Apply GBDT on Donors Choose dataset

In [1]:

```
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np

from tqdm import tqdm
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, Normalizer
from sklearn.model_selection import GridSearchCV
from prettytable import PrettyTable
from sklearn.metrics import roc_curve, auc, confusion_matrix
import matplotlib.pyplot as plt
from wordcloud import WordCloud, STOPWORDS

from scipy.sparse import hstack
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
sns.set()

import pickle
import nltk
nltk.download('vader_lexicon')
from nltk.sentiment.vader import SentimentIntensityAnalyzer

from sklearn.svm import LinearSVC
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import expon

from collections import Counter
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
```

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

In [2]:

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

In [3]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
project_data.head(2)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 's
chool_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']
```

Out[3]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

In [4]:

```
project_data.project_is_approved.value_counts()
```

Out[4]:

```
1    92706
0    16542
Name: project_is_approved, dtype: int64
```

In [5]:

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

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

Out[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

In [6]:

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

Out[6]:

```
literacy_language                       23655
math_science                            17072
literacy_language_math_science          14636
health_sports                           10177
music_arts                               5180
specialneeds                             4226
literacy_language_specialneeds           3961
appliedlearning                          3771
math_science_literacy_language           2289
appliedlearning_literacy_language        2191
history_civics                           1851
math_science_specialneeds                1840
literacy_language_music_arts             1757
math_science_music_arts                  1642
appliedlearning_specialneeds             1467
history_civics_literacy_language         1421
health_sports_specialneeds               1391
warmth_care_hunger                       1309
math_science_appliedlearning             1220
appliedlearning_math_science             1052
literacy_language_history_civics          809
health_sports_literacy_language           803
appliedlearning_music_arts                758
math_science_history_civics               652
literacy_language_appliedlearning         636
appliedlearning_health_sports             608
math_science_health_sports                414
history_civics_math_science               322
history_civics_music_arts                 312
specialneeds_music_arts                   302
health_sports_math_science                271
history_civics_specialneeds               252
health_sports_appliedlearning             192
appliedlearning_history_civics            178
health_sports_music_arts                  155
music_arts_specialneeds                   138
literacy_language_health_sports            72
health_sports_history_civics               43
specialneeds_health_sports                 42
history_civics_appliedlearning             42
health_sports_warmth_care_hunger           23
specialneeds_warmth_care_hunger            23
music_arts_health_sports                   19
music_arts_history_civics                  18
history_civics_health_sports               13
math_science_warmth_care_hunger            11
music_arts_appliedlearning                 10
appliedlearning_warmth_care_hunger         10
```

```
literacy_language_warmth_care_hunger        9
music_arts_warmth_care_hunger               2
history_civics_warmth_care_hunger           1
Name: clean_categories, dtype: int64
```

In [7]:

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

Out[7]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2

In [8]:

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

Out[8]:

```
literacy                                 9486
literacy_mathematics                     8325
literature_writing_mathematics           5923
literacy_literature_writing              5571
mathematics                              5379
                                         ...
other_warmth_care_hunger                    1
esl_teamsports                              1
literature_writing_nutritioneducation       1
parentinvolvement_warmth_care_hunger        1
esl_economics                               1
Name: clean_subcategories, Length: 401, dtype: int64
```

In [9]:

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

Out[9]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2

In [10]:

```
project_data['teacher_prefix'].value_counts()
```

Out[10]:

```
Mrs.       57269
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

In [11]:

```
# check if we have any nan values are there
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
True
number of nan values 3
```

In [12]:

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

In [13]:

```
# Remove '.'
# convert all the chars to small
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('.','')
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

Out[13]:

```
mrs        57272
ms         38955
mr         10648
teacher     2360
dr            13
Name: teacher_prefix, dtype: int64
```

In [14]:

```
# We need to get rid of The spaces between the text and the hyphens because they're special
#Rmoving multiple characters from a string in Python
#https://stackoverflow.com/questions/3411771/multiple-character-replace-with-python

project_grade_category = []

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

In [15]:

```
project_data.drop(['project_grade_category'], axis = 1, inplace = True)
project_data["project_grade_category"] = project_grade_category
print("After removing the special characters ,Column values:  ")
np.unique(project_data["project_grade_category"].values)
```

```
After removing the special characters ,Column values:
```

Out[15]:

```
array(['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2'],
      dtype=object)
```

In [16]:

```
# convert all of them into small letters
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[16]:

```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

Preprocessing Categorical Features:

In [17]:

```
# 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
```

Stopword:

In [18]:

```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they'
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'l
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'u
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'd
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over',
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', '
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'v
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'do
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn'
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing Categorical Features: essay

In [19]:

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

In [20]:

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

In [21]:

```
print("printing some random essay before Preprocessing ")
print(9, project_data['essay'].values[9])
print('-'*50)
print(34, project_data['essay'].values[34])
print('-'*50)
print(147, project_data['essay'].values[147])
```

```
printing some random essay before Preprocessing
9 Over 95% of my students are on free or reduced lunch.  I have a few who
are homeless, but despite that, they come to school with an eagerness to l
earn.  My students are inquisitive eager learners who  embrace the challen
ge of not having great books and other resources  every day.  Many of them
are not afforded the opportunity to engage with these big colorful pages o
f a book on a regular basis at home and they don't travel to the public li
brary.  \r\nIt is my duty as a teacher to do all I can to provide each stu
dent an opportunity to succeed in every aspect of life. \r\nReading is Fun
damental! My students will read these books over and over again while boos
ting their comprehension skills. These books will be used for read alouds,
partner reading and for Independent reading. \r\nThey will engage in readi
ng to build their \"Love for Reading\" by reading for pure enjoyment. They
will be introduced to some new authors as well as some old favorites. I wa
nt my students to be ready for the 21st Century and know the pleasure of h
olding a good hard back book in hand. There's nothing like a good book to
read!  \r\nMy students will soar in Reading, and more because of your cons
ideration and generous funding contribution. This will help build stamina
and prepare for 3rd grade. Thank you so much for reading our proposal!nann
an
--------------------------------------------------
34 My students mainly come from extremely low-income families, and the maj
ority of them come from homes where both parents work full time. Most of m
y students are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm in the a
fter-school program), and they all receive free and reduced meals for brea
kfast and lunch. \r\n\r\n\r\nI want my students to feel  as comfortable in
my classroom as they do at home. Many of my students take on multiple role
s both at home as well as in school. They are sometimes the caretakers of
younger siblings, cooks, babysitters, academics, friends, and most of all,
they are developing who they are going to become as adults.  I consider it
an essential part of my job to model helping others gain knowledge in a po
sitive manner. As a result, I have a community of students who love helpin
g each other in and outside of the classroom. They consistently look for o
pportunities to support each other's learning in a kind and helpful way.I
am excited to be experimenting with alternative seating in my classroom th
is school year. Studies have shown that giving students the option of wher
e they sit in a classroom increases focus as well as motivation.  \r\n\r\n
By allowing students choice in the classroom, they are able to explore and
create in a welcoming environment. Alternative classroom seating has been
experimented with more frequently in recent years. I believe (along with m
any others), that every child learns differently. This does not only apply
to how multiplication is memorized, or a paper is written, but applies to
the space in which they are asked to work. I have had students in the past
ask \"Can I work in the library? Can I work on the carpet?\" My answer was
always, \"As long as you're learning, you can work wherever you want!\" \r
\n\r\nWith the yoga balls and the lap-desks, I will be able to increase th
e options for seating in my classroom and expand its imaginable space.nann
an
--------------------------------------------------
147 My students are eager to learn and make their mark on the world.\r\n\r
\nThey come from a Title 1 school and need extra love.\r\n\r\nMy fourth gr
ade students are in a high poverty area and still come to school every day
```

```
to get their education. I am trying to make it fun and educational for the
m so they can get the most out of their schooling. I created a caring envi
ronment for the students to bloom! They deserve the best.\r\nThank you!\r
\nI am requesting 1 Chromebook to access online interventions, differentia
te instruction, and get extra practice. The Chromebook will be used to sup
plement ELA and math instruction. Students will play ELA and math games th
at are engaging and fun, as well as participate in assignments online. Thi
s in turn will help my students improve their skills. Having a Chromebook
in the classroom would not only allow students to use the programs at thei
r own pace, but would ensure more students are getting adequate time to us
e the programs. The online programs have been especially beneficial to my
students with special needs. They are able to work at their level as well
as be challenged with some different materials. This is making these stude
nts more confident in their abilities.\r\n\r\nThe Chromebook would allow m
y students to have daily access to computers and increase their computing
skills.\r\nThis will change their lives for the better as they become more
successful in school. Having access to technology in the classroom would h
elp bridge the achievement gap.nannan
```

In [22]:

```
preprocessed_essays = preprocess_text(project_data['essay'].values)
```

```
100%|███████████████████████████████████████████████████████████████████████
██| 109248/109248 [04:39<00:00, 391.05it/s]
```

In [23]:

```
print("printing some random essay After preprocessed_essays")
print(9, preprocessed_essays[9])
print('-'*50)
print(34, preprocessed_essays[34])
print('-'*50)
print(147, preprocessed_essays[147])
```

```
printing some random essay After preprocessed_essays
9 95 students free reduced lunch homeless despite come school eagerness lear
n students inquisitive eager learners embrace challenge not great books reso
urces every day many not afforded opportunity engage big colorful pages book
regular basis home not travel public library duty teacher provide student op
portunity succeed every aspect life reading fundamental students read books
boosting comprehension skills books used read alouds partner reading indepen
dent reading engage reading build love reading reading pure enjoyment introd
uced new authors well old favorites want students ready 21st century know pl
easure holding good hard back book hand nothing like good book read students
soar reading consideration generous funding contribution help build stamina
prepare 3rd grade thank much reading proposal nannan
--------------------------------------------------
34 students mainly come extremely low income families majority come homes pa
rents work full time students school 7 30 6 00 pm 2 30 6 00 pm school progra
m receive free reduced meals breakfast lunch want students feel comfortable
classroom home many students take multiple roles home well school sometimes
caretakers younger siblings cooks babysitters academics friends developing g
oing become adults consider essential part job model helping others gain kno
wledge positive manner result community students love helping outside classr
oom consistently look opportunities support learning kind helpful way excite
d experimenting alternative seating classroom school year studies shown givi
ng students option sit classroom increases focus well motivation allowing st
udents choice classroom able explore create welcoming environment alternativ
e classroom seating experimented frequently recent years believe along many
others every child learns differently not apply multiplication memorized pap
er written applies space asked work students past ask work library work carp
et answer always long learning work wherever want yoga balls lap desks able
increase options seating classroom expand imaginable space nannan
--------------------------------------------------
147 students eager learn make mark world come title 1 school need extra love
fourth grade students high poverty area still come school every day get educ
ation trying make fun educational get schooling created caring environment s
tudents bloom deserve best thank requesting 1 chromebook access online inter
ventions differentiate instruction get extra practice chromebook used supple
ment ela math instruction students play ela math games engaging fun well par
ticipate assignments online turn help students improve skills chromebook cla
ssroom would not allow students use programs pace would ensure students gett
ing adequate time use programs online programs especially beneficial student
s special needs able work level well challenged different materials making s
tudents confident abilities chromebook would allow students daily access com
puters increase computing skills change lives better become successful schoo
l access technology classroom would help bridge achievement gap nannan
```

In [24]:

```
#creating a new column with the preprocessed essays and replacing it with the original colu
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
```

In [25]:

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

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest stu
for learning my students learn in many different ways using all of our senses and multiple 
of techniques to help all my students succeed students in my class come from a variety of d
for wonderful sharing of experiences and cultures including native americans our school is 
learners which can be seen through collaborative student project based learning in and out 
in my class love to work with hands on materials and have many different opportunities to p
mastered having the social skills to work cooperatively with friends is a crucial aspect of
montana is the perfect place to learn about agriculture and nutrition my students love to r
in the early childhood classroom i have had several kids ask me can we try cooking with rea
and create common core cooking lessons where we learn important math and writing concepts w
food for snack time my students will have a grounded appreciation for the work that went in
of where the ingredients came from as well as how it is healthy for their bodies this proje
nutrition and agricultural cooking recipes by having us peel our own apples to make homemad
and mix up healthy plants from our classroom garden in the spring we will also create our o
shared with families students will gain math and literature skills as well as a life long e
nannan'
ss = sid.polarity_scores(for_sentiment)

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

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

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

In [26]:

```
# Sentiment Analysis on 'essay'
sid = SentimentIntensityAnalyzer()
negative_sentiments = []
positive_sentiments = []
neutral_sentiments = []
compound_sentiments = []
```

In [27]:

```
for i in tqdm(project_data['preprocessed_essays']):
    sid_sentiments = sid.polarity_scores(i)
    negative_sentiments.append(sid_sentiments['neg'])
    positive_sentiments.append(sid_sentiments['pos'])
    neutral_sentiments.append(sid_sentiments['neu'])
    compound_sentiments.append(sid_sentiments['compound'])
```

```
100%|████████████████████████████████████████████████████████████████████
█| 109248/109248 [12:53<00:00, 141.29it/s]
```

In [28]:

```
# Now append these sentiments columns/freatures to original preprocessed dataframe
project_data['negative_sent'] = negative_sentiments
project_data['positive_sent'] = positive_sentiments
project_data['neutral_sent'] = neutral_sentiments
project_data['compound_sent'] = compound_sentiments
```

In [30]:

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

Out[30]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs	in	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr	fl	

Preprocessing Categorical Features: project_title

In [29]:

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

In [30]:

```
print("printing some random reviews Before preprocessed_titles")
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])
```

```
printing some random reviews Before preprocessed_titles
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!
```

In [31]:

```
preprocessed_titles = preprocess_text(project_data['project_title'].values)
```

```
100%|███████████████████████████████████████████████████████████████████████
█| 109248/109248 [00:15<00:00, 7232.63it/s]
```

In [34]:

```
print("printing some random reviews After preprocessed_titles ")
print(9, preprocessed_titles[9])
print(34, preprocessed_titles[34])
print(147, preprocessed_titles[147])
```

```
printing some random reviews After preprocessed_titles
9 love reading pure pleasure
34 ball
147 needs chromebook
```

In [32]:

```
project_data['project_title'].head(2)
```

Out[32]:

```
0    Educational Support for English Learners at Home
1               Wanted: Projector for Hungry Learners
Name: project_title, dtype: object
```

In [33]:

```
#creating a new column with the preprocessed titles,useful for analysis
project_data['preprocessed_titles'] = preprocessed_titles
```

In [37]:

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

Out[37]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs	in	2

Merging price with project_data

In [34]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index
project_data = pd.merge(project_data, price_data, on='id', how='left')
project_data.head(1)
```

Out[34]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_s
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs	in	2

1 rows × 22 columns

In [39]:

```
x=project_data[0:50000]
y = project_data['project_is_approved'][0:50000].values
```

In [36]:

```
# train test split using sklearn.model selection
from sklearn.model_selection import train_test_split
# Splitting data into Train and cross validation(or test): Stratifie
X_train, X_test, y_train, y_test = train_test_split(project_data, project_data['project_is_
print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
```

```
(73196, 22) (73196,)
(36052, 22) (36052,)
```

In [37]:

```
print('X_train_shape' , X_train.shape)
print('X_test_shape' , X_test.shape)
```

```
X_train_shape (73196, 22)
X_test_shape (36052, 22)
```

In [40]:

```
def response_values(feature, df):
    value_count = df[feature].value_counts()
    response_values_dict = dict()
    for i,j in value_count.items():
        vec = []
        for k in range(0,2):
            res_val =len( df.loc[(df['project_is_approved']==k) & (df[feature]==i)])/len( d
            vec.append(res_val)
            response_values_dict[i]=vec
    return response_values_dict
```

In [41]:

```
def array_response_code(feature, df):
    response_values_dict = response_values(feature, X_train)
    value_count = X_train[feature].value_counts()
    gv_fea = []
    for index, row in df.iterrows():
        if row[feature] in dict(value_count).keys():
            gv_fea.append(response_values_dict[row[feature]])
        else:
            gv_fea.append([0.5,0.5])
    return gv_fea
```

In [42]:

```
response_values('clean_categories', X_train)
```

Out[42]:

```
{'literacy_language': [0.13333333333333333, 0.8666666666666667],
 'math_science': [0.18278168708192163, 0.8172183129180783],
 'literacy_language_math_science': [0.13152486642005753, 0.868475133579942
4],
 'health_sports': [0.14745269286754004, 0.85254730713246],
 'music_arts': [0.14436821040594625, 0.8556317895940537],
 'specialneeds': [0.19218695500523195, 0.807813044994768],
 'literacy_language_specialneeds': [0.13979706877113868, 0.860202931228861
4],
 'appliedlearning': [0.18113357114546175, 0.8188664288545382],
 'math_science_literacy_language': [0.14285714285714285, 0.857142857142857
1],
 'appliedlearning_literacy_language': [0.13370089593383874,
  0.8662991040661613],
 'math_science_specialneeds': [0.1596774193548387, 0.8403225806451613],
 'history_civics': [0.15931372549019607, 0.8406862745098039],
 'math_science_music_arts': [0.16370106761565836, 0.8362989323843416],
 'literacy_language_music_arts': [0.1629162916291629, 0.8370837083708371],
 'appliedlearning_specialneeds': [0.1961577350859454, 0.8038422649140546],
 'history_civics_literacy_language': [0.11580086580086581, 0.884199134199134
2],
 'health_sports_specialneeds': [0.11724915445321307, 0.882750845546787],
 'warmth_care_hunger': [0.07940161104718067, 0.9205983889528193],
 'math_science_appliedlearning': [0.17375, 0.82625],
 'appliedlearning_math_science': [0.1994219653179191, 0.8005780346820809],
 'literacy_language_history_civics': [0.11450381679389313, 0.885496183206106
9],
 'health_sports_literacy_language': [0.1341222879684418, 0.865877712031558
2],
 'appliedlearning_music_arts': [0.18787878787878787, 0.8121212121212121],
 'literacy_language_appliedlearning': [0.1348314606741573, 0.865168539325842
7],
 'math_science_history_civics': [0.14874141876430205, 0.851258581235698],
 'appliedlearning_health_sports': [0.16831683168316833, 0.8316831683168316],
 'math_science_health_sports': [0.19202898550724637, 0.8079710144927537],
 'history_civics_math_science': [0.13596491228070176, 0.8640350877192983],
 'history_civics_music_arts': [0.1523809523809524, 0.8476190476190476],
 'specialneeds_music_arts': [0.1691542288557214, 0.8308457711442786],
 'health_sports_math_science': [0.16243654822335024, 0.8375634517766497],
 'history_civics_specialneeds': [0.1853932584269663, 0.8146067415730337],
 'health_sports_appliedlearning': [0.17293233082706766, 0.8270676691729323],
 'appliedlearning_history_civics': [0.1968503937007874, 0.8031496062992126],
 'health_sports_music_arts': [0.17391304347826086, 0.8260869565217391],
 'music_arts_specialneeds': [0.11458333333333333, 0.8854166666666666],
 'literacy_language_health_sports': [0.18867924528301888, 0.811320754716981
2],
 'health_sports_history_civics': [0.125, 0.875],
 'specialneeds_health_sports': [0.23333333333333334, 0.7666666666666667],
 'history_civics_appliedlearning': [0.3, 0.7],
 'health_sports_warmth_care_hunger': [0.058823529411764705,
  0.9411764705882353],
 'specialneeds_warmth_care_hunger': [0.23529411764705882, 0.764705882352941
1],
 'music_arts_health_sports': [0.2857142857142857, 0.7142857142857143],
 'music_arts_history_civics': [0.3076923076923077, 0.6923076923076923],
 'history_civics_health_sports': [0.08333333333333333, 0.9166666666666666],
 'math_science_warmth_care_hunger': [0.45454545454545453, 0.545454545454545
4],
 'music_arts_appliedlearning': [0.3333333333333333, 0.6666666666666666],
 'appliedlearning_warmth_care_hunger': [0.16666666666666666,
  0.8333333333333334],
 'literacy_language_warmth_care_hunger': [0.0, 1.0],
 'history_civics_warmth_care_hunger': [1.0, 0.0],
 'music_arts_warmth_care_hunger': [1.0, 0.0]}
```

In [43]:

```
X_train_clean_categories_res_code = array_response_code('clean_categories', X_train)
X_test_clean_categories_res_code = array_response_code('clean_categories', X_test)

print("After response coding :")
print(np.shape(X_train_clean_categories_res_code))
print(np.shape(X_test_clean_categories_res_code))
```

```
After response coding :
(73196, 2)
(36052, 2)
```

In [44]:

```
response_values('clean_subcategories', X_train)
```

Out[44]:

```
{'literacy': [0.11990595611285267, 0.8800940438871473],
 'literacy_mathematics': [0.12986547085201794, 0.8701345291479821],
 'literature_writing_mathematics': [0.13348706123494747, 0.866512938765052
5],
 'mathematics': [0.181267217630854, 0.818732782369146],
 'literacy_literature_writing': [0.1348221670802316, 0.8651778329197684],
 'literature_writing': [0.14271653543307086, 0.8572834645669292],
 'specialneeds': [0.19218695500523195, 0.807813044994768],
 'health_wellness': [0.12334983498349834, 0.8766501650165016],
 'appliedsciences_mathematics': [0.17430406852248395, 0.8256959314775161],
 'appliedsciences': [0.19050480769230768, 0.8094951923076923],
 'literacy_specialneeds': [0.131674757281534, 0.868325242718446 6],
 'gym_fitness_health_wellness': [0.12508185985592665, 0.8749181401440733],
 'esl_literacy': [0.13057961359093936, 0.8694203864090606],
 'visualarts': [0.1789052069425901 3, 0.8210947930574098],
 'music': [0.1092184368737475, 0.8907815631262525],
 'warmth_care_hunger': [0.07940161104718067, 0.9205983889528193],
 'literature_writing_specialneeds': [0.15856481481481483, 0.84143518518518
```

In [51]:

```
X_train_clean_subcategories_res_code = array_response_code('clean_subcategories', X_train)
X_test_clean_subcategories_code = array_response_code('clean_subcategories', X_test)

print("After response coding :")
print(np.shape(X_train_clean_subcategories_res_code))
print(np.shape(X_test_clean_subcategories_code))
```

```
After response coding :
(73196, 2)
(36052, 2)
```

In [53]:

```
response_values('teacher_prefix', X_train)
```

Out[53]:

```
{'mrs': [0.1448137848584869, 0.8551862151415132],
 'ms': [0.1567528128720095, 0.8432471871279905],
 'mr': [0.15772380683422763, 0.8422761931657724],
 'teacher': [0.19395465994962216, 0.8060453400503779],
 'dr': [0.5, 0.5]}
```

In [54]:

```
X_train_teacher_prefix_res_code = array_response_code('teacher_prefix', X_train)
X_test_teacher_prefix_code = array_response_code('teacher_prefix', X_test)

print("After response coding :")
print(np.shape(X_train_teacher_prefix_res_code))
print(np.shape(X_test_teacher_prefix_code))
```

```
After response coding :
(73196, 2)
(36052, 2)
```

In [55]:

```
response_values('school_state', X_train)
```

Out[55]:

```
{'ca': [0.13853830349280893, 0.8614616965071911],
 'tx': [0.1874747474747475, 0.8125252525252525],
 'ny': [0.1445978878960195, 0.8554021121039805],
 'fl': [0.16610087293889428, 0.8338991270611057],
 'nc': [0.1430260047281324, 0.8569739952718676],
 'il': [0.14266258086482805, 0.8573374191351719],
 'ga': [0.15867707172054998, 0.84132292827945],
 'sc': [0.13895131086142323, 0.8610486891385768],
 'mi': [0.1626704278326281, 0.8373295721673719],
 'pa': [0.14851001465559355, 0.8514899853444065],
 'in': [0.16280384397964953, 0.8371961560203505],
 'mo': [0.1469248291571754, 0.8530751708428246],
 'oh': [0.12226816302421736, 0.8777318369757826],
 'la': [0.16448598130841122, 0.8355140186915888],
 'ma': [0.13427109974424553, 0.8657289002557544],
 'wa': [0.12572161642078256, 0.8742783835792175],
 'nj': [0.15660252156602522, 0.8433974784339748],
 'ok': [0.1620897521768252, 0.8379102478231748],
 'az': [0.16378714581893572, 0.8362128541810643],
 'va': [0.1464465183058148, 0.8535534816941852],
 'wi': [0.1580246913580247, 0.8419753086419753],
 'ut': [0.15397631133671744, 0.8460236886632826],
 'al': [0.1558219178082192, 0.8441780821917808],
 'ct': [0.12762237762237763, 0.8723776223776224],
 'tn': [0.1444933920704846, 0.8555066079295154],
 'md': [0.1636904761904762, 0.8363095238095238],
 'nv': [0.14778856526429343, 0.8522114347357066],
 'ms': [0.1753607103218646, 0.8246392896781354],
 'ky': [0.13018433179723501, 0.869815668202765],
 'or': [0.15393654524089306, 0.8460634547591069],
 'mn': [0.1547314578005115, 0.8452685421994884],
 'co': [0.16275862068965516, 0.8372413793103448],
 'ar': [0.1652046783625731, 0.8347953216374269],
 'id': [0.1504424778761062, 0.8495575221238938],
 'ks': [0.14754098360655737, 0.8524590163934426],
 'ia': [0.14823529411764705, 0.851764705882353],
 'nm': [0.1385390428211587, 0.8614609571788413],
 'hi': [0.15714285714285714, 0.8428571428571429],
 'dc': [0.21714285714285714, 0.7828571428571428],
 'wv': [0.14121037463976946, 0.8587896253602305],
 'me': [0.15625, 0.84375],
 'nh': [0.11764705882352941, 0.8823529411764706],
 'ak': [0.16170212765957448, 0.8382978723404255],
 'de': [0.12217194570135746, 0.8778280542986425],
 'sd': [0.14150943396226415, 0.8584905660377359],
 'ne': [0.155, 0.845],
 'ri': [0.1631578947368421, 0.8368421052631579],
 'mt': [0.18452380952380953, 0.8154761904761905],
 'nd': [0.13402061855670103, 0.865979381443299],
 'wy': [0.16666666666666666, 0.8333333333333334],
 'vt': [0.16071428571428573, 0.8392857142857143]}
```

In [56]:

```
X_train_school_state_res_code = array_response_code('school_state', X_train)
X_test_school_state_code = array_response_code('school_state', X_test)

print("After response coding :")
print(np.shape(X_train_school_state_res_code))
print(np.shape(X_test_school_state_code))
```

```
After response coding :
(73196, 2)
(36052, 2)
```

In [57]:

```
response_values('project_grade_category', X_train)
```

Out[57]:

```
{'Grades_PreK_2': [0.1530200887563942, 0.8469799112436058],
 'Grades_3_5': [0.1461873725458835, 0.8538126274541166],
 'Grades_6_8': [0.15360169491525424, 0.8463983050847458],
 'Grades_9_12': [0.15940054495912806, 0.840599455040872]}
```

In [58]:

```
X_train_project_grade_category_res_code = array_response_code('project_grade_category', X_t
X_test_project_grade_category_code = array_response_code('project_grade_category', X_test)

print("After response coding :")
print(np.shape(X_train_project_grade_category_res_code))
print(np.shape(X_test_project_grade_category_code))
```

```
After response coding :
(73196, 2)
(36052, 2)
```

In [59]:

```
from sklearn.preprocessing import Normalizer
# Our first Numerical feature - 'price'
normalizer = Normalizer()

# As explainEd above first I will reshape(1, -1)
normalizer.fit(X_train['price'].values.reshape(1, -1))

train_normalized_price = normalizer.transform(X_train['price'].values.reshape(1, -1))

test_df_normalized_price = normalizer.transform(X_test['price'].values.reshape(1, -1))

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_price = train_normalized_price.reshape(-1, 1)


test_df_normalized_price = test_df_normalized_price.reshape(-1, 1)
print(train_normalized_price.shape)
print(test_df_normalized_price.shape)
```

```
(73196, 1)
(36052, 1)
```

In [60]:

```
### Normalizing next numerical feature: teacher_number_of_previously_posted_projects

# Second Numerical feature - 'teacher_number_of_previously_posted_projects'
normalizer = Normalizer()

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

train_normalized_teacher_number_of_previously_posted_projects = normalizer.transform(X_trai

test_df_normalized_teacher_number_of_previously_posted_projects = normalizer.transform(X_te

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_teacher_number_of_previously_posted_projects = train_normalized_teacher_nu

test_df_normalized_teacher_number_of_previously_posted_projects = test_df_normalized_teache
print(train_normalized_teacher_number_of_previously_posted_projects.shape)

print(test_df_normalized_teacher_number_of_previously_posted_projects.shape)
```

```
(73196, 1)
(36052, 1)
```

In [61]:

```
### Normalizing next numerical feature: negative_sent

# Second Numerical feature - 'negative_sent'
normalizer = Normalizer()

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

train_normalized_negative_sent = normalizer.transform(X_train['negative_sent'].values.resha

test_df_normalized_negative_sent = normalizer.transform(X_test['negative_sent'].values.resh

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_negative_sent = train_normalized_negative_sent.reshape(-1, 1)

test_df_normalized_negative_sent = test_df_normalized_negative_sent.reshape(-1, 1)
print(train_normalized_negative_sent.shape)

print(test_df_normalized_negative_sent.shape)
```

```
(73196, 1)
(36052, 1)
```

In [62]:

```
### Normalizing next numerical feature: negative_sent

# Second Numerical feature - 'positive_sent'
normalizer = Normalizer()

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

train_normalized_positive_sent= normalizer.transform(X_train['positive_sent'].values.reshap

test_df_normalized_positive_sent = normalizer.transform(X_test['positive_sent'].values.resh

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_positive_sent = train_normalized_positive_sent.reshape(-1, 1)

test_df_normalized_positive_sent = test_df_normalized_positive_sent.reshape(-1, 1)
print(train_normalized_positive_sent.shape)

print(test_df_normalized_positive_sent.shape)
```

```
(73196, 1)
(36052, 1)
```

In [63]:

```
### Normalizing next numerical feature: negative_sent

# Second Numerical feature - 'neutral_sent'
normalizer = Normalizer()

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

train_normalized_neutral_sent= normalizer.transform(X_train['neutral_sent'].values.reshape(

test_df_normalized_neutral_sent = normalizer.transform(X_test['neutral_sent'].values.reshap

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_neutral_sent = train_normalized_neutral_sent.reshape(-1, 1)

test_df_normalized_neutral_sent = test_df_normalized_neutral_sent.reshape(-1, 1)
print(train_normalized_neutral_sent.shape)

print(test_df_normalized_neutral_sent.shape)
```

```
(73196, 1)
(36052, 1)
```

In [64]:

```
### Normalizing next numerical feature: negative_sent

# Second Numerical feature - 'compound_sent'
normalizer = Normalizer()

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

train_normalized_compound_sent= normalizer.transform(X_train['compound_sent'].values.reshap

test_df_normalized_compound_sent = normalizer.transform(X_test['compound_sent'].values.resh

# After normalization reshape again to (-1, 1) i.e. this time unknown rows (i.e. leaving it
train_normalized_compound_sent = train_normalized_compound_sent.reshape(-1, 1)

test_df_normalized_compound_sent = test_df_normalized_compound_sent.reshape(-1, 1)
print(train_normalized_compound_sent.shape)

print(test_df_normalized_compound_sent.shape)
```

```
(73196, 1)
(36052, 1)
```

TFIDF

In [65]:

```
## Encoding Essay column using tfidf
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)

train_vectorized_tfidf_essay = vectorizer_essay_tfidf.fit_transform(X_train['preprocessed_e

test_df_vectorized_tfidf_essay = vectorizer_essay_tfidf.transform(X_test['preprocessed_essa

print(train_vectorized_tfidf_essay.shape)
print(test_df_vectorized_tfidf_essay.shape)
```

```
(73196, 14142)
(36052, 14142)
```

In [66]:

```
## Encoding preprocessed_titles column using tfidf
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_preprocessed_titles_tfidf = TfidfVectorizer(min_df=10)

train_vectorized_tfidf_preprocessed_titles = vectorizer_preprocessed_titles_tfidf.fit_trans

test_df_vectorized_tfidf_preprocessed_titles = vectorizer_preprocessed_titles_tfidf.transfo

print(train_vectorized_tfidf_preprocessed_titles.shape)
print(test_df_vectorized_tfidf_preprocessed_titles.shape)
```

```
(73196, 2544)
(36052, 2544)
```

TFIDF W2V

In [67]:

```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [68]:

```
# In the TF-IDF Word2Vec vectorization, we have to fit the TfidfVectorizer only on X_train[
# extract 'dictionary' (dictionary with features as the keys and IDF scores as the values)
# 'tfidf_words' (a set of all the features extracted from the vectorizer).
# We have to use the same 'dictionary' and 'tfidf_words' in vectorizing both X_train['essay

# Now, at the very top section of this Notebook, we alrady have this code of Vectorizer on
# vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)
# vectorizer_essay_tfidf.fit(X_train['essay'].values)

# Hence we are now converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(vectorizer_essay_tfidf.get_feature_names(), list(vectorizer_essay_tfi
tfidf_words = set(vectorizer_essay_tfidf.get_feature_names())
```

In [69]:

```
# Function to generate Word2Vec weighted by tf-idf
def generate_w2v_from_text(essays_text_arr):
  # compute average word2vec for each review.
    tfidf_w2v_vectors = []
    # the avg-w2v for each sentence/review is stored in this list

    for sentence in tqdm(essays_text_arr):  # for each 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
        for word in sentence.split():  # for each word in a 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((sen
                tf_idf = dictionary[word] * (
                    sentence.count(word) / len(sentence.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_w2v_vectors.append(vector)
    return tfidf_w2v_vectors

X_train_vectorized_tfidf_w2v_essay = generate_w2v_from_text(X_train['preprocessed_essays'].
X_test_vectorized_tfidf_w2v_essay = generate_w2v_from_text(X_test['preprocessed_essays'].va
```

```
100%|██████████████████████████████████████████████████████████████████████
█████| 73196/73196 [12:20<00:00, 98.87it/s]
100%|██████████████████████████████████████████████████████████████████████
█████| 36052/36052 [06:04<00:00, 98.98it/s]
```

In [68]:

```
len(X_train_vectorized_tfidf_w2v_essay[0])
```

Out[68]:

```
300
```

In [69]:

```
len(X_test_vectorized_tfidf_w2v_essay[0])
```

Out[69]:

```
300
```

In [70]:

```
# In the TF-IDF Word2Vec vectorization, we have to fit the TfidfVectorizer only on X_train[
# extract 'dictionary' (dictionary with features as the keys and IDF scores as the values)
# 'tfidf_words' (a set of all the features extracted from the vectorizer).
# We have to use the same 'dictionary' and 'tfidf_words' in vectorizing both X_train['title

# Now, at the very top section of this Notebook, we alrady have this code of Vectorizer on
# vectorizer_preprocessed_titles_tfidf = TfidfVectorizer(min_df=10)
# vectorizer_preprocessed_titles_tfidf.fit(X_train['title'].values)

# Hence we are now converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(vectorizer_preprocessed_titles_tfidf.get_feature_names(), list(vector
tfidf_words = set(vectorizer_preprocessed_titles_tfidf.get_feature_names())
```

In [71]:

```
# Function to generate Word2Vec weighted by tf-idf
def generate_w2v_from_text(title_text_arr):
  # compute average word2vec for each review.
    tfidf_w2v_vectors = []
    # the avg-w2v for each sentence/review is stored in this list

    for sentence in tqdm(title_text_arr):  # for each 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
        for word in sentence.split():  # for each word in a 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((sen
                tf_idf = dictionary[word] * (
                    sentence.count(word) / len(sentence.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_w2v_vectors.append(vector)
    return tfidf_w2v_vectors

X_train_vectorized_tfidf_w2v_title = generate_w2v_from_text(X_train['preprocessed_titles'].
X_test_vectorized_tfidf_w2v_title = generate_w2v_from_text(X_test['preprocessed_titles'].va
```

```
100%|██████████████████████████████████████████████████████████████████████
███| 73196/73196 [00:14<00:00, 5180.76it/s]
100%|██████████████████████████████████████████████████████████████████████
███| 36052/36052 [00:06<00:00, 5445.73it/s]
```

In [181]:

```
len(X_test_vectorized_tfidf_w2v_title[0])
```

Out[181]:

```
300
```

In [182]:

```
len(X_train_vectorized_tfidf_w2v_title[0])
```

Out[182]:

```
300
```

Merging all categorical, text, numerical vectors,preprocessed Title,Preprocessed Essay and sentiment score based on TFIDF

In [128]:

```
from scipy.sparse import hstack
X_train_hstacked_all_tfidf_features_vectorized = hstack((X_train_clean_categories_res_code,

print('X_train_hstacked_all_tfidf_features_vectorized.shape is ', X_train_hstacked_all_tfid

test_df_hstacked_all_tfidf_features_vectorized =  hstack((X_test_clean_categories_res_code,

print('test_df_hstacked_all_tfidf_features_vectorized.shape is ', test_df_hstacked_all_tfid
```

```
X_train_hstacked_all_tfidf_features_vectorized.shape is  (73196, 16702)
test_df_hstacked_all_tfidf_features_vectorized.shape is  (36052, 16702)
```

Applying GBDT Classifier on TFIDF(Set1):

Set 1: categorical by response coding, numerical features + preprocessed_eassay (TFIDF)+preprocessed_title (TFIDF)+Sentiment scores(preprocessed_essay)

In [129]:

```
from sklearn.model_selection import train_test_split
import xgboost as xgb
from sklearn.model_selection import GridSearchCV
import seaborn as sea
```

In [130]:

```
Gb=XGBClassifier(random_state=42,eval_metric='mlogloss')
n_estimators = [5, 10, 50, 100]
depth = [2, 3, 4, 5]
params = {'n_estimators':n_estimators, 'max_depth': depth}
clf = GridSearchCV(Gb, params, cv=3, scoring='roc_auc',verbose=1,return_train_score=True,n_
clf.fit(X_train_hstacked_all_tfidf_features_vectorized, y_train)
```

```
Fitting 3 folds for each of 16 candidates, totalling 48 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  48 out of  48 | elapsed: 58.5min finished
```

Out[130]:

```
GridSearchCV(cv=3,
             estimator=XGBClassifier(base_score=None, booster=None,
                                     colsample_bylevel=None,
                                     colsample_bynode=None,
                                     colsample_bytree=None,
                                     eval_metric='mlogloss', gamma=None,
                                     gpu_id=None, importance_type='gain',
                                     interaction_constraints=None,
                                     learning_rate=None, max_delta_step=Non
e,
                                     max_depth=None, min_child_weight=None,
                                     missing=nan, monotone_constraints=None,
                                     n_estimators=100, n_jobs=None,
                                     num_parallel_tree=None, random_state=4
2,
                                     reg_alpha=None, reg_lambda=None,
                                     scale_pos_weight=None, subsample=None,
                                     tree_method=None, validate_parameters=N
one,
                                     verbosity=None),
             n_jobs=-1,
             param_grid={'max_depth': [2, 3, 4, 5],
                         'n_estimators': [5, 10, 50, 100]},
             return_train_score=True, scoring='roc_auc', verbose=1)
```

In [131]:

```
print(clf.best_estimator_)
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='mloglos
s',
              gamma=0, gpu_id=-1, importance_type='gain',
              interaction_constraints='', learning_rate=0.300000012,
              max_delta_step=0, max_depth=2, min_child_weight=1, missing=na
n,
              monotone_constraints='()', n_estimators=100, n_jobs=4,
              num_parallel_tree=1, random_state=42, reg_alpha=0, reg_lambda=
1,
              scale_pos_weight=1, subsample=1, tree_method='exact',
              validate_parameters=1, verbosity=None)
```

In [132]:

```
max_depth = [2, 3, 4, 5]
n_estimators = [5, 10, 50, 100]

def get_auc_matrix(x_train, x_test, y_train, y_test ):

    train_auc_final_arr, test_auc_final_arr = [], []

    for depth in tqdm(max_depth):
        train_auc_batch, test_auc_batch = [], []

        for num in n_estimators:
            # Below gives large number of warnings
            # xgb_clf = XGBClassifier(n_estimators=num, eta=l_rate, reg_alpha=0, reg_lambda

            # below works after including eval_metric='mlogloss'
            # xgb_clf = XGBClassifier(n_estimators=num, eval_metric='mlogloss', learning_ra

            xgb_clf = XGBClassifier(n_estimators=num, eval_metric='mlogloss',max_depth=dept

            xgb_clf.fit(x_train, y_train)

            # I have to predict probabilities (clf.predict_proba) instead of classes for ca
            y_train_predicted = xgb_clf.predict_proba(x_train)[:, 1]
            y_test_predicted = xgb_clf.predict_proba(x_test)[:, 1]

            train_auc = roc_auc_score(y_train, y_train_predicted)
            test_auc = roc_auc_score(y_test, y_test_predicted)

            train_auc_batch.append(train_auc)
            test_auc_batch.append(test_auc)

        train_auc_final_arr.append(train_auc_batch)
        test_auc_final_arr.append(test_auc_batch)

    return train_auc_final_arr, test_auc_final_arr


train_auc_final_arr_s1, test_auc_final_arr_s1 = get_auc_matrix(X_train_hstacked_all_tfidf_f
```

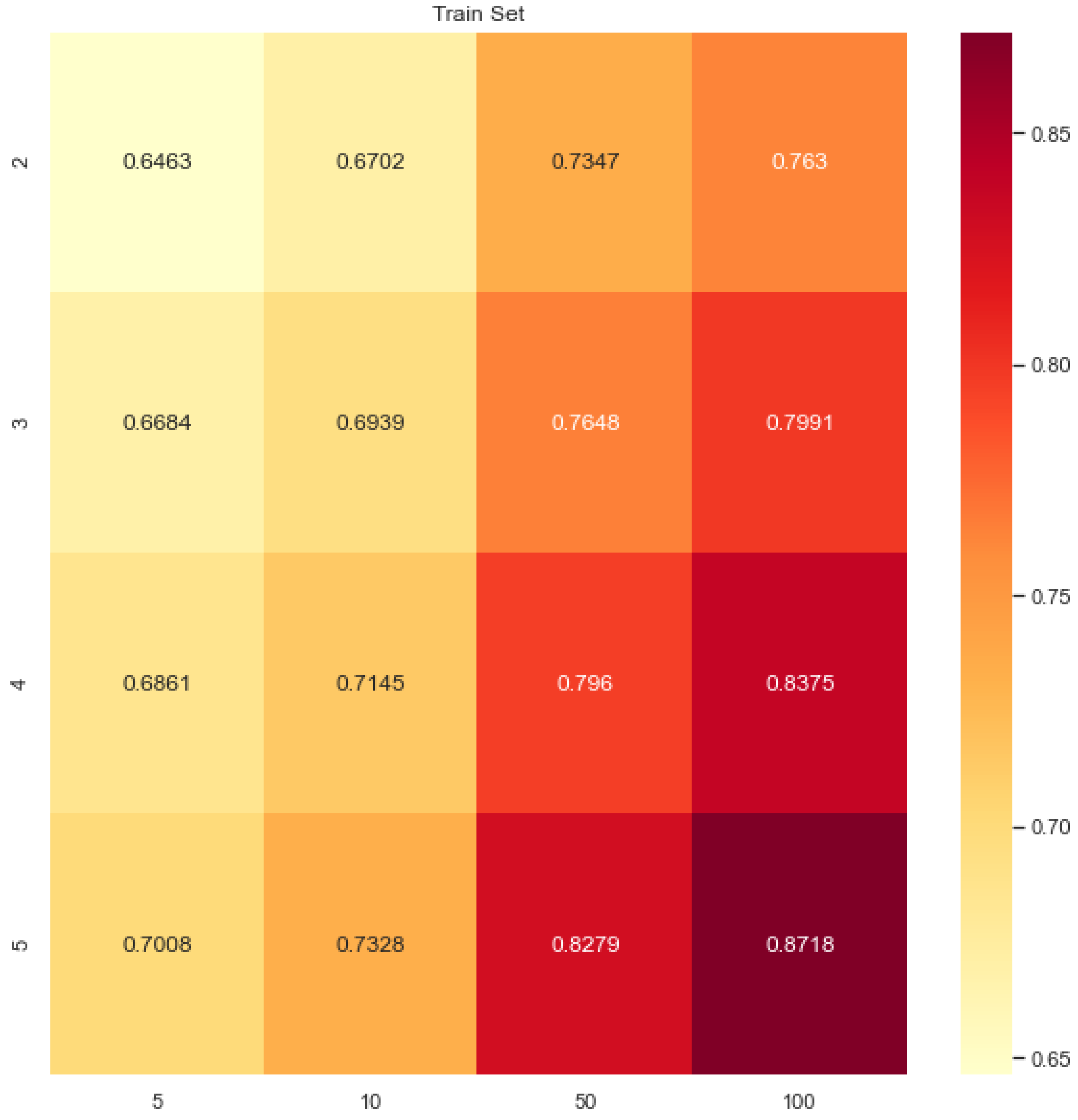
```
100%|██████████████████████████████████████████████████████
█████████| 4/4 [31:45<00:00, 476.38s/it]
```

plot the performance of model both on train data and cross validation data for each hyper parameter

- seaborn heat maps with rows as max_depth, columns as n_estimators, and values inside the cell representing AUC Score.

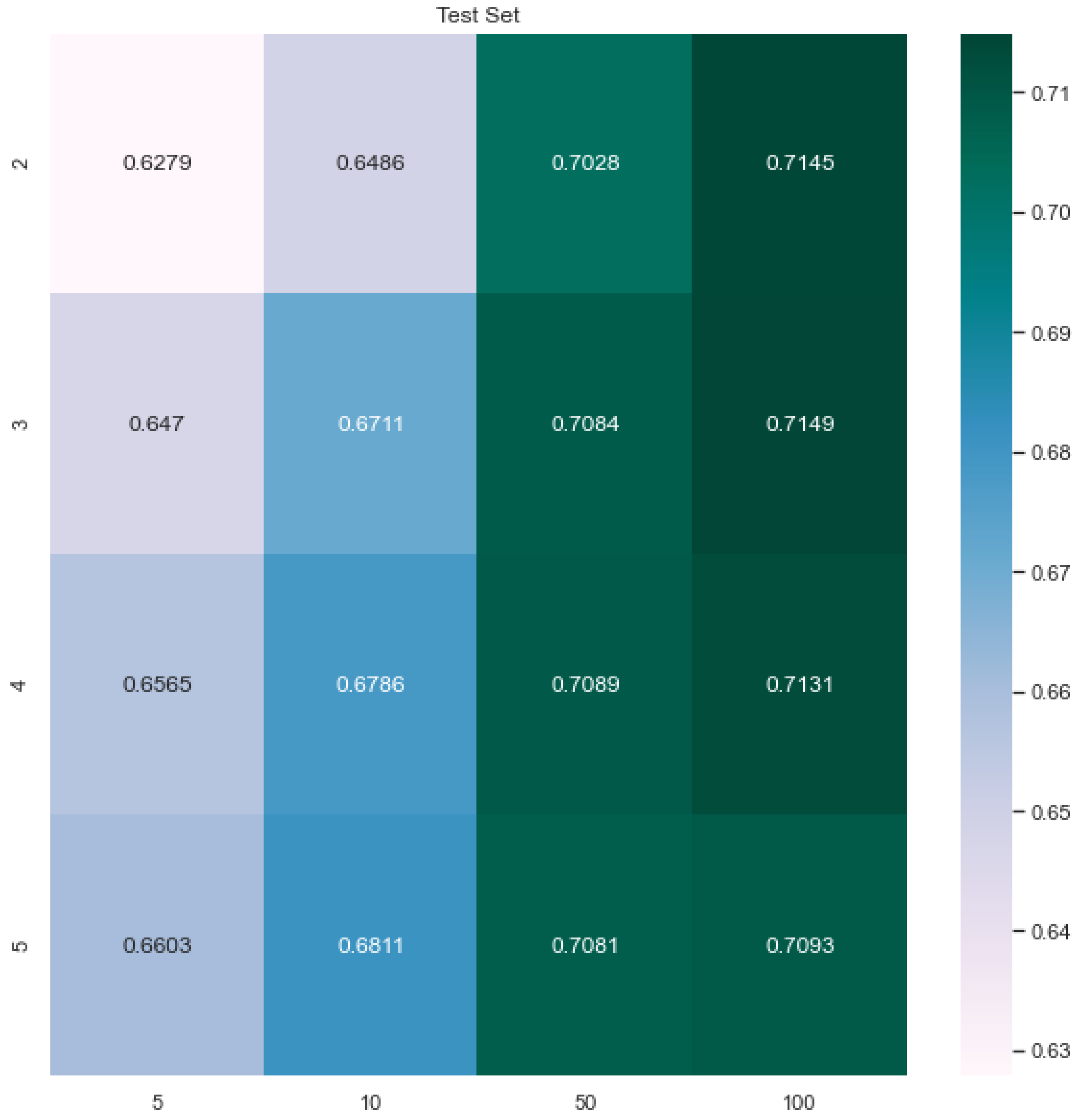
In [133]:

```
## Heatmap for Set S1

train_auc_final_df_s1 = pd.DataFrame(train_auc_final_arr_s1,columns=n_estimators, index=max
fig, ax = plt.subplots(1, figsize=(10,10))
sns.heatmap(train_auc_final_df_s1, annot=True, fmt='.4g', ax=ax,cmap="YlOrRd")
ax.set_title('Train Set')
plt.show()
# train_auc_final_df_s1
```



In [134]:

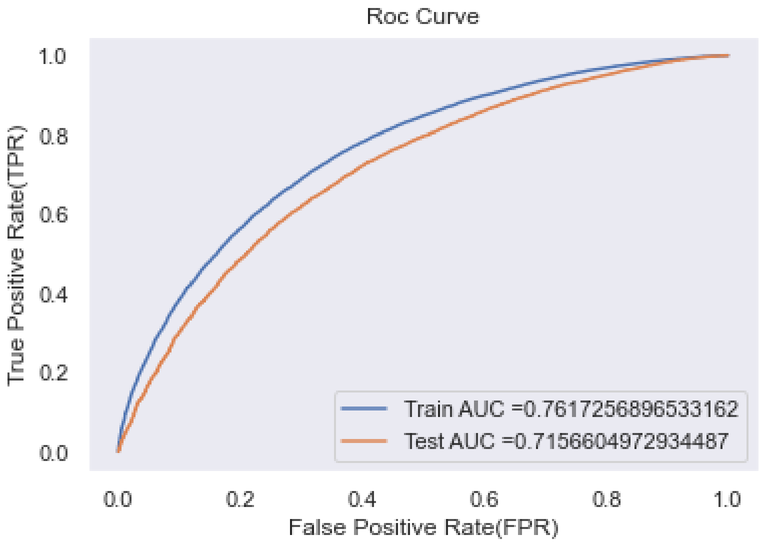
```
## Heatmap for Set S1

test_auc_final_df_s1 = pd.DataFrame(test_auc_final_arr_s1,columns=n_estimators, index=max_d
fig, ax = plt.subplots(1, figsize=(10,10))
sns.heatmap(test_auc_final_df_s1, annot=True, fmt='.4g', ax=ax,cmap="PuBuGn")
ax.set_title('Test Set')
plt.show()
# test_auc_final_df_s1
```



plot the ROC curve on both train and test

In [135]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.me
from sklearn.metrics import roc_curve, auc
xgb_tfidf_Model = XGBClassifier(eval_metric='mlogloss',n_estimators=100,max_depth=2)
xgb_tfidf_Model.fit(X_train_hstacked_all_tfidf_features_vectorized, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs
# y_train_pred = batch_predict(mnb_bow_testModel, x_train_onehot_bow)
y_train_pred=xgb_tfidf_Model.predict_proba(X_train_hstacked_all_tfidf_features_vectorized)[
predictions_train_set1=xgb_tfidf_Model.predict(X_train_hstacked_all_tfidf_features_vectoriz

y_test_pred=xgb_tfidf_Model.predict_proba(test_df_hstacked_all_tfidf_features_vectorized)[:
predictions_test_set1=xgb_tfidf_Model.predict(test_df_hstacked_all_tfidf_features_vectorize


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

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



Confusion Matrix

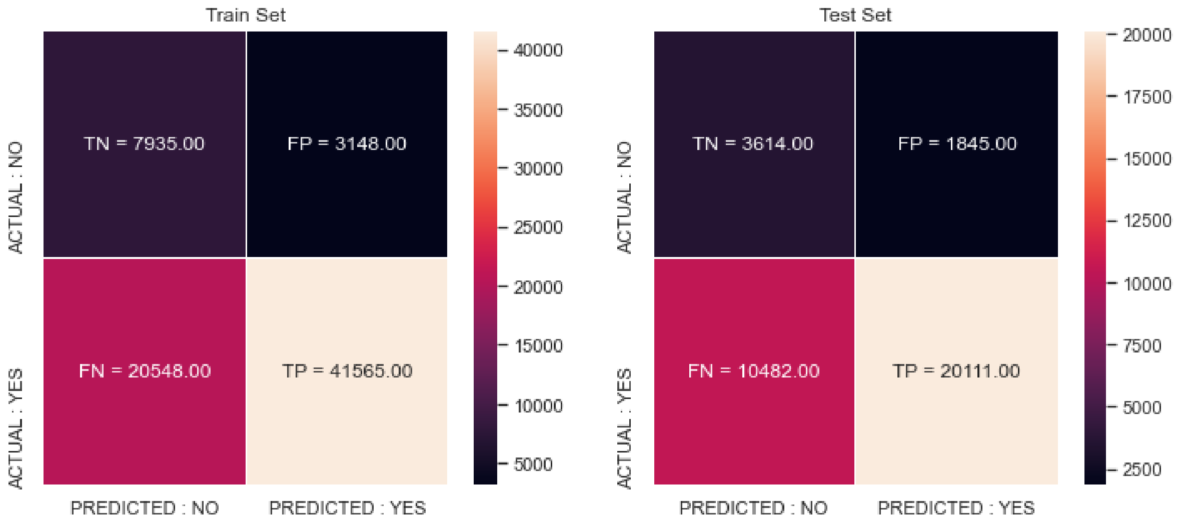
In [136]:

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

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [137]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, tra
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tp

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.f
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.fl

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],y
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'], y

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4838547738648873 for threshold 0.846
the maximum value of tpr*(1-fpr) 0.43712825364814983 for threshold 0.839
```



Merging all categorical, text, numerical vectors,preprocessed Title,Preprocessed Essay based on TFIDF_W2V:

In [72]:

```
from scipy.sparse import coo_matrix
X_train_essay_w2v=coo_matrix(X_train_vectorized_tfidf_w2v_essay)
print(X_train_essay_w2v.shape)
```

```
(73196, 300)
```

In [73]:

```
from scipy.sparse import coo_matrix
X_test_essay_w2v=coo_matrix(X_test_vectorized_tfidf_w2v_essay)
print(X_test_essay_w2v.shape)
```

```
(36052, 300)
```

In [74]:

```
from scipy.sparse import hstack
X_train_hstacked_all_tfidf_w2v_features_vectorized = hstack((X_train_clean_categories_res_c

print('X_train_hstacked_all_tfidf_w2v_features_vectorized.shape is ', X_train_hstacked_all_

test_df_hstacked_all_tfidf_w2v_features_vectorized =  hstack((X_test_clean_categories_res_c

print('test_df_hstacked_all_tfidf_w2v_features_vectorized.shape is ', test_df_hstacked_all_
```

```
X_train_hstacked_all_tfidf_w2v_features_vectorized.shape is  (73196, 612)
test_df_hstacked_all_tfidf_w2v_features_vectorized.shape is  (36052, 612)
```

Apply GBDT Classifier(XGB Classifier) on these feature sets

Set 2: categorical by response code, numerical features + preprocessed_essay (TFIDF W2V) + preprocessed_title (TFIDF W2V)

In [75]:

```
Gb=XGBClassifier(random_state=42,eval_metric='mlogloss')
n_estimators = [5, 10, 50, 100]
depth = [2, 3, 4, 5]
params = {'n_estimators':n_estimators, 'max_depth': depth}
classifier = GridSearchCV(Gb, params, cv=3, scoring='roc_auc',verbose=1,return_train_score=
classifier.fit(X_train_hstacked_all_tfidf_w2v_features_vectorized, y_train)
```

```
Fitting 3 folds for each of 16 candidates, totalling 48 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  48 out of  48 | elapsed: 275.5min finished
```

Out[75]:

```
GridSearchCV(cv=3,
             estimator=XGBClassifier(base_score=None, booster=None,
                                     colsample_bylevel=None,
                                     colsample_bynode=None,
                                     colsample_bytree=None,
                                     eval_metric='mlogloss', gamma=None,
                                     gpu_id=None, importance_type='gain',
                                     interaction_constraints=None,
                                     learning_rate=None, max_delta_step=Non
e,
                                     max_depth=None, min_child_weight=None,
                                     missing=nan, monotone_constraints=None,
                                     n_estimators=100, n_jobs=None,
                                     num_parallel_tree=None, random_state=4
2,
                                     reg_alpha=None, reg_lambda=None,
                                     scale_pos_weight=None, subsample=None,
                                     tree_method=None, validate_parameters=N
one,
                                     verbosity=None),
             n_jobs=-1,
             param_grid={'max_depth': [2, 3, 4, 5],
                         'n_estimators': [5, 10, 50, 100]},
             return_train_score=True, scoring='roc_auc', verbose=1)
```

In [76]:

```
print(classifier.best_estimator_)
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='mloglos
s',
              gamma=0, gpu_id=-1, importance_type='gain',
              interaction_constraints='', learning_rate=0.300000012,
              max_delta_step=0, max_depth=2, min_child_weight=1, missing=na
n,
              monotone_constraints='()', n_estimators=100, n_jobs=4,
              num_parallel_tree=1, random_state=42, reg_alpha=0, reg_lambda=
1,
              scale_pos_weight=1, subsample=1, tree_method='exact',
              validate_parameters=1, verbosity=None)
```

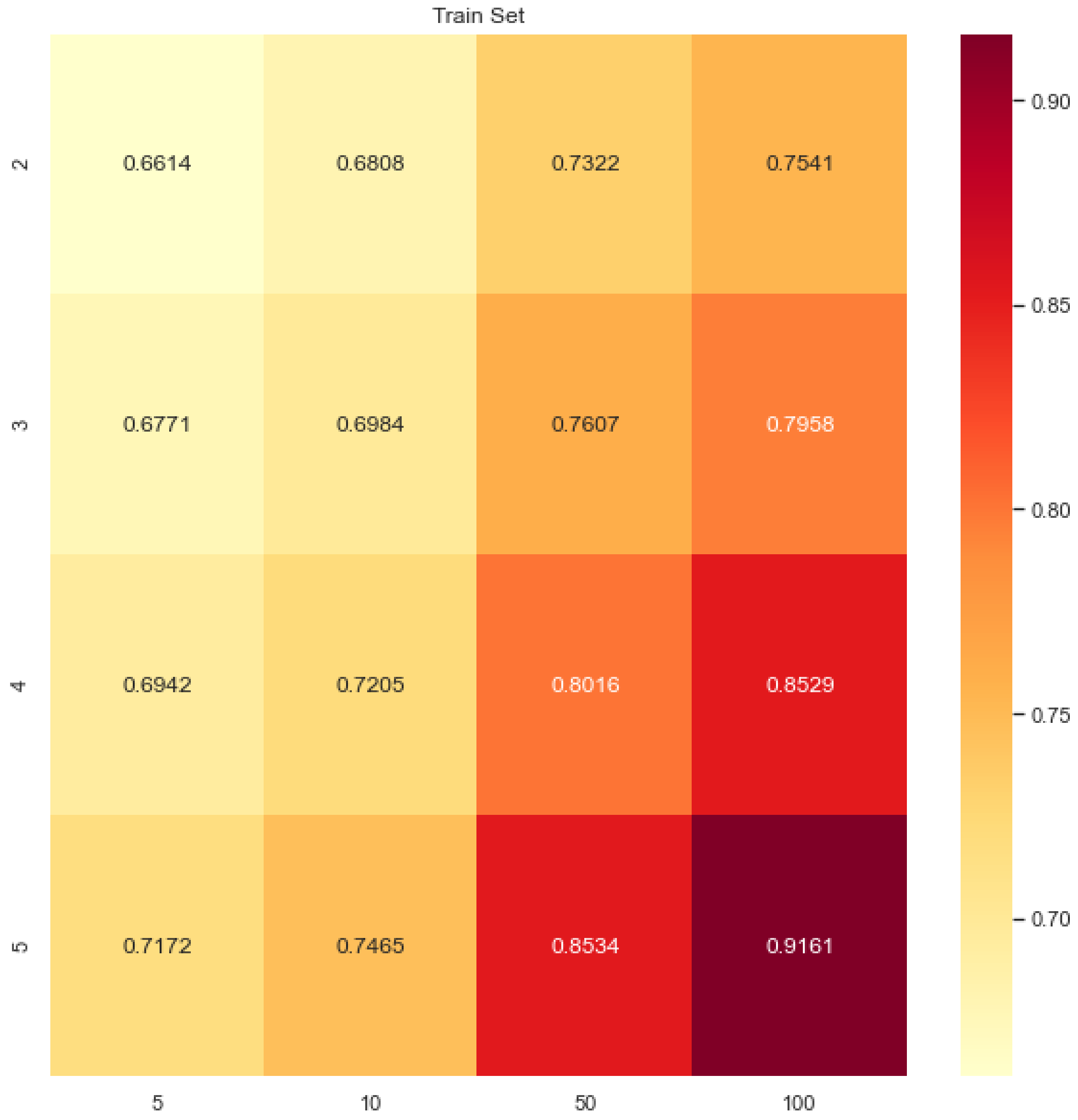
In [75]:

```
max_depth = [2, 3, 4, 5]
n_estimators = [5, 10, 50, 100]

def get_auc_matrix(x_train, x_test, y_train, y_test ):

    train_auc_final_arr, test_auc_final_arr = [], []

    for depth in tqdm(max_depth):
        train_auc_batch, test_auc_batch = [], []

        for num in n_estimators:
            # Below gives large number of warnings
            # xgb_clf = XGBClassifier(n_estimators=num, eta=l_rate, reg_alpha=0, reg_lambda

            # below works after including eval_metric='mlogloss'
            # xgb_clf = XGBClassifier(n_estimators=num, eval_metric='mlogloss', learning_ra

            # Only changing the name of the parameter learning_rate to eta
            xgb_clf = XGBClassifier(n_estimators=num, eval_metric='mlogloss',max_depth=dept

            xgb_clf.fit(x_train, y_train)

            # I have to predict probabilities (clf.predict_proba) instead of classes for ca
            y_train_predicted = xgb_clf.predict_proba(x_train)[:, 1]
            y_test_predicted = xgb_clf.predict_proba(x_test)[:, 1]

            train_auc = roc_auc_score(y_train, y_train_predicted)
            test_auc = roc_auc_score(y_test, y_test_predicted)

            train_auc_batch.append(train_auc)
            test_auc_batch.append(test_auc)

        train_auc_final_arr.append(train_auc_batch)
        test_auc_final_arr.append(test_auc_batch)

    return train_auc_final_arr, test_auc_final_arr


train_auc_final_arr_s2, test_auc_final_arr_s2 = get_auc_matrix(X_train_hstacked_all_tfidf_w
```

```
100%|███████████████████████████████████████████████████████████████████████
█████████| 4/4 [1:58:59<00:00, 1784.98s/it]
```

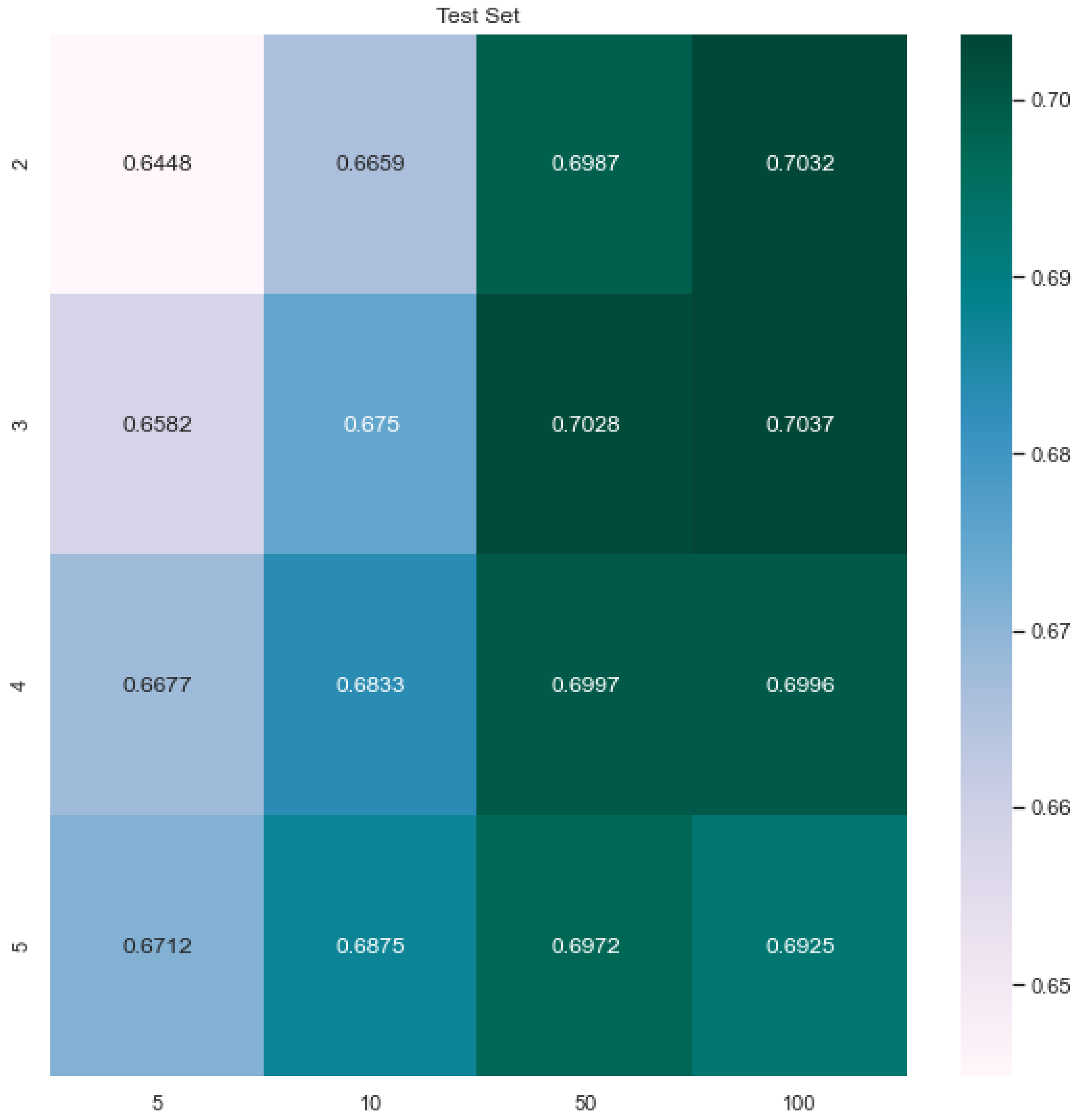
In [76]:

```
## Heatmap for Set S2

train_auc_final_df_s2 = pd.DataFrame(train_auc_final_arr_s2,columns=n_estimators, index=max
fig, ax = plt.subplots(1, figsize=(10,10))
sns.heatmap(train_auc_final_df_s2, annot=True, fmt='.4g', ax=ax,cmap="YlOrRd")
ax.set_title('Train Set')
plt.show()
# train_auc_final_df_s2
```



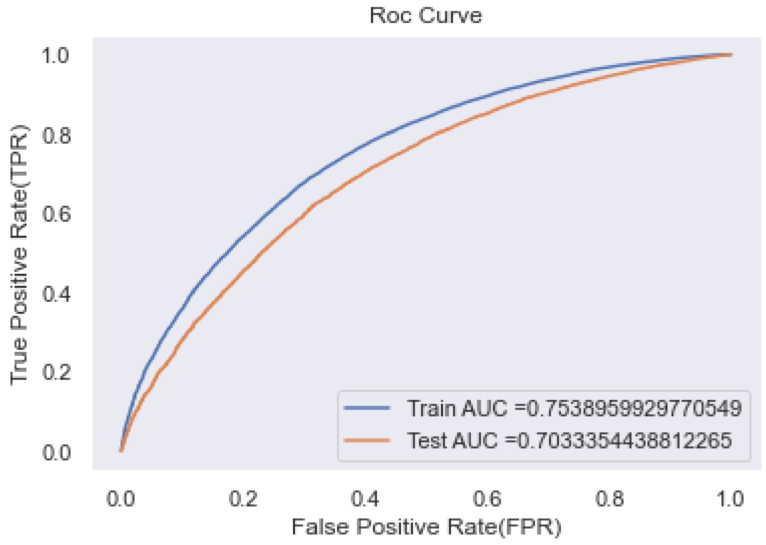
In [77]:

```
## Heatmap for Set S2

test_auc_final_df_s2 = pd.DataFrame(test_auc_final_arr_s2,columns=n_estimators, index=max_d
fig, ax = plt.subplots(1, figsize=(10,10))
sns.heatmap(test_auc_final_df_s2, annot=True, fmt='.4g', ax=ax,cmap="PuBuGn")
ax.set_title('Test Set')
plt.show()
# test_auc_final_df_s2
```



In [78]:

```
#https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.me
from sklearn.metrics import roc_curve, auc
xgb_tfidf_w2v_Model = XGBClassifier(eval_metric='mlogloss',n_estimators=100,max_depth=2)
xgb_tfidf_w2v_Model.fit(X_train_hstacked_all_tfidf_w2v_features_vectorized, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs
# y_train_pred = batch_predict(mnb_bow_testModel, x_train_onehot_bow)
y_train_pred=xgb_tfidf_w2v_Model.predict_proba(X_train_hstacked_all_tfidf_w2v_features_vect
predictions_train_set1=xgb_tfidf_w2v_Model.predict(X_train_hstacked_all_tfidf_w2v_features_

y_test_pred=xgb_tfidf_w2v_Model.predict_proba(test_df_hstacked_all_tfidf_w2v_features_vecto
predictions_test_set1=xgb_tfidf_w2v_Model.predict(test_df_hstacked_all_tfidf_w2v_features_v


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

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



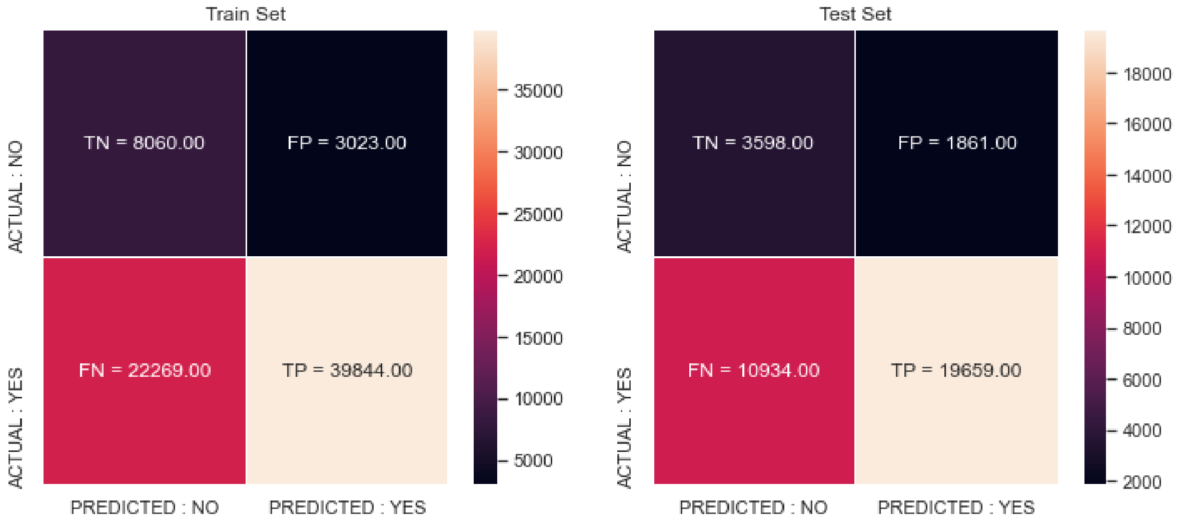
In [79]:

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

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [80]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, tra
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tp

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(12,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.f
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.fl

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],y
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'], y

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.47637898345486945 for threshold 0.854
the maximum value of tpr*(1-fpr) 0.4262495541584087 for threshold 0.843
```



Conclusion:

In [81]:

```
# Please compare all your models using Prettytable library
#how to use pretty table http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= (" Vectorizer ", " Max_depth ", "n_estimators"," Test -AUC ")
tb.add_row([" Tf - Idf", 2 , 100 , 71.56 ])
tb.add_row(["Tf_idf W2v", 2 , 100 ,70.33])
print(tb.get_string(titles = "GBDT- Observations"))
```

```
+--------------+-------------+--------------+-------------+
|  Vectorizer  |  Max_depth  | n_estimators |  Test -AUC  |
+--------------+-------------+--------------+-------------+
|   Tf - Idf   |      2      |     100      |    71.56    |
|  Tf_idf W2v  |      2      |     100      |    70.33    |
+--------------+-------------+--------------+-------------+
```

Refernce:

- https://colab.research.google.com/drive/170sML9x7Edz3vpCJAvbWy81_DUABhJvr (https://colab.research.google.com/drive/170sML9x7Edz3vpCJAvbWy81_DUABhJvr)
- https://github.com/FaisalRasheed99/Applying-Random-Forest-and-XGBoost-on-Donors-Choose-Dataset/blob/master/9_DonorsChoose_RF_GBDT-Solution.ipynb (https://github.com/FaisalRasheed99/Applying-Random-Forest-and-XGBoost-on-Donors-Choose-Dataset/blob/master/9_DonorsChoose_RF_GBDT-Solution.ipynb)