 7.2. BOW encoding of preprocessed_titles

In [56]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer7 = CountVectorizer(min_df=5)
title_bow_Xtrain = vectorizer7.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtrain.shape)
title_bow_Xtest = vectorizer7.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtest.shape)
title_bow_Xcv = vectorizer7.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 2032)
Shape of matrix after one hot encodig  (16500, 2032)
Shape of matrix after one hot encodig  (11055, 2032)
```

## 7.3. TFIDF encoding of preprocessed_essays

In [57]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer8 = TfidfVectorizer(min_df=5)
text_tfidf_Xtrain = vectorizer8.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtrain.shape)
```

```
text_tfidf_Xtest = vectorizer8.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtest.shape)
text_tfidf_Xcv = vectorizer8.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 11969)
Shape of matrix after one hot encodig  (16500, 11969)
Shape of matrix after one hot encodig  (11055, 11969)
```

## 7.4. TFIDF encoding of preprocessed_titles

In [58]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer9 = TfidfVectorizer(min_df=5)
title_tfidf_Xtrain = vectorizer9.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtrain.shape)
title_tfidf_Xtest = vectorizer9.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtest.shape)
title_tfidf_Xcv = vectorizer9.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 2032)
Shape of matrix after one hot encodig  (16500, 2032)
Shape of matrix after one hot encodig  (11055, 2032)
```

## 7.5. Average Word2Vec encoding of preprocessed_essays on Train Data

In [59]:

```
# 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('D:\glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [60]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xtrain.append(vector)

print(len(avg_w2v_vectors_essays_Xtrain))
print(len(avg_w2v_vectors_essays_Xtrain[2]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 22445/22445
[00:11<00:00, 1920.87it/s]
```

```
22445
300
```

In [61]:

```
average_w2v_on_essay_Xtrain = np.vstack(avg_w2v_vectors_essays_Xtrain)
```

```
print(average_w2v_on_essay_Xtrain.shape)
```

```
(22445, 300)
```

## 7.6. Average Word2Vec encoding of preprocessed_essays on Test Data

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xtest.append(vector)

print(len(avg_w2v_vectors_essays_Xtest))
print(len(avg_w2v_vectors_essays_Xtest[2]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:08<00:00, 2011.42it/s]
```

```
16500
300
```

In [63]:

```
average_w2v_on_essay_Xtest = np.vstack(avg_w2v_vectors_essays_Xtest)
print(average_w2v_on_essay_Xtest.shape)
```

```
(16500, 300)
```

## 7.7. Average Word2Vec encoding of preprocessed_essays on CV Data

In [64]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xcv.append(vector)

print(len(avg_w2v_vectors_essays_Xcv))
print(len(avg_w2v_vectors_essays_Xcv[2]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:05<00:00, 2028.02it/s]
```

```
11055
300
```

300

In [65]:

```
average_w2v_on_essay_Xcv = np.vstack(avg_w2v_vectors_essays_Xcv)
print(average_w2v_on_essay_Xcv.shape)
```

(11055, 300)

## 7.8. Average Word2Vec encoding of preprocessed_titles on Train Data

In [66]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_train['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xtrain.append(vector)

print(len(avg_w2v_vectors_titles_Xtrain))
print(len(avg_w2v_vectors_titles_Xtrain[0]))
```

100%|██████████| 22445/22445 [00:00<00:00, 36576.35it/s]

22445
300

In [67]:

```
average_w2v_on_titles_Xtrain = np.vstack(avg_w2v_vectors_titles_Xtrain)
print(average_w2v_on_titles_Xtrain.shape)
```

(22445, 300)

## 7.9. Average Word2Vec encoding of preprocessed_titles on Test Data

In [68]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_test['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xtest.append(vector)

print(len(avg_w2v_vectors_titles_Xtest))
```

```
print(len(avg_w2v_vectors_titles_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 36125.61it/s]
```

```
16500
300
```

In [69]:

```
average_w2v_on_titles_Xtest = np.vstack(avg_w2v_vectors_titles_Xtest)
print(average_w2v_on_titles_Xtest.shape)
```

```
(16500, 300)
```

## 7.10. Average Word2Vec encoding of preprocessed_titles on CV Data

In [70]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_cv['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xcv.append(vector)

print(len(avg_w2v_vectors_titles_Xcv))
print(len(avg_w2v_vectors_titles_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 38274.73it/s]
```

```
11055
300
```

In [71]:

```
average_w2v_on_titles_Xcv = np.vstack(avg_w2v_vectors_titles_Xcv)
print(average_w2v_on_titles_Xcv.shape)
```

```
(11055, 300)
```

## 7.11. TFIDF weighted Word2Vec encoding of preprocessed_essays on Train Data

In [72]:

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

In [73]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtrain = []; # the avg-w2v for each sentence/review is stored i
n this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 22445/22445 [01:
11<00:00, 312.84it/s]
```

```
22445
300
```

In [74]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtrain)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
```

```
(22445, 300)
```

# 7.12. TFIDF weighted Word2Vec encoding of preprocessed_essays on Test Data

In [75]:

```
# # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
# tfidf_model = TfidfVectorizer()
# tfidf_model.fit(X_test['preprocessed_essays'].values)
# # 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 [76]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtest = []; # the avg-w2v for each sentence/review is stored in
this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
```

```
    tfidf_weighted_w2v_vectors_eassays_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtest))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500 [00:49<00:00, 333.10it/s]
```

```
16500
300
```

In [77]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtest)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
```

```
(16500, 300)
```

## 7.13. TFIDF weighted Word2Vec encoding of preprocessed_essays on CV Data

In [78]:

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

In [79]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xcv.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xcv))
print(len(tfidf_weighted_w2v_vectors_eassays_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055 [00:36<00:00, 303.72it/s]
```

```
11055
300
```

In [80]:

```
tfidf_weighted_w2v_on_essay_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xcv)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
```

```
(11055, 300)
```

## 7.14. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Train Data

In [81]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_titles'].values)
# 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 [82]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xtrain = []; # the avg-w2v for each sentence/review is stored in
this list
for t in tqdm(X_train['preprocessed_titles'].values): # 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 t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtrain))
print(len(tfidf_weighted_w2v_vectors_title_Xtrain[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 22445/22445
[00:01<00:00, 19972.05it/s]
```

```
22445
300
```

In [83]:

```
tfidf_weighted_w2v_on_title_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_title_Xtrain)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
```

```
(22445, 300)
```

## 7.15. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Test Data

In [84]:

```
# # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
# tfidf_model = TfidfVectorizer()
# tfidf_model.fit(X_test['preprocessed_titles'].values)
# # 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.
tfidf_weighted_w2v_vectors_title_Xtest = []; # the avg-w2v for each sentence/review is stored in t
his list
for t in tqdm(X_test['preprocessed_titles'].values): # 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 t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtest))
print(len(tfidf_weighted_w2v_vectors_title_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:01<00:00, 16407.45it/s]
```

```
16500
300
```

In [86]:

```
tfidf_weighted_w2v_on_title_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_title_Xtest)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
```

```
(16500, 300)
```

## 7.16. TFIDF Weighted Word2Vec encoding of preprocessed_titles on CV Data

In [87]:

```
# # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
# tfidf_model = TfidfVectorizer()
# tfidf_model.fit(X_cv['preprocessed_titles'].values)
# # 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 [88]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xcv = []; # the avg-w2v for each sentence/review is stored in thi
s list
for t in tqdm(X_cv['preprocessed_titles'].values): # 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 t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xcv.append(vector)
```

```
print(len(tfidf_weighted_w2v_vectors_title_Xcv))
print(len(tfidf_weighted_w2v_vectors_title_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 15712.21it/s]
```

```
11055
300
```

In [89]:

```
tfidf_weighted_w2v_on_title_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_title_Xcv)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
```

```
(11055, 300)
```

# 8. Encoding of Numerical Data

## 8.1. Encoding of price on Train,Test and CV data

In [90]:

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


scalar = MinMaxScaler()

price_standardized_Xtrain = scalar.fit_transform(X_train['price'].values.reshape(-1, 1))
price_standardized_Xtest = scalar.transform(X_test['price'].values.reshape(-1,1))
price_standardized_Xcv = scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

In [91]:

```
price_standardized_Xtrain
```

Out[91]:

```
array([[0.0084564 ],
       [0.02172761],
       [0.01587964],
       ...,
       [0.02642939],
       [0.00493382],
       [0.03008499]])
```

In [92]:

```
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

## 8.4. Encoding of quantity on Train,Test and CV data

In [93]:

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

```
from sklearn.preprocessing import MinMaxScaler

scalar = MinMaxScaler()

quantity_standardized_Xtrain = scalar.fit_transform(X_train['quantity'].values.reshape(-1, 1))
quantity_standardized_Xtest = scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_Xcv = scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
```

In [94]:

```
quantity_standardized_Xtrain
```

Out[94]:

```
array([[0.00222469],
       [0.01112347],
       [0.07341491],
       ...,
       [0.00889878],
       [0.00222469],
       [0.02558398]])
```

In [95]:

```
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

## 8.7. Encoding of teacher_number_of_previously_posted_projects on Train,Test and CV data

In [96]:

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

scalar = MinMaxScaler()

# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_Xtrain = scalar.fit_transform(X_train['t
eacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xtest =
scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xcv =
scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
```

In [97]:

```
teacher_number_of_previously_posted_projects_standardized_Xtrain
```

Out[97]:

```
array([[0.00487805],
       [0.        ],
       [0.02926829],
       ...,
       [0.00243902],
       [0.00487805],
       [0.00243902]])
```

In [98]:

```
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
```

```
print(teacher_number_of_previously_posted_projects_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

# 9. Printing Dimensions of all Preprocessed Data

In [99]:

```
print(categories_one_hot_Xtrain.shape)
print(categories_one_hot_Xtest.shape)
print(categories_one_hot_Xcv.shape)
print(sub_categories_one_hot_Xtrain.shape)
print(sub_categories_one_hot_Xtest.shape)
print(sub_categories_one_hot_Xcv.shape)
print(school_state_one_hot_Xtrain.shape)
print(school_state_one_hot_Xtest.shape)
print(school_state_one_hot_Xcv.shape)
print(teacher_prefix_one_hot_Xtrain.shape)
print(teacher_prefix_one_hot_Xtest.shape)
print(teacher_prefix_one_hot_Xcv.shape)
print(grade_one_hot_Xtrain.shape)
print(grade_one_hot_Xtest.shape)
print(grade_one_hot_Xcv.shape)
print(text_bow_Xtrain.shape)
print(text_bow_Xtest.shape)
print(text_bow_Xcv.shape)
print(title_bow_Xtrain.shape)
print(title_bow_Xtest.shape)
print(title_bow_Xcv.shape)
print(text_tfidf_Xtrain.shape)
print(text_tfidf_Xtest.shape)
print(text_tfidf_Xcv.shape)
print(title_tfidf_Xtrain.shape)
print(title_tfidf_Xtest.shape)
print(title_tfidf_Xcv.shape)
print(average_w2v_on_essay_Xtrain.shape)
print(average_w2v_on_essay_Xtest.shape)
print(average_w2v_on_essay_Xcv.shape)
print(average_w2v_on_titles_Xtrain.shape)
print(average_w2v_on_titles_Xtest.shape)
print(average_w2v_on_titles_Xcv.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xcv .shape)
```

```
(22445, 9)
(16500, 9)
(11055, 9)
(22445, 30)
(16500, 30)
(11055, 30)
(22445, 51)
(16500, 51)
(11055, 51)
(22445, 5)
(16500, 5)
(11055, 5)
(22445, 4)
(16500, 4)
(11055, 4)
(22445, 11969)
(16500, 11969)
(11055, 11969)
(22445, 2032)
(16500, 2032)
(11055, 2032)
(22445, 11969)
(16500, 11969)
(11055, 11969)
(22445, 2032)
(16500, 2032)
(11055, 2032)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 1)
(16500, 1)
(11055, 1)
(22445, 1)
(16500, 1)
(11055, 1)
(22445, 1)
(16500, 1)
(11055, 1)
```

# 10. Creating Different Sets of Data for Training Model

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

In [100]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain1 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,text_bow_Xtrain,title_bow_Xtrain
)).tocsr()
Xtest1 = hstack((categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest,
teacher_prefix_one_hot_Xtest,
grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previous
ly_posted_projects_standardized_Xtest,text_bow_Xtest,title_bow_Xtest)).tocsr()
Xcv1 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,text_bow_Xcv,title_bow_Xcv)).tocsr()
```

```
viously_posted_projects_standardized_Xcv,text_bow_Xcv,title_bow_Xcv)).tocsr()

print(Xtrain1.shape,y_train.shape)
print(Xtest1.shape,y_test.shape)
print(Xcv1.shape,y_cv.shape)
```

```
(22445, 14103) (22445,)
(16500, 14103) (16500,)
(11055, 14103) (11055,)
```

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

In [101]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain2 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,text_tfidf_Xtrain,title_tfidf_Xtr
ain)).tocsr()
Xtest2 = hstack((categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest,
teacher_prefix_one_hot_Xtest,
grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previous
ly_posted_projects_standardized_Xtest,text_tfidf_Xtest,title_tfidf_Xtest)).tocsr()
Xcv2 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,text_tfidf_Xcv,title_tfidf_Xcv)).tocsr()

print(Xtrain2.shape,y_train.shape)
print(Xtest2.shape,y_test.shape)
print(Xcv2.shape,y_cv.shape)
```

```
(22445, 14103) (22445,)
(16500, 14103) (16500,)
(11055, 14103) (11055,)
```

# Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)

In [102]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain3 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,average_w2v_on_essay_Xtrain,aver
age_w2v_on_titles_Xtrain)).tocsr()
Xtest3 = hstack((categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest,
teacher_prefix_one_hot_Xtest,
grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previous
ly_posted_projects_standardized_Xtest,average_w2v_on_essay_Xtest,average_w2v_on_titles_Xtest)).toc
sr()
Xcv3 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,average_w2v_on_essay_Xcv,average_w2v_on_titles_Xcv)).tocs
r()

print(Xtrain3.shape,y_train.shape)
print(Xtest3.shape,y_test.shape)
print(Xcv3.shape,y_cv.shape)
```

```
(22445, 702) (22445,)
(16500, 702) (16500,)
(11055, 702) (11055,)
```

## Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

In [103]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain4 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,tfidf_weighted_w2v_on_essay_matri
_Xtrain,tfidf_weighted_w2v_on_title_matrix_Xtrain)).tocsr()
Xtest4 = hstack((categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest,
teacher_prefix_one_hot_Xtest,
grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previous
ly_posted_projects_standardized_Xtest,tfidf_weighted_w2v_on_essay_matrix_Xtest,tfidf_weighted_w2v_o
n_title_matrix_Xtest)).tocsr()
Xcv4 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,tfidf_weighted_w2v_on_essay_matrix_Xcv,tfidf_weighted_w2v_
on_title_matrix_Xcv)).tocsr()

print(Xtrain4.shape,y_train.shape)
print(Xtest4.shape,y_test.shape)
print(Xcv4.shape,y_cv.shape)
```

```
(22445, 702) (22445,)
(16500, 702) (16500,)
(11055, 702) (11055,)
```

In [ ]:

```
```

In [ ]:

```
```

# 11. Appling Decision Tree on different kind of featurization

## 11.1. Applying Decision Trees on BOW, SET 1

## Function for predicting Target values Batchwise

In [107]:

```
# def batch_predict(clf, data):
#     # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the po
sitive 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 tr_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
#     if data.shape[0]%1000 !=0:
#         y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

#     return y_data_pred
```

## 11.1.1. Finding The Best Hyperparameter "max_depth" and "min_samples_split"

In [170]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb


DT = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth':(1,5,10,50,100,500) , 'min_samples_split':(5,10,100,500)}
DTREE = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=True)
DTREE.fit(Xtrain1, y_train)
print(DTREE.best_estimator_)
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

## 11.1.2. Creating Data For Heatmap

In [171]:

```
DTREE = pd.DataFrame.from_dict(DTREE.cv_results_)
```

In [172]:

```
# DTREE = pd.DataFrame(DTREE.cv_results_)
```

In [173]:

```
DTREE.head()
```

Out[173]:

| | mean_fit_time | std_fit_time | mean_score_time | std_score_time | param_max_depth | param_min_samples_split | params | split |
|---|---|---|---|---|---|---|---|---|
| **0** | 0.191485 | 0.049815 | 0.015628 | 5.234360e-06 | 1 | 5 | {'max_depth': 1, 'min_samples_split': 5} | |
| **1** | 0.162516 | 0.007784 | 0.011922 | 3.071434e-03 | 1 | 10 | {'max_depth': 1, 'min_samples_split': 10} | |
| **2** | 0.156255 | 0.000011 | 0.015601 | 9.989584e-07 | 1 | 100 | {'max_depth': 1, 'min_samples_split': 100} | |
| **3** | 0.156248 | 0.000009 | 0.015632 | 5.939766e-06 | 1 | 500 | {'max_depth': 1, 'min_samples_split': 500} | |
| **4** | 0.609346 | 0.012748 | 0.015631 | 6.899965e-06 | 5 | 5 | {'max_depth': 5, 'min_samples_split': 5} | |

In [174]:

```
max_scores_bow = DTREE.groupby(['param_min_samples_split',
                                'param_max_depth']).max()
```

In [175]:

```
max_scores_bow.head()
```

Out[175]:

| | | mean_fit_time | std_fit_time | mean_score_time | std_score_time | params | split0_t |
|---|---|---|---|---|---|---|---|
| **param_min_samples_split** | **param_max_depth** | | | | | | |
| **5** | **1** | 0.191485 | 0.049815 | 0.015628 | 5.234360e-06 | {'max_depth': 1, 'min_samples_split': 5} | |
| | **5** | 0.609346 | 0.012748 | 0.015631 | 6.899965e-06 | {'max_depth': 5, 'min_samples_split': 5} | |
| | **10** | 2.171725 | 0.132587 | 0.015634 | 8.050722e-06 | {'max_depth': 10, 'min_samples_split': 5} | |
| | **50** | 8.442153 | 0.194873 | 0.020832 | 7.363392e-03 | {'max_depth': 50, 'min_samples_split': 5} | |
| | **100** | 11.686723 | 0.232082 | 0.015625 | 3.893359e-07 | {'max_depth': 100, 'min_samples_split': 5} | |

In [176]:

```
max_scores_bow = max_scores_bow.unstack()[['mean_test_score', 'mean_train_score']]
```

In [177]:

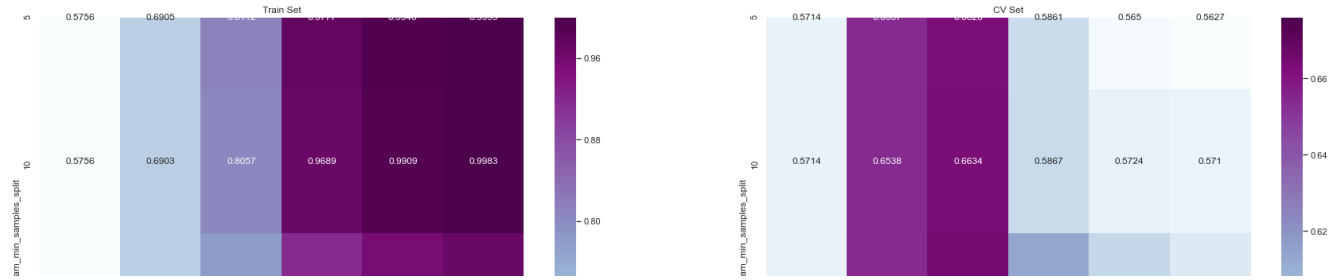
```
max_scores_bow.head()
```

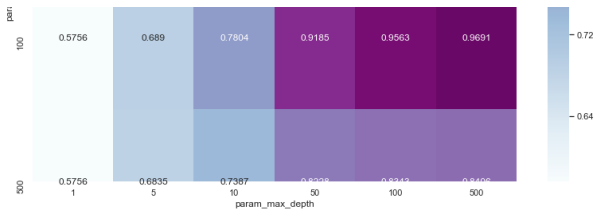
Out[177]:

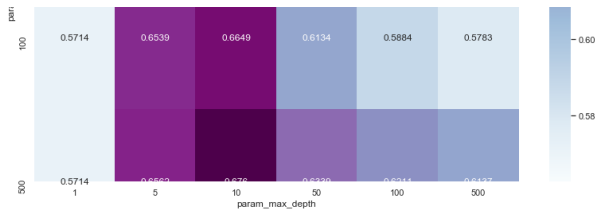
| | **mean_test_score** | | | | | | **mean_train_score** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **param_max_depth** | **1** | **5** | **10** | **50** | **100** | **500** | **1** | **5** | **10** | **50** | **100** |
| **param_min_samples_split** | | | | | | | | | | | |
| **5** | 0.571393 | 0.653745 | 0.662842 | 0.586147 | 0.564988 | 0.562682 | 0.575635 | 0.690545 | 0.811215 | 0.977670 | 0.99477 |
| **10** | 0.571393 | 0.653823 | 0.663438 | 0.586661 | 0.572425 | 0.570970 | 0.575635 | 0.690257 | 0.805745 | 0.968920 | 0.99085 |
| **100** | 0.571393 | 0.653899 | 0.664873 | 0.613356 | 0.588389 | 0.578317 | 0.575635 | 0.689041 | 0.780447 | 0.918518 | 0.95633 |
| **500** | 0.571393 | 0.656189 | 0.675952 | 0.633867 | 0.621117 | 0.613681 | 0.575635 | 0.683540 | 0.738674 | 0.822785 | 0.83428 |

In [178]:

```
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_bow.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_bow.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```





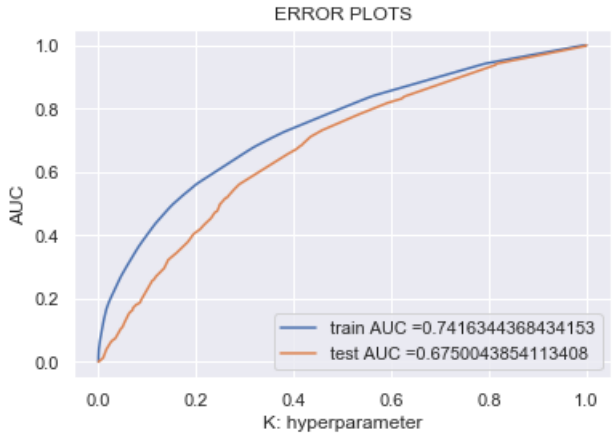

## 11.1.3. Testing the performance of the model on test data, plotting ROC Curves

In [179]:

```
best_parameters_bow = [{'max_depth':[10], 'min_samples_split':[500] } ]
```

In [180]:

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


DT1 = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10, min_samples_split=500)
DT1.fit(Xtrain1, 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_bow = DT1.predict_proba(Xtrain1)[:,1]
y_test_pred_bow = DT1.predict_proba(Xtest1)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_bow)

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(True)
plt.show()
```




## 11.1.4. Building Confusion matrix

In [181]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

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

In [182]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_bow, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_bow, best_t)))
```

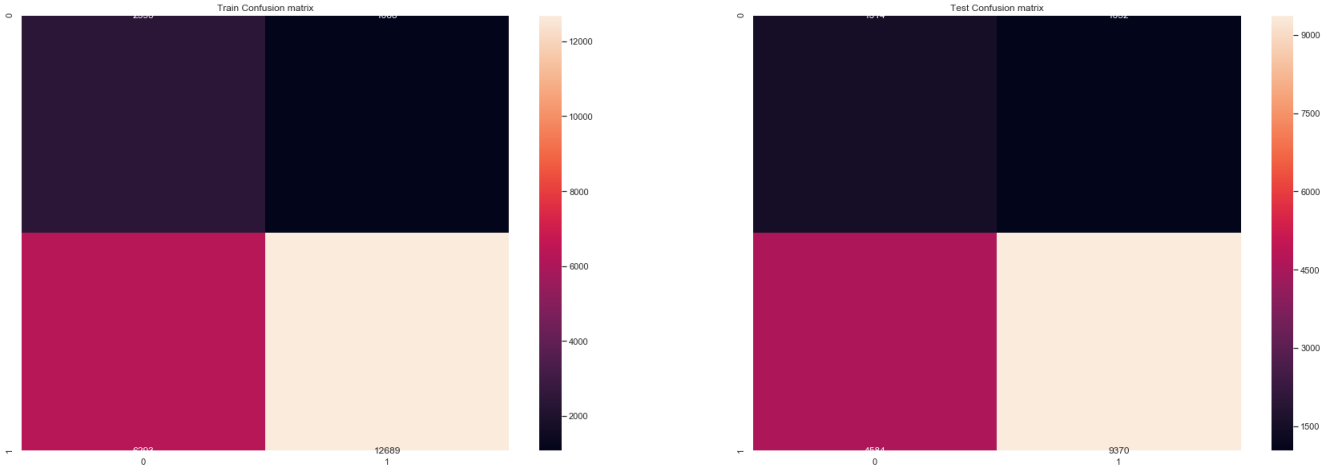
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.46231550031759505 for threshold 0.495
Train confusion matrix
[[ 2395  1068]
 [ 6293 12689]]
Test confusion matrix
[[1514 1032]
 [4584 9370]]
```

In [183]:

```
confusion_matrix_train_bow = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_bow, best_t)))
confusion_matrix_test_bow = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_bow, best_t)))
```

In [184]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_bow,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_bow,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



## 11.1.5. Extracting False Positive

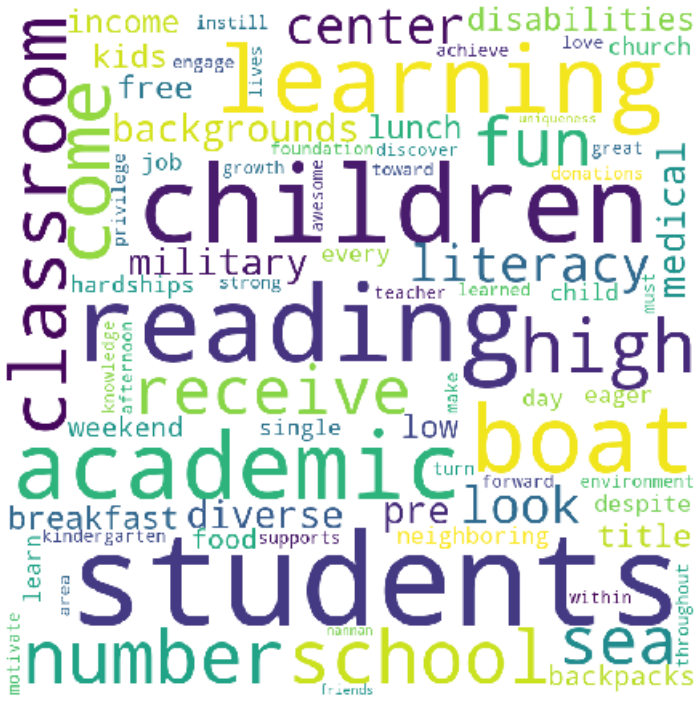
In [185]:

```
FalsePositive_bow = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions_of_y[i] == 1) :
        FalsePositive_bow.append(i)
fp_essay_bow = []
for i in FalsePositive_bow :
    fp_essay_bow.append(X_test['preprocessed_essays'].values[i])
```

## 11.1.6. Word Cloud

In [186]:

```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay_bow :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```




In [187]:

```
cols = X_test.columns

X_test_falsePos_bow = pd.DataFrame(columns=cols)

for i in FalsePositive_bow :   #indexes of false positive points
```

```
        X_test_falsePos_bow = X_test_falsePos_bow.append(X_test.filter(items=[i], axis=0))
```

In [188]:

```
cols
```

Out[188]:

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

In [189]:

```
X_test_falsePos_bow.head()
```

Out[189]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | project_submitted_datetime | project_essay_1 |
|---|---|---|---|---|---|---|---|
| **8** | 112489 | p045029 | 487448f5226005d08d36bdd75f095b31 | Mrs. | SC | 2016-09-25 17:00:26 | My students are enthusiastic and inquisitive l... |
| **110** | 48513 | p105695 | 556f373fb3af0e85aa8ea8d19a72dbae | Ms. | LA | 2016-07-16 19:49:34 | We begin our day hanging our booksacks and tak... |
| **232** | 88732 | p054552 | ea528e57aaed6353d1665e7d54a22f7b | Ms. | IN | 2016-10-19 14:28:50 | Each day, the students at my school come full ... |
| **323** | 40195 | p068184 | 22770595aaf1bd535156c9286d612b82 | Ms. | WI | 2017-03-23 16:43:47 | My amazing 3, 4 and 5 year-olds are so fun to ... |
| **411** | 158475 | p147795 | 5c57ca197966faa9daf958ce52f138d4 | Mrs. | OH | 2016-05-15 20:00:29 | Every morning we start our \"rug time\" with c... |

In [190]:

```
print(X_test_falsePos_bow.shape)
```

```
(348, 19)
```

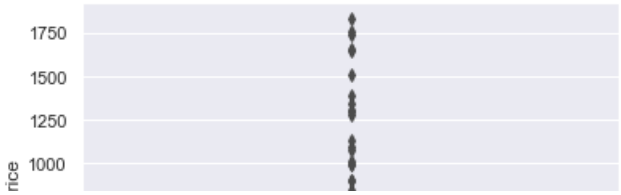
# 11.1.7. Boxplot for 'price' Data

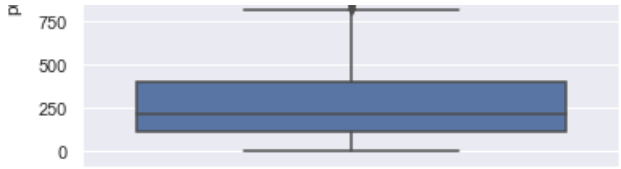
In [191]:

```
sns.boxplot(y='price', data=X_test_falsePos_bow)
```

Out[191]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x259c456ab00>
```

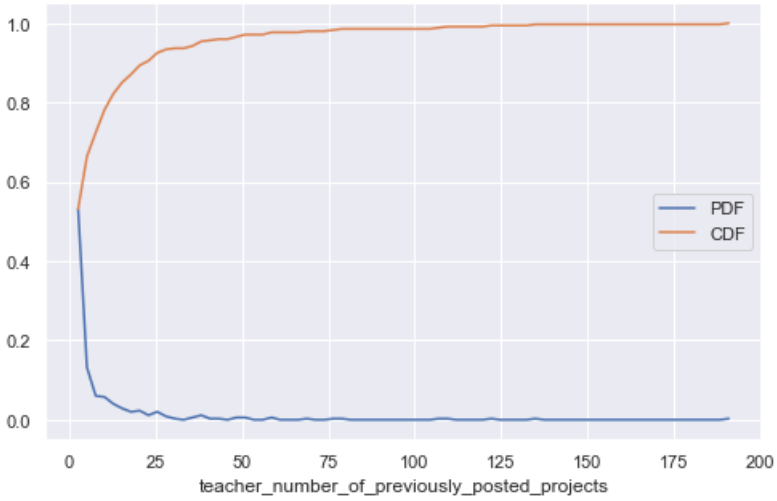





## 11.1.8. PDF and CDF for 'teacher_number_of_previously_posted_projects' data

In [192]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges =
np.histogram(X_test_falsePos_bow['teacher_number_of_previously_posted_projects'],bins='auto', dens
ity=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```




## 11.1.9. Visualizing Decision Tree using Graphviz

In [199]:

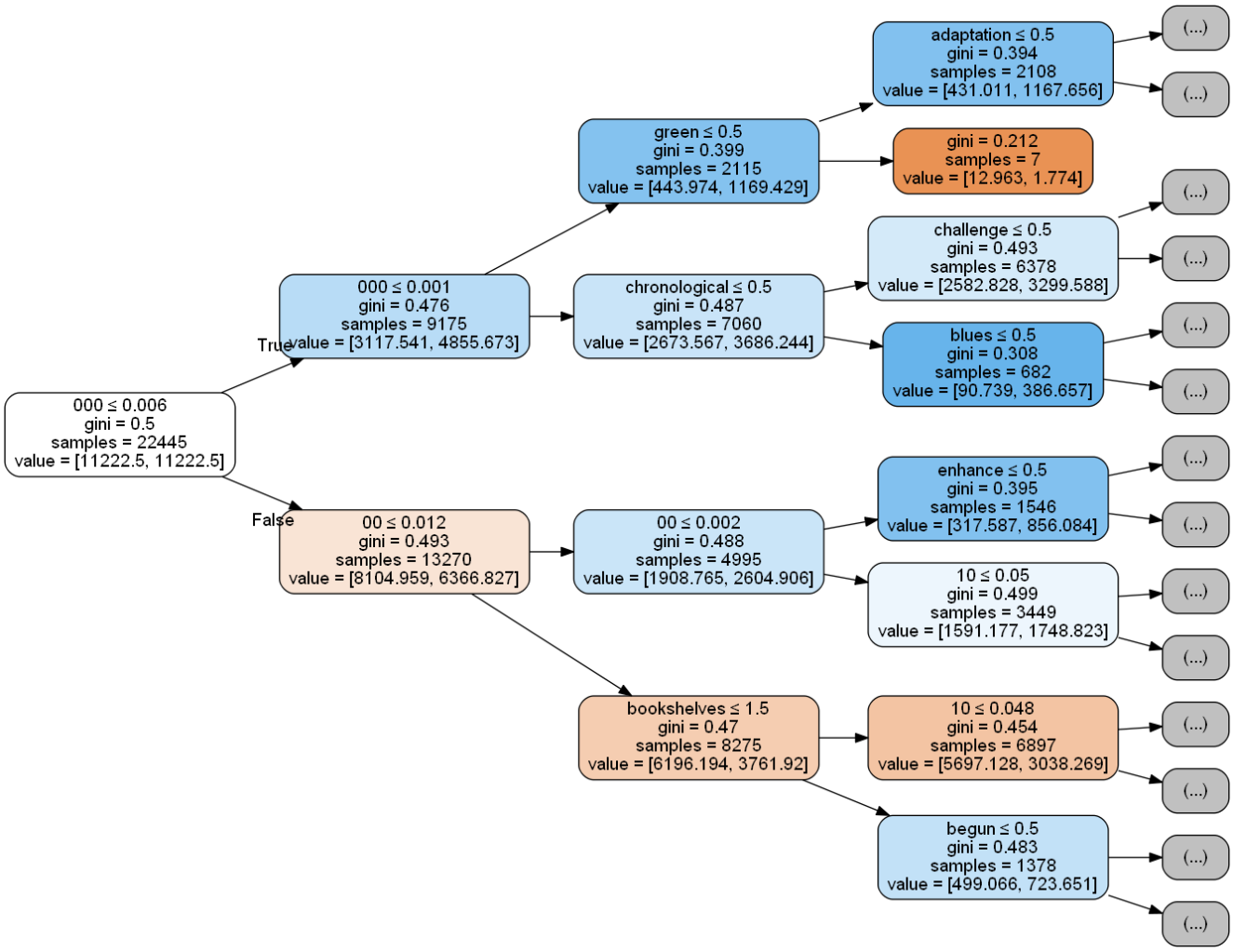
```
#https://stackoverflow.com/questions/32530283/how-to-add-feature-names-to-output-of-decision-tree-
in-scikit-learn
#Feature aggregation
f1=vectorizer1.get_feature_names()        #clean_categories
f2=vectorizer2.get_feature_names()        #clean_subcategories
f3=vectorizer3.get_feature_names()        #school_state
f4=vectorizer4.get_feature_names()        #teacher_prefix
f5=vectorizer5.get_feature_names()        #project_grade_clean_category
f6=vectorizer6.get_feature_names()        #preprocessed_esaays with bow
f7=vectorizer7.get_feature_names()        #preprocessed_titles with bow
f8=vectorizer8.get_feature_names()       #preprocessed_esaays with tfidf
f9=vectorizer9.get_feature_names()       #preprocessed_titles with tfidf

feature_agg_bow = f1 + f2 + f3 + f4 + f5 + f6 + f7
feature_agg_tfidf = f1 + f2 + f3 + f4 + f5 + f8 + f9

feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_number_of_previously_posted_projects')
```

```
feature_agg_tfidf.append('teacher_number_of_previously_posted_projects')
```

In [200]:

```
import os
import graphviz
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from subprocess import call
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
os.environ['PATH'] += os.pathsep+'C:/Program Files (x86)/Graphviz2.38/bin/'
export_graphviz(DT1, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature
_names=feature_agg_bow,rotate=True,max_depth=3)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[200]:




# 11.2. Applying Decision Trees on TFIDF, SET 2

In [104]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb


DT = DecisionTreeClassifier(class_weight = 'balanced')
```

```
parameters = {'max_depth':(1,5,10,50,100,500) , 'min_samples_split':(5,10,100,500)}
DTREE2 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=True)
DTREE2.fit(Xtrain2, y_train)
print(DTREE2.best_estimator_)
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

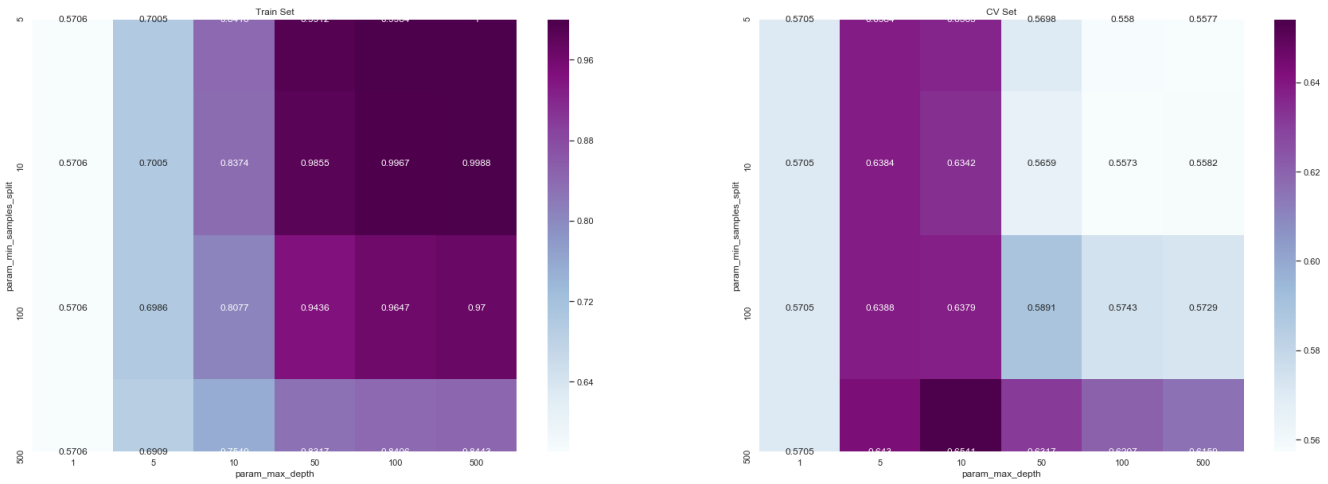
## 11.2.1. Finding The Best Hyperparameter "max_depth" and "min_samples_split"

In [105]:

```
DTREE2 = pd.DataFrame.from_dict(DTREE2.cv_results_)
```

In [106]:

```
max_scores_tfidf = DTREE2.groupby(['param_min_samples_split',
                                   'param_max_depth']).max()
max_scores_tfidf = max_scores_tfidf.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidf.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_tfidf.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```




In [107]:

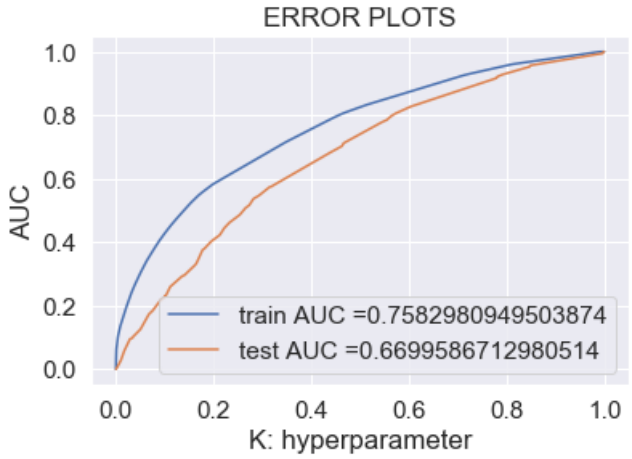
```
best_parameters_tfidf = [{'max_depth':[10], 'min_samples_split':[500] } ]
```

## 11.2.2. Testing the performance of the model on test data, plotting ROC Curves

In [205]:

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

```
DT2 = DecisionTreeClassifier(class_weight = 'balanced', max_depth= 10 ,min_samples_split =  500)
DT2.fit(Xtrain2, 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_tfidf = DT2.predict_proba(Xtrain2)[:,1]
y_test_pred_tfidf = DT2.predict_proba(Xtest2)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf)
sns.set(font_scale = 1.4)
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(True)
plt.show()
```

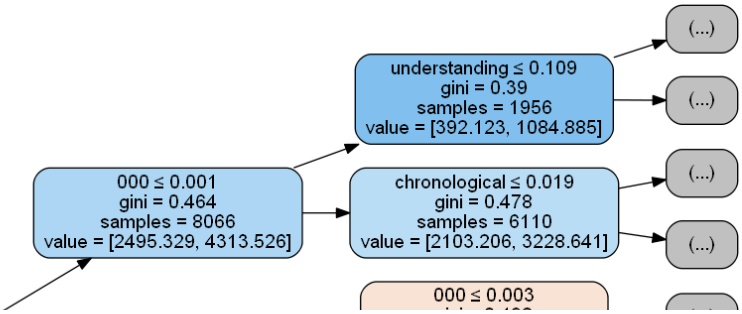


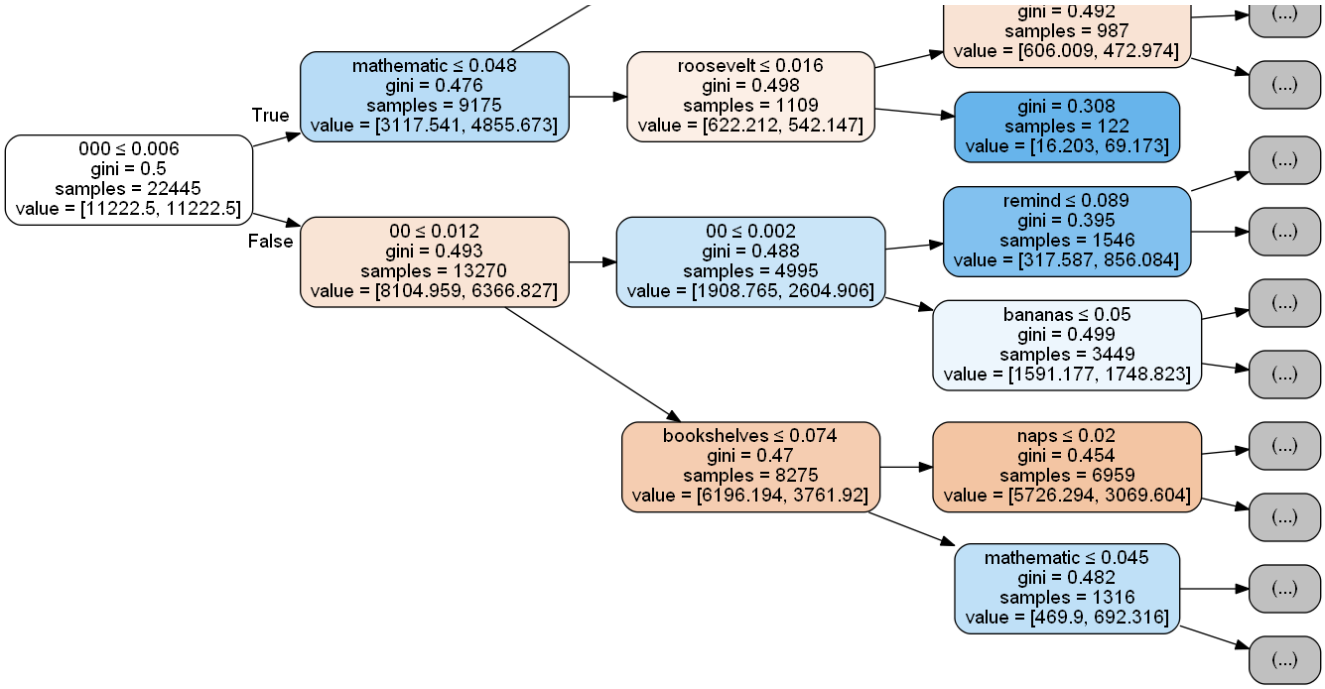

## 11.2.3. Visualizing Decision Tree using Graphviz

In [206]:

```
import os
import graphviz
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from subprocess import call
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
os.environ['PATH'] += os.pathsep+'C:/Program Files (x86)/Graphviz2.38/bin/'
export_graphviz(DT2, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature
_names=feature_agg_tfidf,rotate=True,max_depth=3)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[206]:






# 11.2.4. Buiding Confusion Matrix

In [207]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

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

In [208]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf, best_t)))
```

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

the maximum value of tpr*(1-fpr) 0.46970747520037603 for threshold 0.47
Train confusion matrix
[[ 2362  1101]
 [ 5910 13072]]
Test confusion matrix
[[1432 1114]
 [4449 9505]]
```

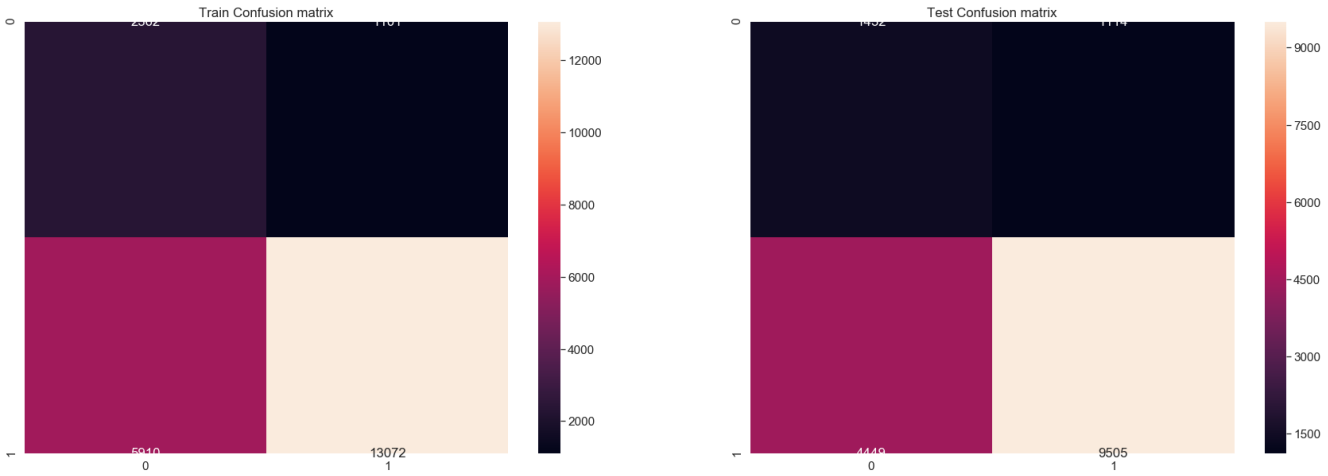
In [209]:

```
confusion_matrix_train_tfidf = pd.DataFrame(confusion_matrix(y_train
```

```
confusion_matrix_train_tfidf = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf, best_t)))
confusion_matrix_test_tfidf = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf, best_t)))
```

In [210]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```




## 11.2.5. Extracting False Positives

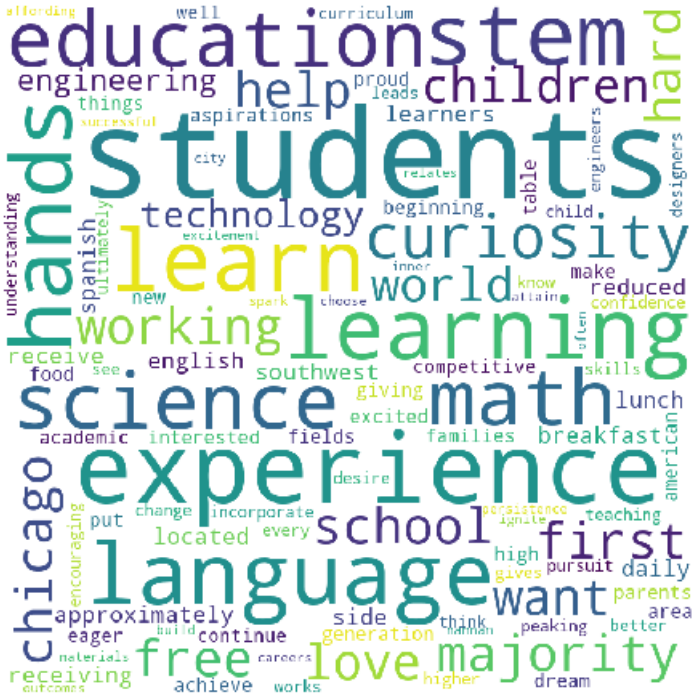
In [211]:

```
FalsePositive_tfidf = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions_of_y[i] == 1) :
        FalsePositive_tfidf.append(i)
fp_essay_tfidf = []
for i in FalsePositive_tfidf :
    fp_essay_tfidf.append(X_test['preprocessed_essays'].values[i])
```

## 11.2.6. Word Cloud

In [212]:

```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay_tfidf :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```




In [213]:

```
cols = X_test.columns
cols
X_test_falsePos = pd.DataFrame(columns=cols)
# get the data of the false positives
for i in FalsePositive_tfidf :
        X_test_falsePos = X_test_falsePos.append(X_test.filter(items=[i], axis=0))
```

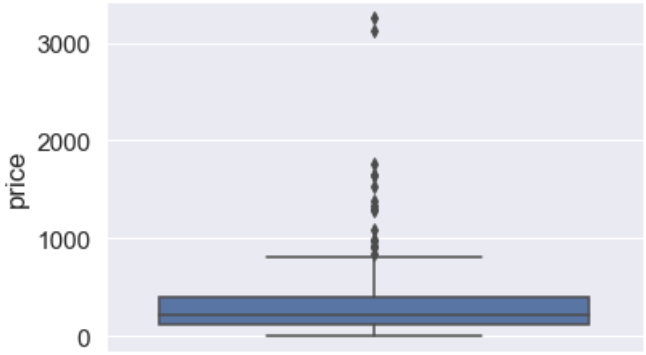
## 11.2.7 Boxplot for 'price' data

In [214]:

```
sns.boxplot(y='price', data=X_test_falsePos)
```

Out[214]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x259c4ec25f8>
```

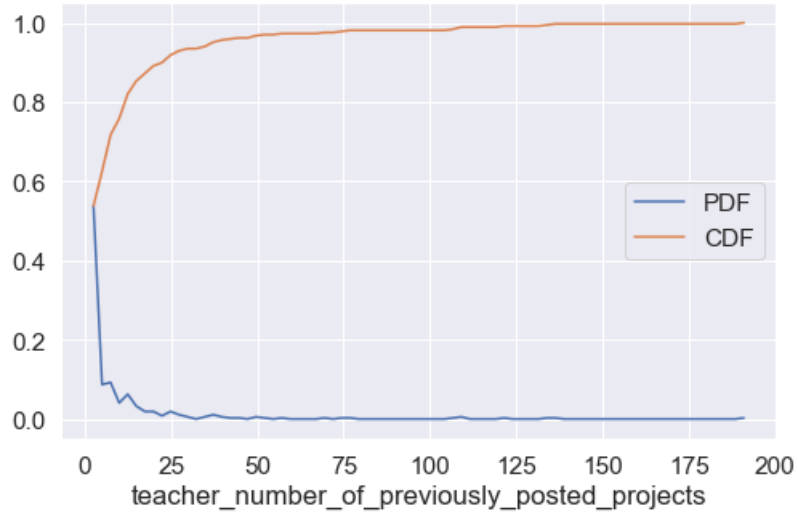



## 11.2.8. PDF and CDF for 'teacher_number_of_previously_posted_projects' data

In [215]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
```

```
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos['teacher_number_of_previously_posted_projects'],b
ins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```




## 11.3. Applying Decision Trees on Average Word2Vec, SET 3

In [168]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb


DT = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth':(1,5,10,50,100,500) , 'min_samples_split':(5,10,100,500)}
DTREE3 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=True)
DTREE3.fit(Xtrain3, y_train)
print(DTREE3.best_estimator_)
```

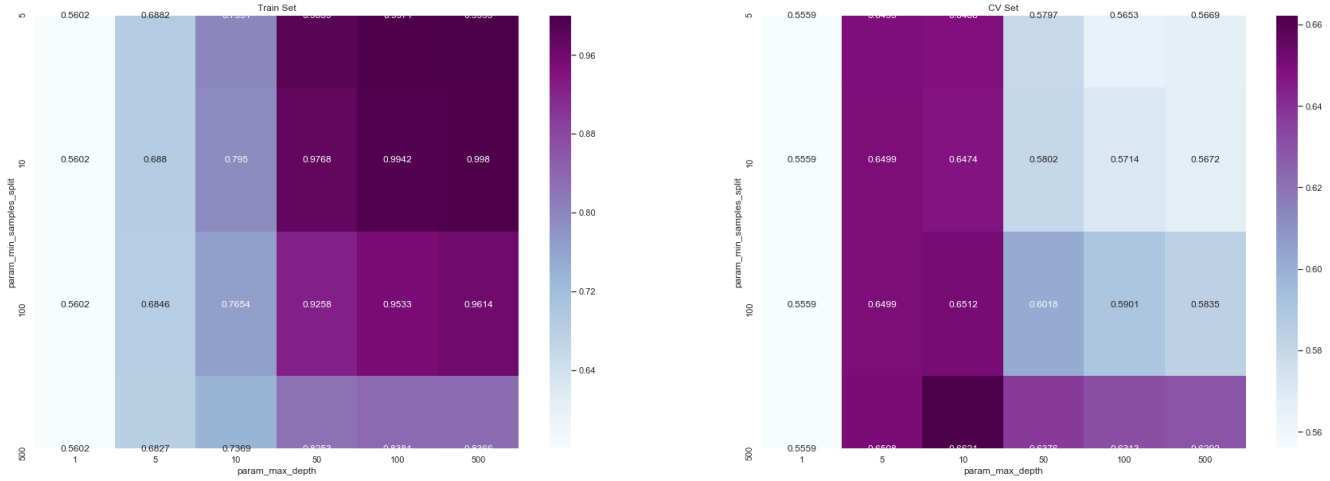
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

### 11.3.1. Finding The Best Hyperparameter "max_depth" and "min_samples_split"

In [169]:

```
DTREE3 = pd.DataFrame(DTREE3.cv_results_)
max_scores_avg_w2v = DTREE.groupby(['param_min_samples_split',
                                   'param_max_depth']).max()
max_scores_avg_w2v = max_scores_avg_w2v.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
```

```
sns.heatmap(max_scores_avg_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_avg_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



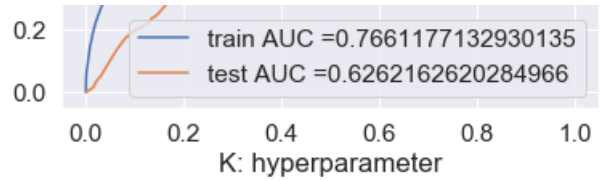

In [185]:

```
best_parameters_avg_w2v = [{'max_depth':[10], 'min_samples_split':[500] } ]
```

## 11.3.2. Testing the performance of the model on test data, plotting ROC Curves

In [219]:

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


DT3 = DecisionTreeClassifier(class_weight = 'balanced', max_depth = 10 ,min_samples_split = 500)
DT3.fit(Xtrain3, 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_avg_w2v = DT3.predict_proba(Xtrain3)[:,1]
y_test_pred_avg_w2v = DT3.predict_proba(Xtest3)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avg_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avg_w2v)

sns.set(font_scale = 1.4)
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(True)
plt.show()
```




## 11.3.4. Building Confusion matrix

In [173]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

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

In [174]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_avg_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

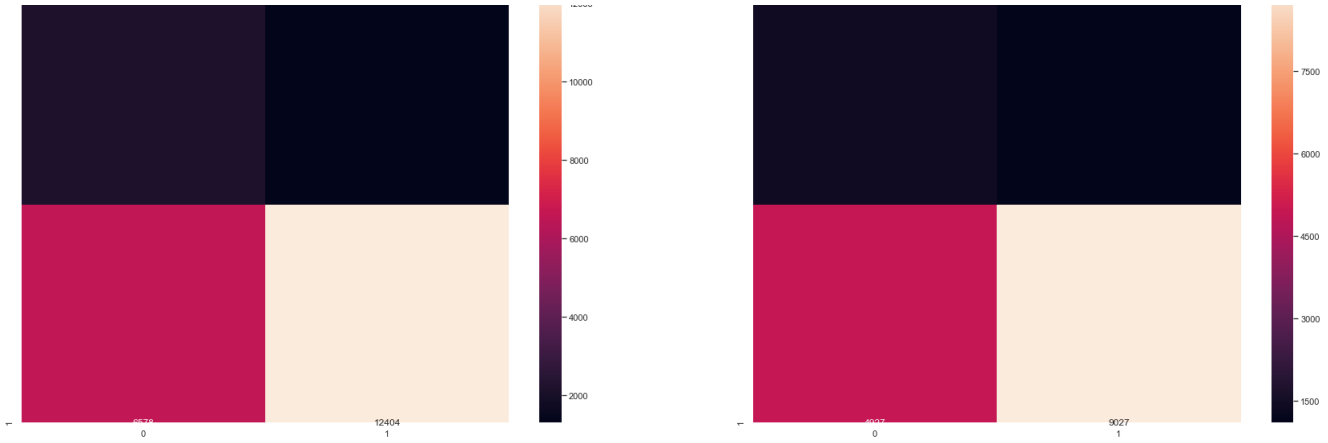
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.40796507583989244 for threshold 0.507
Train confusion matrix
[[ 2162  1301]
 [ 6578 12404]]
Test confusion matrix
[[1441 1105]
 [4927 9027]]
```

In [175]:

```
confusion_matrix_train_avg_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_avg_w2v, best_t)))
confusion_matrix_test_avg_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

In [176]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_avg_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_avg_w2v,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```




## 11.3.5. Extracting False Positives

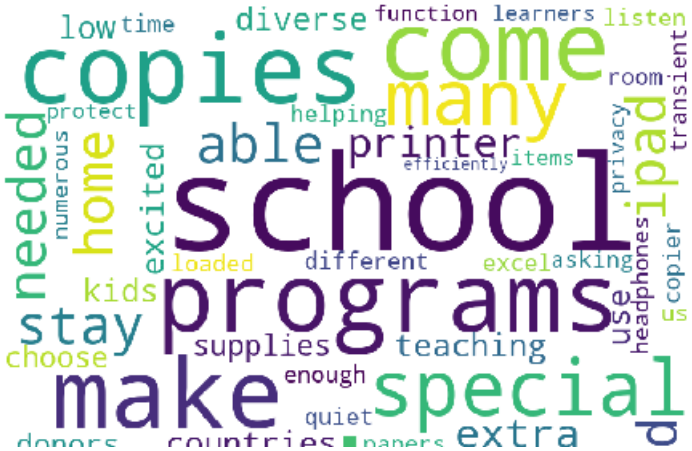
In [177]:

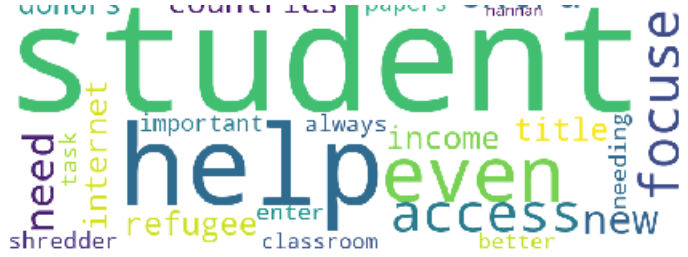
```
FalsePositive_avg_w2v = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions_of_y[i] == 1) :
        FalsePositive_avg_w2v.append(i)
fp_essay_avg_w2v = []
for i in FalsePositive_avg_w2v :
    fp_essay_avg_w2v.append(X_test['preprocessed_essays'].values[i])
```

## 11.3.6. Word Cloud

In [178]:

```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay_avg_w2v :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```






In [179]:

```
cols = X_test.columns
cols
X_test_falsePos = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in FalsePositive_avg_w2v : # (in fpi all the false positives data points indexes)
        X_test_falsePos = X_test_falsePos.append(X_test.filter(items=[i], axis=0))
```

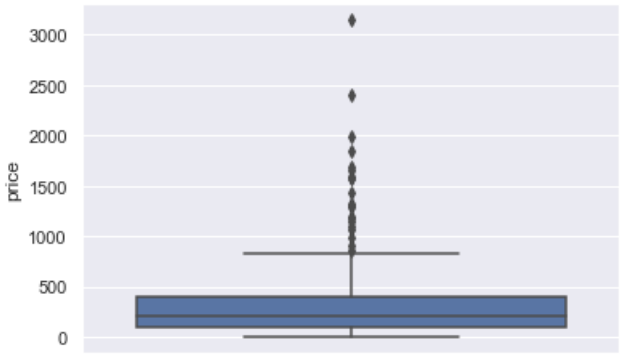
## 11.3.7. Box Plot for 'price' data

In [180]:

```
sns.boxplot(y='price', data=X_test_falsePos)
```

Out[180]:

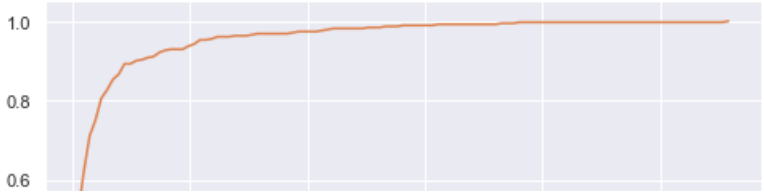
```
<matplotlib.axes._subplots.AxesSubplot at 0x1e20c476f60>
```

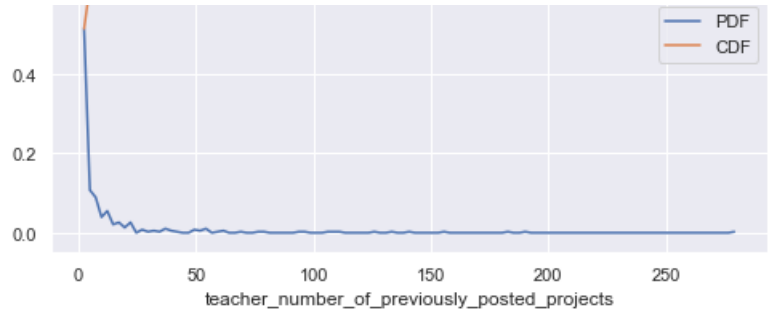



## 11.3.8. PDF and CDF for 'teacher_number_of_previously_posted_projects' data

In [181]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos['teacher_number_of_previously_posted_projects'],b
ins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```






In [ ]:

```
```

# 11.4. Applying Decision Trees on Weighted TFIDF Word2Vec, SET 4

In [182]:

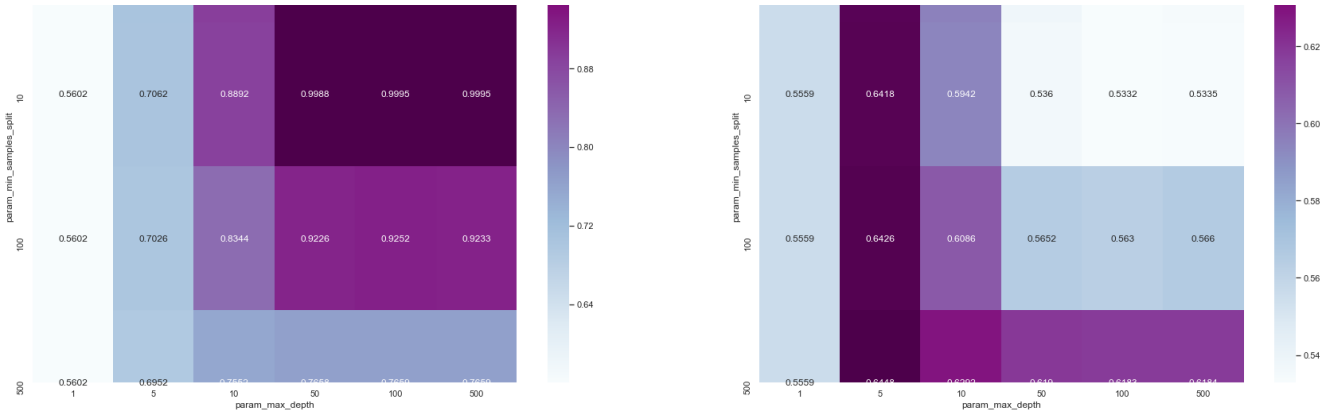
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb


DT = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth':(1,5,10,50,100,500) , 'min_samples_split':(5,10,100,500)}
DTREE4 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=True)
DTREE4.fit(Xtrain4, y_train)
print(DTREE4.best_estimator_)
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

# 11.4.1. Finding The Best Hyperparameter "max_depth" and "min_samples_split"

In [183]:

```
DTREE4 = pd.DataFrame(DTREE4.cv_results_)
max_scores_tfidff_weighted_w2v = DTREE4.groupby(['param_min_samples_split',
                                     'param_max_depth']).max()
max_scores_tfidff_weighted_w2v = max_scores_tfidff_weighted_w2v.unstack()[['mean_test_score', 'mea
n_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidff_weighted_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu",
ax=ax[0])
sns.heatmap(max_scores_tfidff_weighted_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax
=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



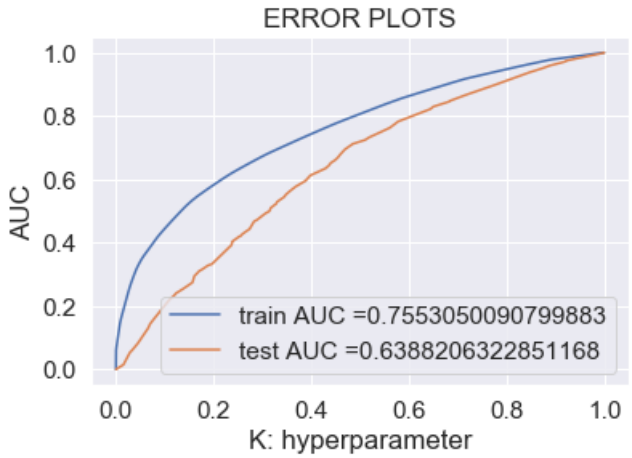

In [196]:

```
best_parameters_tfidff_weighted_w2v = [{'max_depth':[10], 'min_samples_split':[500] } ]
```

## 11.4.2. Testing the performance of the model on test data, plotting ROC Curves

In [220]:

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


DT4 = DecisionTreeClassifier(class_weight = 'balanced', max_depth = 10 ,min_samples_split=500)
DT4.fit(Xtrain4, 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_tfidf_weighted_w2v = DT4.predict_proba(Xtrain4)[:,1]
y_test_pred_tfidf_weighted_w2v = DT4.predict_proba(Xtest4)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_weighted_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_weighted_w2v)
sns.set(font_scale = 1.4)
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(True)
plt.show()
```




## 11.4.3. Building Confusion Matrix

## 11.4.3. Building Confusion Matrix

In [185]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

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

In [186]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

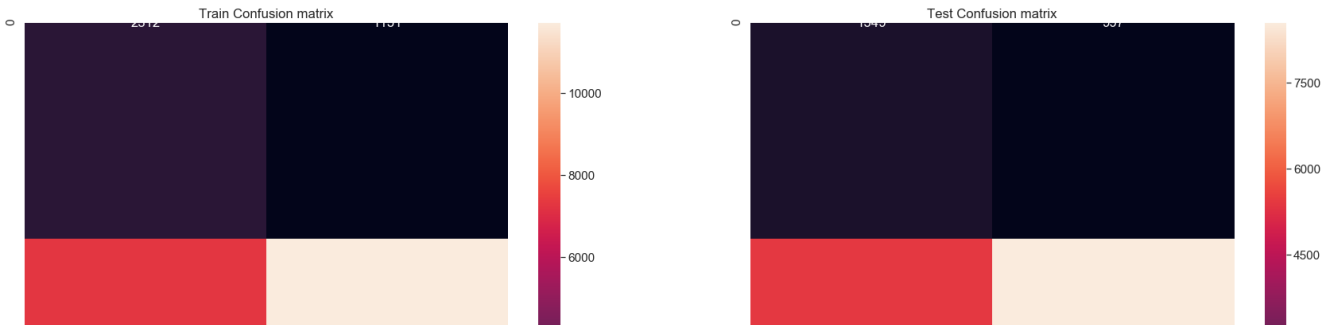
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.4120716457279937 for threshold 0.489
Train confusion matrix
[[ 2312  1151]
 [ 7266 11716]]
Test confusion matrix
[[1549  997]
 [5406 8548]]
```

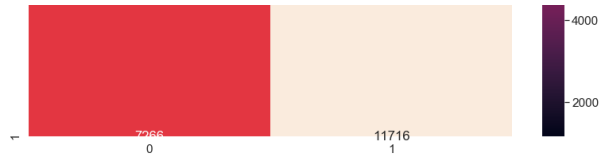
In [187]:

```
confusion_matrix_train_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
confusion_matrix_test_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

In [188]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf_weighted_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf_weighted_w2v,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```







## 11.4.4. Extracting False Positives

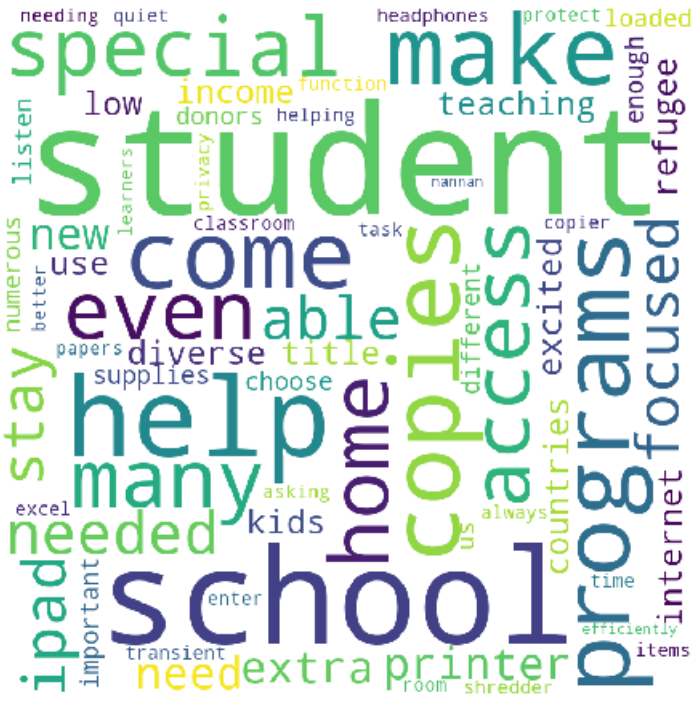
In [189]:

```
FalsePositive_tfidf_weighted_w2v = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions_of_y[i] == 1) :
        FalsePositive_tfidf_weighted_w2v.append(i)
fp_essay_tfidf_weighted_w2v = []
for i in FalsePositive_tfidf_weighted_w2v :
    fp_essay_tfidf_weighted_w2v.append(X_test['preprocessed_essays'].values[i])
```

## 11.4.5. Word Cloud

In [190]:

```
#Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay_tfidf_weighted_w2v :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



In [191]:

```
cols = X_test.columns
cols
X_test_falsePos = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in FalsePositive_tfidf_weighted_w2v : # (in fpi all the false positives data points indexes)
        X_test_falsePos = X_test_falsePos.append(X_test.filter(items=[i], axis=0))
```

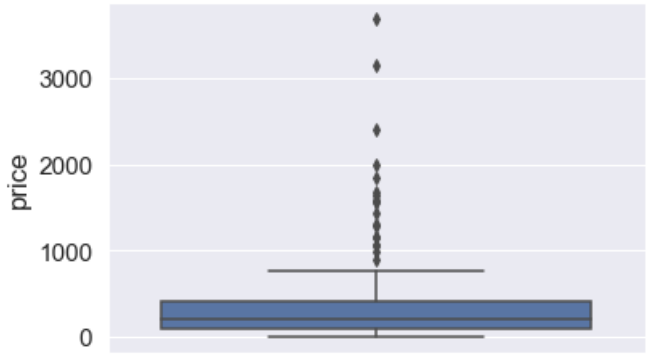
## 11.4.6. Boxplot for 'price' data

In [192]:

```
sns.boxplot(y='price', data=X_test_falsePos)
```

Out[192]:

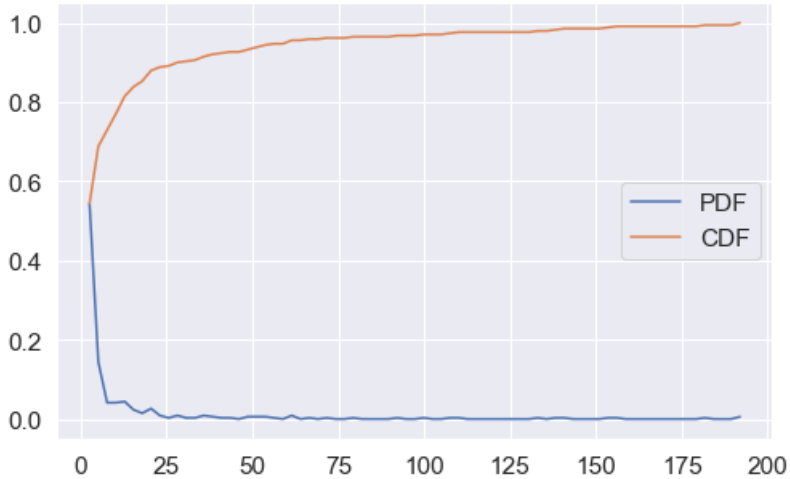
```
<matplotlib.axes._subplots.AxesSubplot at 0x1e20963f208>
```




## 11.4.7. PDF and CDF for 'teacher_number_of_previously_posted_projects' data

In [193]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos['teacher_number_of_previously_posted_projects'],b
ins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



teacher_number_of_previously_posted_projects

# 12. Finding Top 5000 features of SET2 using Decision Trees's Feature*importances*

In [110]:

```
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb
DT = DecisionTreeClassifier(class_weight = "balanced")
DTREE5 = DT.fit(Xtrain2,y_train)
newX = DTREE5.feature_importances_
```

In [111]:

```
newX
```

Out[111]:

```
array([0., 0., 0., ..., 0., 0., 0.])
```

***The above values which we got as 0 means that column is not selected in top 5000***

In [290]:

```
# k = 5000
# ind = DTREE5.feature_importances_.argsort()[-k:][::-1]
# X_train_shortlisted = Xtrain2[:,ind]
```

In [295]:

```
# (X_train_shortlisted.shape)
```

Out[295]:

```
(22445, 5000)
```

# 12.1. Function for returning top 5000 features

In [108]:

```
def bestFeatures(model, X, k=5000):
    return X[:,model.feature_importances_.argsort()[-k:][::-1]]
```

In [112]:

```
Xtrain5 = bestFeatures(DTREE5,Xtrain2,5000)
Xtest5 = bestFeatures(DTREE5, Xtest2, 5000)
Xcv5 = bestFeatures(DTREE5,Xcv2,5000)
print(Xtrain5.shape)
print(Xtest5.shape)
print(Xcv5.shape)
```

```
(22445, 5000)
(16500, 5000)
(11055, 5000)
```

In [113]:

```
print(Xtrain5)
```

```
  (0, 630) 1.0
```

```
  (0, 148) 1.0
  (0, 540) 1.0
  (0, 0) 0.008456403763024662
  (0, 1) 0.0022246941045606225
  (0, 4) 0.004878048780487805
  (0, 4850) 0.09563634909495991
  (0, 436) 0.04386698360456328
  (0, 4945) 0.09363890253003687
  (0, 153) 0.17785161411955164
  (0, 586) 0.07803915652616256
  (0, 253) 0.045216150203112294
  (0, 4011) 0.06662151328724232
  (0, 400) 0.07365440176690831
  (0, 3) 0.04277188755141287
  (0, 387) 0.05689284051182552
  (0, 4808) 0.10236875617477335
  (0, 434) 0.05576055982907345
  (0, 750) 0.0864904416885331
  (0, 687) 0.10696141399750818
  (0, 206) 0.0590880843141432
  (0, 70) 0.0317695466347216
  (0, 14) 0.029136124861913165
  (0, 242) 0.04224318259670466
  (0, 1090) 0.058766757778391 84
  : :
  (22444, 18) 0.07584075499939126
  (22444, 2349) 0.06441667545224858
  (22444, 89) 0.026368098862423636
  (22444, 2092) 0.07102900513595119
  (22444, 2) 0.014228448745647252
  (22444, 63) 0.05474189119382864
  (22444, 37) 0.0787086478555171
  (22444, 249) 0.0669880655127585
  (22444, 541) 0.04433670194058425
  (22444, 53) 0.04252360970438756
  (22444, 511) 0.04741211172546635
  (22444, 338) 0.06626539380649087
  (22444, 164) 0.044146411639400335
  (22444, 7) 0.06850664953619312
  (22444, 341) 0.039319212832911496
  (22444, 332) 0.17312253027798566
  (22444, 190) 0.061958344481997524
  (22444, 118) 0.028056764764216112
  (22444, 883) 0.07503821057241152
  (22444, 138) 0.07647056873149423
  (22444, 232) 0.05125674013522187
  (22444, 90) 0.11299728676731693
  (22444, 330) 0.031880006625219066
  (22444, 26) 0.11086207406349657
  (22444, 106) 0.05458224561995724
```

In [114]:

```
print(Xtrain5.shape)
print(Xtest5.shape)
print(Xcv5.shape)
```

```
(22445, 5000)
(16500, 5000)
(11055, 5000)
```

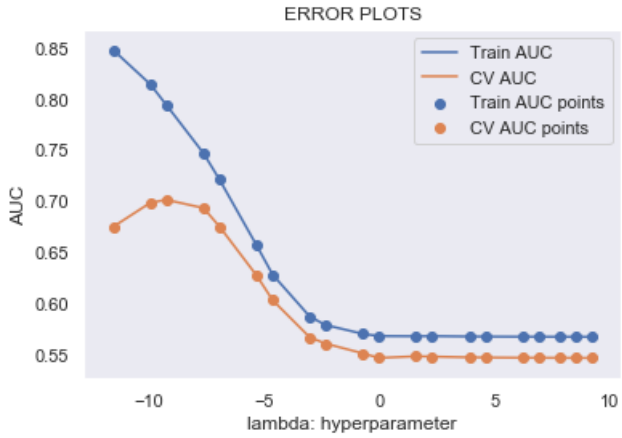
## 12.2. Applying Logistic Regression on Our Top features

In [115]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
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 = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight = 'ba
lanced')
    LR.fit(Xtrain5, y_train)

    y_train_pred_tfidf5 = LR.predict_proba(Xtrain5)[:,1]
    y_cv_pred_tfidf5 = LR.predict_proba(Xcv5)[:,1]

    # 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_tfidf5))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidf5))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

plt.plot(log_alpha, train_auc, label='Train AUC')
plt.plot(log_alpha, cv_auc, label='CV AUC')

plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████| 20/20
[00:04<00:00,  7.53it/s]
100%|██████████| 20/20
[00:00<00:00, 20054.05it/s]
```




In [116]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_set5 = optimal_alpha_cv
print(best_alpha_set5)
```

```
Maximum AUC score of cv is: 0.7014625746859661
Corresponding alpha value of cv is: 0.0001

0.0001
```

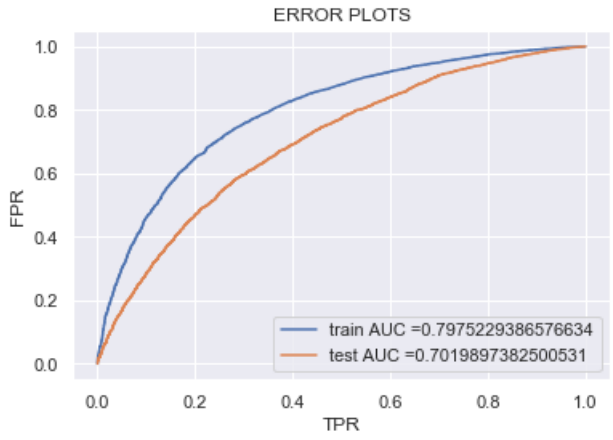
In [117]:

```
# best_alpha = 0.003
```

## 12.3. Testing the performance of the model on test data, plotting ROC Curves

In [118]:

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


LR =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_set5 , max_iter = 1000,class_wei
ght = 'balanced')
LR.fit(Xtrain5, 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_tfidf5 = LR.predict_proba(Xtrain5)[:,1]
y_test_pred_tfidf5 = LR.predict_proba(Xtest5)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf5)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf5)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```




In [119]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

def predict_with_best_t(proba, threshould):
```

```
    predictions = []
    global predictions_of_y
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions_of_y = predictions
    return predictions_of_y
```

In [121]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf5, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf5, best_t)))
```

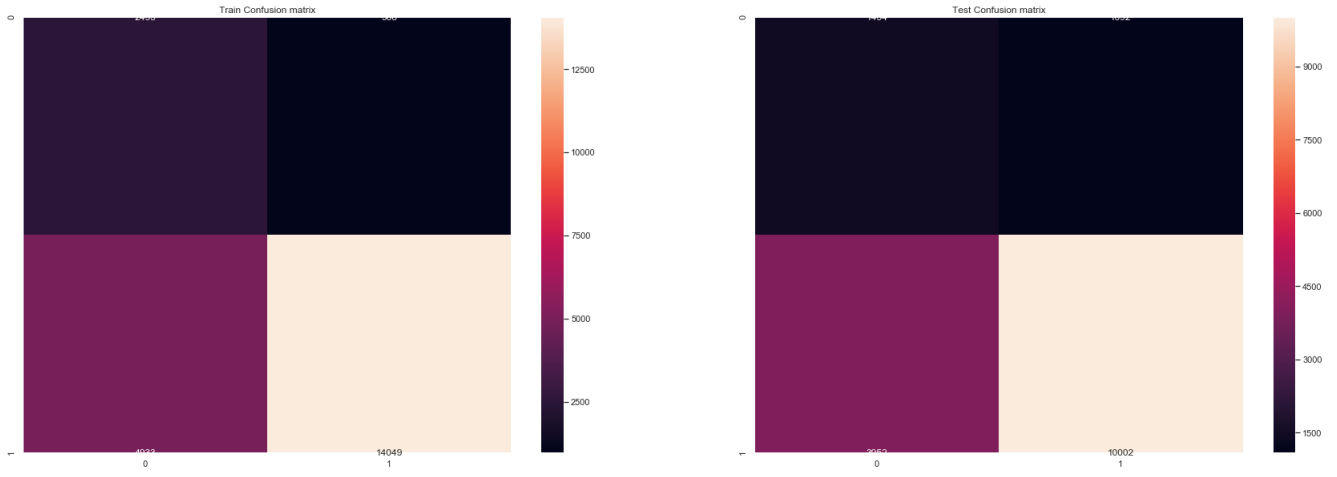
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.5332385046270716 for threshold 0.487
Train confusion matrix
[[ 2495   968]
 [ 4933 14049]]
Test confusion matrix
[[ 1454  1092]
 [ 3952 10002]]
```

In [122]:

```
confusion_matrix_train_lr_set5 = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf5, best_t)))
confusion_matrix_test_lr_set5 = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf5, best_t)))
```

In [124]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_lr_set5,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_lr_set5,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```




## 12.4. Applying Decission Tree on Our Top features

In [125]:

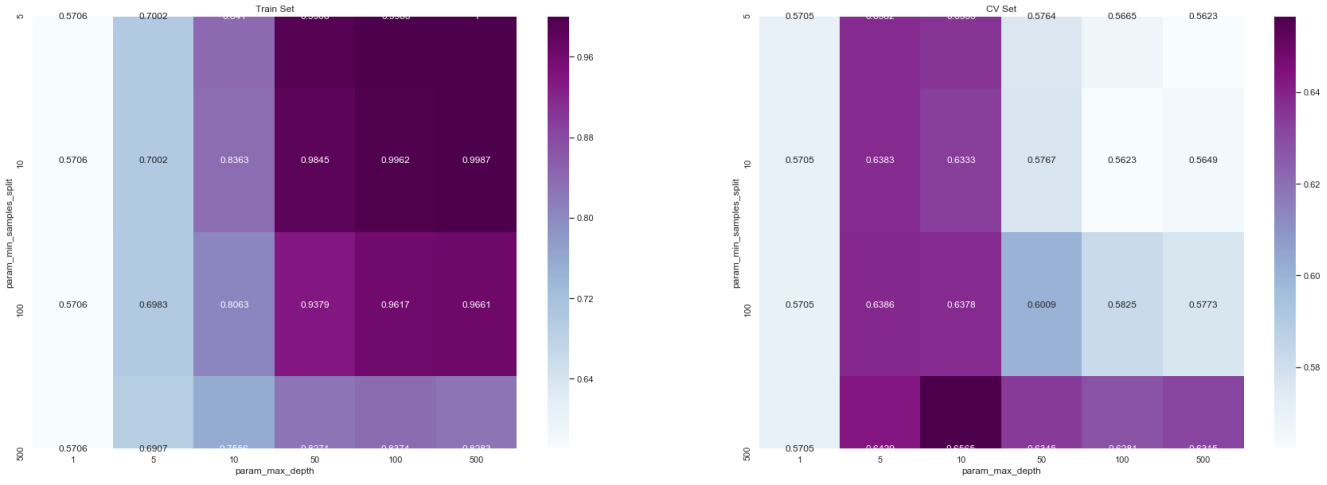
```
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
import seaborn as sb


DT = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth':(1,5,10,50,100,500) , 'min_samples_split':(5,10,100,500)}
DTREE6 = GridSearchCV(DT, parameters, cv=3, scoring='roc_auc',return_train_score=True)
DTREE6.fit(Xtrain5, y_train)
print(DTREE6.best_estimator_)
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

## 12.5. Finding The Best Hyperparameter "max_depth" and "min_samples_split"

In [127]:

```
DTREE6 = pd.DataFrame(DTREE6.cv_results_)
max_scores_5 = DTREE6.groupby(['param_min_samples_split',
                               'param_max_depth']).max()
max_scores_5 = max_scores_5.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_5.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_5.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```

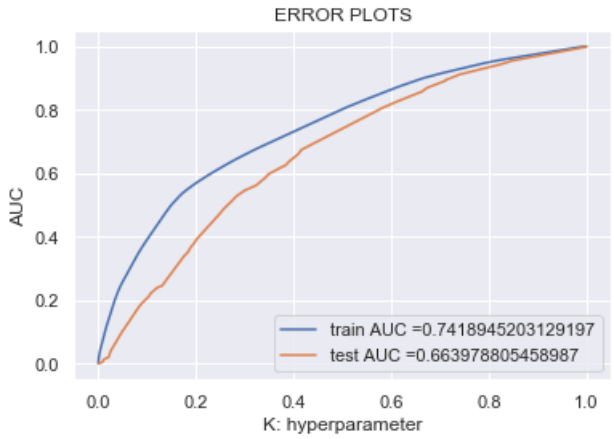



## 12.6. Testing the performance of the model on test data, plotting ROC Curves

In [128]:

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


DT6 = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,min_samples_split=500)
```

```
DT6 = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,min_samples_split=500)
DT6.fit(Xtrain5, 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_set5 = DT6.predict_proba(Xtrain5)[:,1]
y_test_pred_set5 = DT6.predict_proba(Xtest5)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_set5)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_set5)

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(True)
plt.show()
```




## 12.7. Building Confusion Matrix

In [129]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

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

In [130]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_set5, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_set5, best_t)))
```

==========

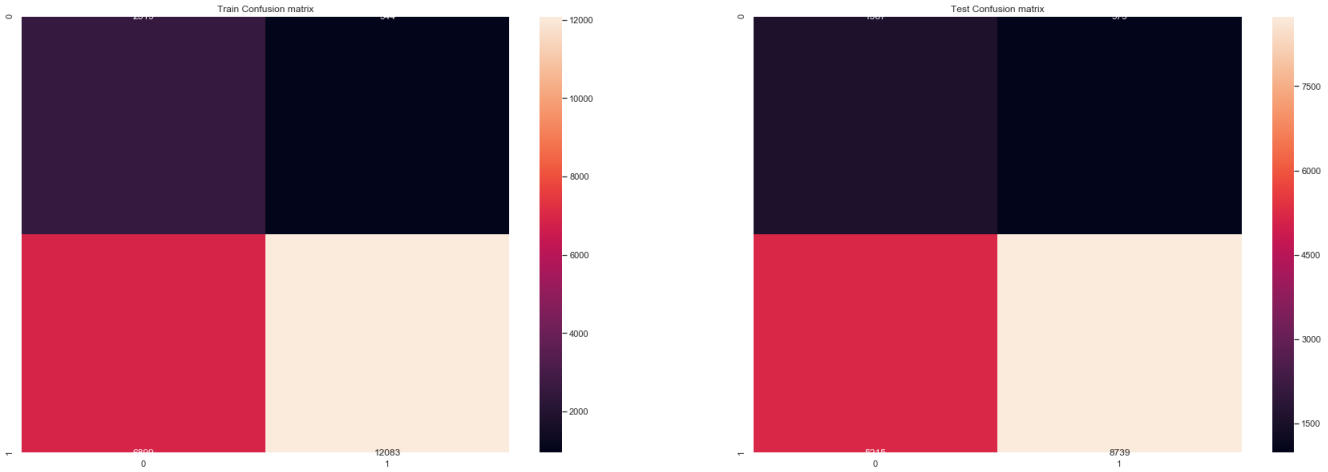
```
the maximum value of tpr*(1-fpr) 0.4630293093753607 for threshold 0.463
Train confusion matrix
[[ 2519   944]
 [ 6899 12083]]
Test confusion matrix
[[1567  979]
 [5215 8739]]
```

In [131]:

```
confusion_matrix_train_set5 = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_set5, best_t)))
confusion_matrix_test_set5 = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_set5, best_t)))
```

In [132]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_set5,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_set5,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```




# 13. Conclusion

In [133]:

```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

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

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Max Depth","Min Sample Split", "Train AUC" , "Test AUC"]

x.add_row(["BOW", "Decision Tree", 10,500, 0.7416,0.6750])
x.add_row(["TFIDF", "Decision Tree", 10,500, 0.7582, 0.6699])
x.add_row(["W2V","Decision Tree", 10,500, 0.7661,0.6262])
x.add_row(["TFIDF W2V","Decision Tree", 10,500, 0.7553, 0.6388])
x.add_row(["SET5","Decision Tree", 10,500, 0.7418, 0.6639])
```

In [134]:

```
from prettytable import PrettyTable

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

```
y = PrettyTable()

y.field_names = ["Vectorizer", "Model", "Alpha", "Train AUC" , "Test AUC"]


y.add_row(["SET5","Logistic Regression", 0.0001, 0.7975, 0.7019])
```

In [135]:

```
print(x)
print(y)
```

```
+------------+---------------+-----------+------------------+-----------+----------+
| Vectorizer |     Model     | Max Depth | Min Sample Split | Train AUC | Test AUC |
+------------+---------------+-----------+------------------+-----------+----------+
|    BOW     | Decision Tree |     10    |       500        |   0.7416  |  0.675   |
|   TFIDF    | Decision Tree |     10    |       500        |   0.7582  |  0.6699  |
|    W2V     | Decision Tree |     10    |       500        |   0.7661  |  0.6262  |
| TFIDF W2V  | Decision Tree |     10    |       500        |   0.7553  |  0.6388  |
|    SET5    | Decision Tree |     10    |       500        |   0.7418  |  0.6639  |
+------------+---------------+-----------+------------------+-----------+----------+
+------------+---------------------+--------+-----------+----------+
| Vectorizer |        Model        | Alpha  | Train AUC | Test AUC |
+------------+---------------------+--------+-----------+----------+
|    SET5    | Logistic Regression | 0.0001 |   0.7975  |  0.7019  |
+------------+---------------------+--------+-----------+----------+
```

In [ ]:

```

```