9_DonorsChoose_RF_GBDT

October 9, 2019

1 DonorsChoose

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

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

How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible

```
<li>How to increase the consistency of project vetting across different volunteers to improve t
<li>How to focus volunteer time on the applications that need the most assistance</li>
</ul>
```

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

1.1 About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`

`project_title` | Title of the project. **Examples:**

Art Will Make You Happy!

First Grade Fun

`project_grade_category` | Grade level of students for which the project is targeted. One of the following enumerated values:

Grades PreK-2

Grades 3-5

Grades 6-8

Grades 9-12

`project_subject_categories` | One or more (comma-separated) subject categories for the project from the following enumerated list of values:

Applied Learning
Care & Hunger
Health & Sports
History & Civics
Literacy & Language
Math & Science
Music & The Arts
Special Needs
Warmth
Examples:
Music & The Arts
Literacy & Language, Math & Science

`school_state` | State where school is located (Two-letter U.S. postal code). **Example:** `WY`

`project_subject_subcategories` | One or more (comma-separated) subject subcategories for the project. **Examples:**

Literacy
Literature & Writing, Social Sciences

`project_resource_summary` | An explanation of the resources needed for the project. **Example:**

My students need hands on literacy materials to manage sensory needs!</code

`project_essay_1` | First application essay

`project_essay_2` | *Second application essay* `project_essay_3` | Third application essay ***`project_essay_4`*** | *Fourth application essay* `project_submitted_datetime` | Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`

`teacher_id` | A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`

`teacher_prefix` | Teacher's title. One of the following enumerated values:

nan
Dr.
Mr.
Mrs.
Ms.
Teacher.

`teacher_number_of_previously_posted_projects` | Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

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

1.1.1 Notes on the Essay Data

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

project_essay_1: "Introduce us to your classroom"

project_essay_2: "Tell us more about your students"

project_essay_3: "Describe how your students will use the materials you're requesting"

project_essay_3: "Close by sharing why your project will make a difference"

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

project_essay_1: "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

project_essay_2: "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

```
In [267]: %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.model_selection import train_test_split
          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 collections import Counter
import plotly.offline as offline
import chart_studio.plotly as py
import plotly.graph_objs as go
# import plotly.offline as offline

offline.init_notebook_mode()
# suppress warnings
warnings.filterwarnings("ignore")
```

1.2 1.1 Reading Data

In [269]:
```
res_base_path = '../resources/'

project_data = pd.read_csv( res_base_path + 'train_data.csv',nrows=50000)
resource_data = pd.read_csv(res_base_path + 'resources.csv')
project_data.head(3)
```

Out[269]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	project_subject_categories	project_subject_subcategories	project_title
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2	Literacy & Language	ESL, Literacy	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades 6-8	History & Civics, Health & Sports	Civics & Government, Team Sports	
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grades 6-8	Health & Sports	Health & Wellness, Team Sports	

```
0   Educational Support for English Learners at Home
1               Wanted: Projector for Hungry Learners
2  Soccer Equipment for AWESOME Middle School Stu...

                                      project_essay_1  \
0  My students are English learners that are work...
1  Our students arrive to our school eager to lea...
2  \r\n\"True champions aren't always the ones th...

                                      project_essay_2 project_essay_3  \
0  \"The limits of your language are the limits o...             NaN
1  The projector we need for our school is very c...             NaN
2  The students on the campus come to school know...             NaN

  project_essay_4                          project_resource_summary  \
0             NaN  My students need opportunities to practice beg...
1             NaN  My students need a projector to help with view...
2             NaN  My students need shine guards, athletic socks,...

   teacher_number_of_previously_posted_projects  project_is_approved
0                                             0                   0
1                                             7                   1
2                                             1                   0
```

In [270]:
```
print("Number of data points in project data frame", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in project data frame (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 [271]:
```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/408403
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.c

#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/40
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)

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

```
In [272]: print("Number of data points in our resource data frame", resource_data.shape)
          print(resource_data.columns.values)
          resource_data.head(2)

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

Out[272]:

	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 [273]: # https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for
          price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset
          price_data.head(2)
```

Out[273]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

```
In [274]: # join two dataframes in python:
          project_data = pd.merge(project_data, price_data, on='id', how='left')
          project_data.head(5)
```

Out[274]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_categories	project_subject_subcategories
0	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	Applied Learning	Early Development
1	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	Literacy & Language	Literacy
2	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs.	CA	2016-04-27 01:10:09	Grades 3-5	Math & Science, History & Civics	Mathematics, Social Sciences
3	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms.	CA	2016-04-27 02:04:15	Grades PreK-2	Literacy & Language	ESL, Literacy
4	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms.	IL	2016-04-27 07:19:44	Grades PreK-2	Literacy & Language	Literacy

```
                            project_title  \
0    Flexible Seating for Flexible Learning
1    Going Deep: The Art of Inner Thinking!
2        Breakout Box to Ignite Engagement!
3                          iPad for Learners
4  A flexible classroom for flexible minds!

                                    project_essay_1  \
0  I recently read an article about giving studen...
1  My students crave challenge, they eat obstacle...
2  It's the end of the school year. Routines have...
3  Never has society so rapidly changed. Technolo...
4  My students yearn for a classroom environment ...

                                    project_essay_2  \
0  I teach at a low-income (Title 1) school. Ever...
1  We are an urban, public k-5 elementary school...
2  My students desire challenges, movement, and c...
3  Our Language Arts and Social Justice Magnet Sc...
4  I have the privilege of teaching an incredible...

                                    project_essay_3  \
0  We need a classroom rug that we can use as a c...
1  With the new common core standards that have b...
2  I will design different clues using specific c...
3  \"Is it my turn, Ms. K? When am I going to be ...
4  Ideally, I would love to delve right into \"fl...

                                    project_essay_4  \
0  Benjamin Franklin once said, \"Tell me and I f...
1  These remarkable gifts will provide students w...
2  Donations to this project will immediately imp...
3  By donating to this project, you will give my ...
4  This project will be so beneficial for my stud...

                           project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...
2  My students need items from a \"Breakout Box\"...
3                  My students need 1 ipad mini.
4  My students need 5 Hokki Stools and an easel o...

   teacher_number_of_previously_posted_projects  project_is_approved   price  \
0                                             2                    1  481.04
1                                             2                    1   17.74
2                                             6                    1  102.50
3                                           127                    1  299.99
4                                             1                    1  393.83
```

```
   quantity
0         9
1        14
2        11
3         1
4         9
```

```
In [275]: print("Number of data points in project data after merging price and quantity", proje
          print(project_data.columns.values)
```

```
Number of data points in project data after merging price and quantity (50000, 19)
['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state' 'Date'
 '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' 'price' 'quantity']
```

```
In [276]: project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 50000 entries, 0 to 49999
Data columns (total 19 columns):
Unnamed: 0                                      50000 non-null int64
id                                              50000 non-null object
teacher_id                                      50000 non-null object
teacher_prefix                                  49998 non-null object
school_state                                    50000 non-null object
Date                                            50000 non-null datetime64[ns]
project_grade_category                          50000 non-null object
project_subject_categories                      50000 non-null object
project_subject_subcategories                   50000 non-null object
project_title                                   50000 non-null object
project_essay_1                                 50000 non-null object
project_essay_2                                 50000 non-null object
project_essay_3                                 1685 non-null object
project_essay_4                                 1685 non-null object
project_resource_summary                        50000 non-null object
teacher_number_of_previously_posted_projects    50000 non-null int64
project_is_approved                             50000 non-null int64
price                                           50000 non-null float64
quantity                                        50000 non-null int64
dtypes: datetime64[ns](1), float64(1), int64(4), object(13)
memory usage: 7.6+ MB
```

1.3 1.2 Handling Null Values

In [277]:
```
# from above matric I know that teacher_prefix has 3 null values we need to handle t
# also most of values of project_essay_3 and project_essay_4 are null

project_data["teacher_prefix"].fillna( value = 'Mrs.', inplace = True)
```

In [278]:
```
## 1.5 Combining 4 essay columns to get a single Essay column

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)

project_data.drop(['project_essay_1','project_essay_2','project_essay_3','project_ess
# project_data['essay'].head()
```

In [279]:
```
# it can be clearly seen that we have handled all null values in our data frame.
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 50000 entries, 0 to 49999
Data columns (total 16 columns):
Unnamed: 0                                      50000 non-null int64
id                                              50000 non-null object
teacher_id                                      50000 non-null object
teacher_prefix                                  50000 non-null object
school_state                                    50000 non-null object
Date                                            50000 non-null datetime64[ns]
project_grade_category                          50000 non-null object
project_subject_categories                      50000 non-null object
project_subject_subcategories                   50000 non-null object
project_title                                   50000 non-null object
project_resource_summary                        50000 non-null object
teacher_number_of_previously_posted_projects    50000 non-null int64
project_is_approved                             50000 non-null int64
price                                           50000 non-null float64
quantity                                        50000 non-null int64
essay                                           50000 non-null object
dtypes: datetime64[ns](1), float64(1), int64(4), object(10)
memory usage: 6.5+ MB
```

In [280]:
```
# df_approved = project_data[project_data.project_is_approved==1].tail(500)
# df_rejected = project_data[project_data.project_is_approved==0].tail(500)

# final_df = pd.concat([df_approved, df_rejected])
# print(final_df.shape)

final_df = project_data
```

1.4 1.3 preprocessing of `project_subject_categories`

```
In [281]: def preprocess_text(column_name):
              catogories = list(final_df[column_name].values)
              # remove special characters from list of strings python: https://stackoverflow.c
              # https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
              # https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from
              # https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-
              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",
                      if 'The' in j.split(): # this will split each of the catogory based on sp
                          j=j.replace('The','') # if we have the words "The" we are going to r
                      j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
                      temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
                      temp = temp.replace('&','_') # we are replacing the & value into
                  cat_list.append(temp.strip())
              return cat_list


In [282]: # preprocessing of `project_subject_categories`
          final_df['clean_categories'] = preprocess_text('project_subject_categories')
          final_df.drop(['project_subject_categories'], axis=1, inplace=True)
```

1.5 1.4 preprocessing of `project_subject_subcategories`

```
In [283]: # preprocessing of `project_subject_subcategories`
          final_df['clean_subcategories'] = preprocess_text('project_subject_subcategories')
          final_df.drop(['project_subject_subcategories'], axis=1, inplace=True)
```

1.6 1.5 Adding New Feature `No. of words in project_title`

```
In [284]: final_df['title_word_count'] = final_df['project_title'].apply(lambda x: len(x.split

In [285]: final_df.head(2)

Out[285]:    Unnamed: 0       id                         teacher_id teacher_prefix  \
          0      100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs.
          1       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs.

            school_state                Date project_grade_category  \
          0           GA 2016-04-27 00:53:00          Grades PreK-2
          1           WA 2016-04-27 01:05:25             Grades 3-5

                                    project_title  \
          0  Flexible Seating for Flexible Learning
          1  Going Deep: The Art of Inner Thinking!
```

```
                              project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...

   teacher_number_of_previously_posted_projects  project_is_approved   price  \
0                                             2                    1  481.04
1                                             2                    1   17.74

   quantity                                                 essay  \
0         9  I recently read an article about giving studen...
1        14  My students crave challenge, they eat obstacle...

    clean_categories clean_subcategories  title_word_count
0    AppliedLearning    EarlyDevelopment                 5
1  Literacy_Language           Literacy                 7
```

1.7 1.6 Preprocessing project grade category

```
In [286]: # replacing space with _.
          final_df['project_grade_category'] = final_df['project_grade_category'].apply(lambda
          print('Post Preprocessing: ')
          final_df['project_grade_category'].value_counts()
```

```
Post Preprocessing:
```

```
Out[286]: Grades_PreK_2    20316
          Grades_3_5       16968
          Grades_6_8        7750
          Grades_9_12       4966
          Name: project_grade_category, dtype: int64
```

1.8 1.7 Preprocessing teacher_prefix

```
In [287]: # replacing '.' with ''
          final_df['teacher_prefix'] = final_df['teacher_prefix'].apply(lambda x: x.replace('.
          print('Post Preprocessing: ')
          final_df['teacher_prefix'].value_counts()
```

```
Post Preprocessing:
```

```
Out[287]: Mrs        26142
          Ms         17936
          Mr          4859
          Teacher     1061
          Dr             2
          Name: teacher_prefix, dtype: int64
```

1.9 1.8 Adding New Feature No. of words in Essay

```
In [288]: final_df['essay_word_count'] = final_df['essay'].apply(lambda x: len(x.split()))
```

```
In [289]: final_df.head(2)
```

```
Out[289]:    Unnamed: 0       id                         teacher_id teacher_prefix  \
          0      100660  p234804  cbc0e38f522143b86d372f8b43d4cff3            Mrs
          1       33679  p137682  06f6e62e17de34fcf81020c77549e1d5            Mrs

            school_state                 Date project_grade_category  \
          0           GA  2016-04-27 00:53:00          Grades_PreK_2
          1           WA  2016-04-27 01:05:25             Grades_3_5

                                    project_title  \
          0  Flexible Seating for Flexible Learning
          1  Going Deep: The Art of Inner Thinking!

                                    project_resource_summary  \
          0  My students need flexible seating in the class...
          1  My students need copies of the New York Times ...

             teacher_number_of_previously_posted_projects  project_is_approved   price  \
          0                                             2                    1  481.04
          1                                             2                    1   17.74

             quantity                                              essay  \
          0         9  I recently read an article about giving studen...
          1        14  My students crave challenge, they eat obstacle...

              clean_categories clean_subcategories  title_word_count  essay_word_count
          0    AppliedLearning    EarlyDevelopment                 5               225
          1  Literacy_Language           Literacy                 7               184
```

1.10 1.9 Preprocessing of essay

```
In [290]: # https://stackoverflow.com/a/47091490/4084039
          import re
          from tqdm import tqdm

          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


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


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

In [291]:
```
final_df['clean_essay'] = preprocess_sentences('essay')
final_df.drop(['essay'], axis=1, inplace=True)
final_df.head(2)
```

```
100%|| 50000/50000 [00:30<00:00, 1655.89it/s]
```

Out[291]:
```
   Unnamed: 0       id                         teacher_id teacher_prefix  \
```

```
0      100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs
1       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs

  school_state               Date project_grade_category  \
0           GA 2016-04-27 00:53:00          Grades_PreK_2
1           WA 2016-04-27 01:05:25             Grades_3_5

                           project_title  \
0  Flexible Seating for Flexible Learning
1  Going Deep: The Art of Inner Thinking!

                           project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...

   teacher_number_of_previously_posted_projects  project_is_approved   price  \
0                                             2                    1  481.04
1                                             2                    1   17.74

   quantity   clean_categories clean_subcategories  title_word_count  \
0         9    AppliedLearning    EarlyDevelopment                 5
1        14  Literacy_Language            Literacy                 7

   essay_word_count                                        clean_essay
0               225  recently read article giving students choice l...
1               184  students crave challenge eat obstacles breakfa...
```

1.11 1.10 Preprocessing of `project_title`

In [292]:
```
# preprocessing of `project_title`
final_df['clean_title'] = preprocess_sentences('project_title')
final_df.drop(['project_title'], axis=1, inplace=True)
final_df.head(2)
```

```
100%|| 50000/50000 [00:01<00:00, 37061.12it/s]
```

Out[292]:
```
   Unnamed: 0       id                         teacher_id teacher_prefix  \
0      100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs
1       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs

  school_state               Date project_grade_category  \
0           GA 2016-04-27 00:53:00          Grades_PreK_2
1           WA 2016-04-27 01:05:25             Grades_3_5

                           project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...
```

```
   teacher_number_of_previously_posted_projects  project_is_approved   price  \
0                                             2                    1  481.04
1                                             2                    1   17.74

   quantity   clean_categories clean_subcategories  title_word_count  \
0         9    AppliedLearning    EarlyDevelopment                 5
1        14  Literacy_Language            Literacy                 7

   essay_word_count                                        clean_essay  \
0               225  recently read article giving students choice l...
1               184  students crave challenge eat obstacles breakfa...

                         clean_title
0  flexible seating flexible learning
1       going deep art inner thinking
```

1.12 1.11 Calculate Sentiment Scores for the essays

In [293]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
nltk.download('vader_lexicon')

analyzer = SentimentIntensityAnalyzer()

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

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

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

```
[nltk_data] Downloading package vader_lexicon to
```

```
[nltk_data]     /Users/rohitsingh/nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

```
In [295]: import nltk
          from nltk.sentiment.vader import SentimentIntensityAnalyzer


          neg=[]
          pos=[]
          neu=[]
          compound = []

          for i in tqdm(range(len(final_df['clean_essay']))):
              sentiment_scores = analyzer.polarity_scores(final_df['clean_essay'][i])
              neg.append(sentiment_scores['neg'])
              pos.append(sentiment_scores['pos'])
              neu.append(sentiment_scores['neu'])
              compound.append(sentiment_scores['compound'])


          final_df['essay_sent_pos'] = pos
          final_df['essay_sent_neg'] = neg
          final_df['essay_sent_neu'] = neu
          final_df['essay_sent_compound'] = compound



          # final_df['essay_sent_pos'] = final_df['clean_essay'].apply(lambda x: analyzer.pola
          # final_df['essay_sent_neg'] = final_df['clean_essay'].apply(lambda x: analyzer.pola
          # final_df['essay_sent_neu'] = final_df['clean_essay'].apply(lambda x: analyzer.pola
          # final_df['essay_sent_compound'] = final_df['clean_essay'].apply(lambda x: analyzer

          final_df.head()
```

```
100%|| 50000/50000 [01:18<00:00, 638.58it/s]
```

Out[295]:

	Unnamed: 0	id	teacher_id	teacher_prefix	\
0	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs	
1	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs	
2	146723	p099708	c0a28c79fe8ad5810da49de47b3fb491	Mrs	
3	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms	
4	57854	p099430	4000cfe0c8b2df75a218347c1765e283	Ms	

	school_state	Date	project_grade_category	\
0	GA	2016-04-27 00:53:00	Grades_PreK_2	
1	WA	2016-04-27 01:05:25	Grades_3_5	

```
2          CA 2016-04-27 01:10:09            Grades_3_5
3          CA 2016-04-27 02:04:15         Grades_PreK_2
4          IL 2016-04-27 07:19:44         Grades_PreK_2

                          project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...
2  My students need items from a \"Breakout Box\"...
3                  My students need 1 ipad mini.
4  My students need 5 Hokki Stools and an easel o...

   teacher_number_of_previously_posted_projects  project_is_approved  ...  \
0                                             2                   1  ...
1                                             2                   1  ...
2                                             6                   1  ...
3                                           127                   1  ...
4                                             1                   1  ...

             clean_categories         clean_subcategories title_word_count  \
0             AppliedLearning            EarlyDevelopment                5
1           Literacy_Language                    Literacy                7
2  Math_Science History_Civics  Mathematics SocialSciences                5
3           Literacy_Language                ESL Literacy                3
4           Literacy_Language                    Literacy                6

  essay_word_count                                        clean_essay  \
0              225  recently read article giving students choice l...
1              184  students crave challenge eat obstacles breakfa...
2              285  end school year routines run course students n...
3              317  never society rapidly changed technology invad...
4              275  students yearn classroom environment matches d...

                        clean_title essay_sent_pos essay_sent_neg  \
0  flexible seating flexible learning         0.194         0.031
1       going deep art inner thinking         0.315         0.031
2      breakout box ignite engagement         0.295         0.014
3                    ipad learners         0.164         0.068
4   flexible classroom flexible minds         0.424         0.012

   essay_sent_neu  essay_sent_compound
0           0.775               0.9524
1           0.653               0.9873
2           0.691               0.9935
3           0.768               0.9484
4           0.564               0.9976

[5 rows x 22 columns]
```

2.1 Splitting data into Train, Cross validation and Test: Stratified Sampling

```
In [297]: # I have divided the data into train, cv and test set with ratio 60:20:20 .

          y_true = final_df['project_is_approved']

          # X_1, X_test, y_1, y_test = train_test_split(final_df, y_true, test_size=0.2, rando
          # X_train, X_cv, y_train, y_cv = train_test_split(X_1, y_1, test_size=0.2,random_sta

          X_1, X_test, y_1, y_test = train_test_split(final_df, y_true, stratify=y_true, test_
          X_train, X_cv, y_train, y_cv = train_test_split(X_1, y_1, test_size=0.2, stratify=y_

In [298]: # X_train.drop(['project_is_approved'], axis=1, inplace=True)
          # X_cv.drop(['project_is_approved'], axis=1, inplace=True)
          # X_test.drop(['project_is_approved'], axis=1, inplace=True)
```

2.2 Make Data Model Ready: encoding numerical, categorical features

```
In [299]: X_train.columns

Out[299]: Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
                 'Date', 'project_grade_category', 'project_resource_summary',
                 'teacher_number_of_previously_posted_projects', 'project_is_approved',
                 'price', 'quantity', 'clean_categories', 'clean_subcategories',
                 'title_word_count', 'essay_word_count', 'clean_essay', 'clean_title',
                 'essay_sent_pos', 'essay_sent_neg', 'essay_sent_neu',
                 'essay_sent_compound'],
                dtype='object')
```

we are going to consider

```
- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- title_word_count: No. of words in project_title
_ essay_word_count: No. of words in essay.


- project_grade_category : categorical data
- teacher_prefix : categorical data

- clean_title : text data
- clean_essay : text data
- project_resource_summary: text data (optinal)

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

2.2.1 Vectorizing numerical features

- I am using one hot encoding technique to encode our categorical features.

A) Price

```
In [300]: # encoding price
          from sklearn.preprocessing import StandardScaler

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


          standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['price'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

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


          print('Post Standardization')
          print(price_train.shape, y_train.shape)
          print(price_cv.shape, y_cv.shape)
          print(price_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 300.18863124999996, Standard deviation : 379.86522901654905

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

B) Quantity

```
In [301]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['quantity'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          quantity_train = standardizer.transform(X_train['quantity'].values.reshape(-1, 1))
```

```
        quantity_cv = standardizer.transform(X_cv['quantity'].values.reshape(-1, 1))
        quantity_test = standardizer.transform(X_test['quantity'].values.reshape(-1, 1))


        print('Post Standardization')
        print(quantity_train.shape, y_train.shape)
        print(quantity_cv.shape, y_cv.shape)
        print(quantity_test.shape, y_test.shape)
        print('*'*100)
```

```
Mean : 17.15259375, Standard deviation : 26.355897042169918

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

C) Number of projects previously posted by Teacher

```
In [302]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.resha
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          prev_teacher_proj_train = standardizer.transform(X_train['teacher_number_of_previousl
          prev_teacher_proj_cv = standardizer.transform(X_cv['teacher_number_of_previously_post
          prev_teacher_proj_test = standardizer.transform(X_test['teacher_number_of_previously_


          print('Post Standardization')
          print(prev_teacher_proj_train.shape, y_train.shape)
          print(prev_teacher_proj_cv.shape, y_cv.shape)
          print(prev_teacher_proj_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 11.27425, Standard deviation : 28.24448573505101

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

D) Title word Count

```
In [303]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['title_word_count'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          title_word_count_train = standardizer.transform(X_train['title_word_count'].values.re
          title_word_count_cv = standardizer.transform(X_cv['title_word_count'].values.reshape
          title_word_count_test = standardizer.transform(X_test['title_word_count'].values.resh


          print('Post Standardization')
          print(title_word_count_train.shape, y_train.shape)
          print(title_word_count_cv.shape, y_cv.shape)
          print(title_word_count_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 5.1594375, Standard deviation : 2.1039141340828884

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

E) Essay word Count

```
In [304]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['essay_word_count'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          essay_word_count_train = standardizer.transform(X_train['essay_word_count'].values.re
          essay_word_count_cv = standardizer.transform(X_cv['essay_word_count'].values.reshape
          essay_word_count_test = standardizer.transform(X_test['essay_word_count'].values.resh


          print('Post Standardization')
          print(essay_word_count_train.shape, y_train.shape)
          print(essay_word_count_cv.shape, y_cv.shape)
          print(essay_word_count_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 255.203, Standard deviation : 65.4401237086239

Post Standardization
(32000, 1) (32000,)
```

```
(8000, 1) (8000,)
(10000, 1) (10000,)
**********
```

F) Essay Sentiment Pos

```
In [305]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['essay_sent_pos'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          essay_sent_pos_train = standardizer.transform(X_train['essay_sent_pos'].values.reshap
          essay_sent_pos_cv = standardizer.transform(X_cv['essay_sent_pos'].values.reshape(-1,
          essay_sent_pos_test = standardizer.transform(X_test['essay_sent_pos'].values.reshape


          print('Post Standardization')
          print(essay_sent_pos_train.shape, y_train.shape)
          print(essay_sent_pos_cv.shape, y_cv.shape)
          print(essay_sent_pos_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.28189700000000006, Standard deviation : 0.07763431476157949

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
**********
```

G) Essay Sentiment Neg

```
In [306]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['essay_sent_neg'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          essay_sent_neg_train = standardizer.transform(X_train['essay_sent_neg'].values.reshap
          essay_sent_neg_cv = standardizer.transform(X_cv['essay_sent_neg'].values.reshape(-1,
          essay_sent_neg_test = standardizer.transform(X_test['essay_sent_neg'].values.reshape

          print('Post Standardization')
          print(essay_sent_neg_train.shape, y_train.shape)
          print(essay_sent_neg_cv.shape, y_cv.shape)
          print(essay_sent_neg_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.047956874999999996, Standard deviation : 0.03577885744730224

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
**************************************************************************************************
```

H) Essay Sentiment Neu

```
In [307]: # final_df['essay_sent_neu'] = final_df['clean_essay'].apply(lambda x: analyzer.pola

          standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['essay_sent_neu'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          essay_sent_neu_train = standardizer.transform(X_train['essay_sent_neu'].values.reshap
          essay_sent_neu_cv = standardizer.transform(X_cv['essay_sent_neu'].values.reshape(-1,
          essay_sent_neu_test = standardizer.transform(X_test['essay_sent_neu'].values.reshape

          print('Post Standardization')
          print(essay_sent_neu_train.shape, y_train.shape)
          print(essay_sent_neu_cv.shape, y_cv.shape)
          print(essay_sent_neu_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.67014475, Standard deviation : 0.07556945843022497

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
**************************************************************************************************
```

I) Essay Sentiment Compound

```
In [308]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['essay_sent_compound'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          essay_sent_compound_train = standardizer.transform(X_train['essay_sent_compound'].val
          essay_sent_compound_cv = standardizer.transform(X_cv['essay_sent_compound'].values.re
          essay_sent_compound_test = standardizer.transform(X_test['essay_sent_compound'].value
```

```
        print('Post Standardization')
        print(essay_sent_compound_train.shape, y_train.shape)
        print(essay_sent_compound_cv.shape, y_cv.shape)
        print(essay_sent_compound_test.shape, y_test.shape)
        print('*'*100)
```

```
Mean : 0.9588204906250001, Standard deviation : 0.1525656035626864

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

1.13 2.2.2 Encoding categorical features (Response Coding)

```
In [309]: from sklearn.feature_extraction.text import CountVectorizer
          from collections import Counter
```

```
In [310]: proj_approved = X_train[project_data.project_is_approved==1]
          proj_rejected = X_train[project_data.project_is_approved==0]


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


          print(proj_approved.shape)
          print(proj_rejected.shape)
```

```
(27063, 22)
(4937, 22)
```

A) Encoding clean_categories

```
In [311]: all_proj_categories = X_train['clean_categories'].value_counts()
          approved_proj_categories = proj_approved['clean_categories'].value_counts()
          rejected_proj_categories = proj_rejected['clean_categories'].value_counts()

          approved_cat = {}
          rejected_cat = {}

          for key, val in approved_proj_categories.iteritems():
              approved_cat[key] = val / all_proj_categories[key]
```

```
    for key, val in rejected_proj_categories.iteritems():
        rejected_cat[key] = val / all_proj_categories[key]


    print('Approved Project Categories: ')
    print(approved_cat)
    print('*'*100)

    print('Rejected Project Categories: ')
    print(rejected_cat)
    print('*'*100)


    X_train['categories_approved'] = X_train['clean_categories'].apply(lambda x: approved
    X_train['categories_rejected'] = X_train['clean_categories'].apply(lambda x: rejected

    X_cv['categories_approved'] = X_cv['clean_categories'].apply(lambda x: approved_cat[x
    X_cv['categories_rejected'] = X_cv['clean_categories'].apply(lambda x: rejected_cat[x

    X_test['categories_approved'] = X_test['clean_categories'].apply(lambda x: approved_
    X_test['categories_rejected'] = X_test['clean_categories'].apply(lambda x: rejected_


    X_test.head(2)
```

```
Approved Project Categories:
{'Literacy_Language': 0.8676092544987146, 'Math_Science': 0.8144622240226859, 'Literacy_Languag
**************************************************************************************************
Rejected Project Categories:
{'Literacy_Language': 0.13239074550128535, 'Math_Science': 0.18553777597731416, 'Literacy_Langu
**************************************************************************************************
```

Out[311]:

	Unnamed: 0	id	teacher_id	teacher_prefix
39510	97629	p030866	51e1ea41970d4da12b26c8a9517198a0	Mrs
37058	110225	p029816	78563a0f693b77d5cad7216898d5b695	Ms

	school_state	Date	project_grade_category
39510	AL	2017-01-26 11:31:02	Grades_3_5
37058	GA	2017-01-08 21:04:31	Grades_PreK_2

	project_resource_summary
39510	My students need one special needs swing to en...
37058	My students need Chromebooks in our classroom ...

	teacher_number_of_previously_posted_projects	price	...
39510	12	447.29	...

```
37058                                          5  242.29  ...

       title_word_count essay_word_count  \
39510                 3              208
37058                 2              235

                                                clean_essay          clean_title  \
39510  pe teacher elementary school poverty level stu...  special needs swing
37058  every day adventure every day great day classr...     chromebook craze

       essay_sent_pos essay_sent_neg essay_sent_neu  essay_sent_compound  \
39510           0.335          0.063          0.601                0.9847
37058           0.281          0.012          0.707                0.9921

       categories_approved  categories_rejected
39510             0.806131             0.193869
37058             0.863268             0.136732

[2 rows x 23 columns]
```

In [312]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['categories_approved'].values.reshape(-1,1))
print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

# Now standardize the data with above mean and variance.

categories_approved_train = standardizer.transform(X_train['categories_approved'].val
categories_approved_cv = standardizer.transform(X_cv['categories_approved'].values.re
categories_approved_test = standardizer.transform(X_test['categories_approved'].value


print('Post Standardization')
print(categories_approved_train.shape, y_train.shape)
print(categories_approved_cv.shape, y_cv.shape)
print(categories_approved_test.shape, y_test.shape)
print('*'*100)
```

```
Mean : 0.84575, Standard deviation : 0.030535329539086557

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************
```

In [313]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['categories_rejected'].values.reshape(-1,1))
```

```
        print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

        # Now standardize the data with above mean and variance.

        categories_rejected_train = standardizer.transform(X_train['categories_rejected'].val
        categories_rejected_cv = standardizer.transform(X_cv['categories_rejected'].values.re
        categories_rejected_test = standardizer.transform(X_test['categories_rejected'].value


        print('Post Standardization')
        print(categories_rejected_train.shape, y_train.shape)
        print(categories_rejected_cv.shape, y_cv.shape)
        print(categories_rejected_test.shape, y_test.shape)
        print('*'*100)
```

```
Mean : 0.154625, Standard deviation : 0.034519244271284576

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

B) Encoding clean_subcategories

```
In [314]: all_proj_sub_categories = X_train['clean_subcategories'].value_counts()
          approved_proj_sub_categories = proj_approved['clean_subcategories'].value_counts()
          rejected_proj_sub_categories = proj_rejected['clean_subcategories'].value_counts()

          approved_sub_cat = {}
          rejected_sub_cat = {}

          for key, val in approved_proj_sub_categories.iteritems():
              approved_sub_cat[key] = val / all_proj_sub_categories[key]

          for key, val in rejected_proj_sub_categories.iteritems():
              rejected_sub_cat[key] = val / all_proj_sub_categories[key]


          print('Approved Project Sub Categories: ')
          print(approved_sub_cat)
          print('*'*100)

          print('Rejected Project Sub Categories: ')
          print(rejected_sub_cat)
          print('*'*100)
```

```
X_train['sub_categories_approved'] = X_train['clean_subcategories'].apply(lambda x: a
X_train['sub_categories_rejected'] = X_train['clean_subcategories'].apply(lambda x: r

X_cv['sub_categories_approved'] = X_cv['clean_subcategories'].apply(lambda x: approve
X_cv['sub_categories_rejected'] = X_cv['clean_subcategories'].apply(lambda x: rejecte

X_test['sub_categories_approved'] = X_test['clean_subcategories'].apply(lambda x: app
X_test['sub_categories_rejected'] = X_test['clean_subcategories'].apply(lambda x: rej


X_test.head(2)
```

```
Approved Project Sub Categories:
{'Literacy': 0.8907296439901304, 'Literacy Mathematics': 0.8674749163879598, 'Literature_Writin
```

Out[314]:

	Unnamed: 0	id	teacher_id	teacher_prefix	\
39510	97629	p030866	51e1ea41970d4da12b26c8a9517198a0	Mrs	
37058	110225	p029816	78563a0f693b77d5cad7216898d5b695	Ms	

	school_state	Date	project_grade_category	\
39510	AL	2017-01-26 11:31:02	Grades_3_5	
37058	GA	2017-01-08 21:04:31	Grades_PreK_2	

	project_resource_summary	\
39510	My students need one special needs swing to en...	
37058	My students need Chromebooks in our classroom ...	

	teacher_number_of_previously_posted_projects	price	...	\
39510	12	447.29	...	
37058	5	242.29	...	

	clean_essay	clean_title	\
39510	pe teacher elementary school poverty level stu...	special needs swing	
37058	every day adventure every day great day classr...	chromebook craze	

	essay_sent_pos	essay_sent_neg	essay_sent_neu	essay_sent_compound	\
39510	0.335	0.063	0.601	0.9847	
37058	0.281	0.012	0.707	0.9921	

	categories_approved	categories_rejected	sub_categories_approved	\
39510	0.806131	0.193869	0.806131	
37058	0.863268	0.136732	0.860329	

```
       sub_categories_rejected
39510                 0.193869
37058                 0.139671

[2 rows x 25 columns]
```

```
In [315]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['sub_categories_approved'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          sub_categories_approved_train = standardizer.transform(X_train['sub_categories_approv
          sub_categories_approved_cv = standardizer.transform(X_cv['sub_categories_approved'].v
          sub_categories_approved_test = standardizer.transform(X_test['sub_categories_approved


          print('Post Standardization')
          print(sub_categories_approved_train.shape, y_train.shape)
          print(sub_categories_approved_cv.shape, y_cv.shape)
          print(sub_categories_approved_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.84621875, Standard deviation : 0.048390147935883934

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

```
In [316]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['sub_categories_rejected'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          sub_categories_rejected_train = standardizer.transform(X_train['sub_categories_rejec
          sub_categories_rejected_cv = standardizer.transform(X_cv['sub_categories_rejected'].v
          sub_categories_rejected_test = standardizer.transform(X_test['sub_categories_rejected


          print('Post Standardization')
          print(sub_categories_rejected_train.shape, y_train.shape)
          print(sub_categories_rejected_cv.shape, y_cv.shape)
          print(sub_categories_rejected_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.16271875, Standard deviation : 0.0919259901619598

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
**********
```

C) Encoding school_state

```
In [317]: all_school_states = X_train['school_state'].value_counts()
          approved_school_states = proj_approved['school_state'].value_counts()
          rejected_school_states = proj_rejected['school_state'].value_counts()

          approved_states = {}
          rejected_states = {}

          for key, val in approved_school_states.iteritems():
              approved_states[key] = val / all_school_states[key]

          for key, val in rejected_school_states.iteritems():
              rejected_states[key] = val / all_school_states[key]


          print('Approved School States:')
          print(approved_states)
          print('*'*100)

          print('Rejected School States:')
          print(rejected_states)
          print('*'*100)

          X_train['school_state_approved'] = X_train['school_state'].apply(lambda x: approved_s
          X_train['school_state_rejected'] = X_train['school_state'].apply(lambda x: rejected_s

          X_cv['school_state_approved'] = X_cv['school_state'].apply(lambda x: approved_states
          X_cv['school_state_rejected'] = X_cv['school_state'].apply(lambda x: rejected_states

          X_test['school_state_approved'] = X_test['school_state'].apply(lambda x: approved_sta
          X_test['school_state_rejected'] = X_test['school_state'].apply(lambda x: rejected_sta


          X_test.head(2)
```

```
Approved School States:
{'CA': 0.8558981233243967, 'NY': 0.8603910868576625, 'TX': 0.8045540796963947, 'FL': 0.81661271
**********
```

```
Rejected School States:
{'CA': 0.14410187667560323, 'TX': 0.1954459203036053, 'FL': 0.18338727076591155, 'NY': 0.139608
**********************************************************************************************
```

Out[317]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_resource_summary	teacher_number_of_previously_posted_projects	price	...	essay_sent_pos	essay_sent_neg	essay_sent_neu	essay_sent_compound	categories_approved	categories_rejected	sub_categories_approved	sub_categories_rejected	school_state_approved	school_state_rejected
39510	97629	p030866	51e1ea41970d4da12b26c8a9517198a0	Mrs	AL	2017-01-26 11:31:02	Grades_3_5	My students need one special needs swing to en...	12	447.29	...	0.335	0.063	0.601	0.9847	0.806131	0.193869	0.806131	0.193869	0.843750	0.156250
37058	110225	p029816	78563a0f693b77d5cad7216898d5b695	Ms	GA	2017-01-08 21:04:31	Grades_PreK_2	My students need Chromebooks in our classroom ...	5	242.29	...	0.281	0.012	0.707	0.9921	0.863268	0.136732	0.860329	0.139671	0.847257	0.152743

[2 rows x 27 columns]

In [318]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['school_state_approved'].values.reshape(-1,1))
print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

# Now standardize the data with above mean and variance.

school_state_approved_train = standardizer.transform(X_train['school_state_approved']
school_state_approved_cv = standardizer.transform(X_cv['school_state_approved'].value
school_state_approved_test = standardizer.transform(X_test['school_state_approved'].v



print('Post Standardization')
```

```
          print(school_state_approved_train.shape, y_train.shape)
          print(school_state_approved_cv.shape, y_cv.shape)
          print(school_state_approved_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.84571875, Standard deviation : 0.020942484553066854

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

```
In [319]: standardizer = StandardScaler(with_mean=False)
          standardizer.fit(X_train['school_state_rejected'].values.reshape(-1,1))
          print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

          # Now standardize the data with above mean and variance.

          school_state_rejected_train = standardizer.transform(X_train['school_state_rejected']
          school_state_rejected_cv = standardizer.transform(X_cv['school_state_rejected'].value
          school_state_rejected_test = standardizer.transform(X_test['school_state_rejected'].v


          print('Post Standardization')
          print(school_state_rejected_train.shape, y_train.shape)
          print(school_state_rejected_cv.shape, y_cv.shape)
          print(school_state_rejected_test.shape, y_test.shape)
          print('*'*100)
```

```
Mean : 0.15428125, Standard deviation : 0.020942484553066857

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

D) Encoding teacher_prefix

```
In [320]: all_teacher_prefix = X_train['teacher_prefix'].value_counts()
          approved_teacher_prefix= proj_approved['teacher_prefix'].value_counts()
          rejected_teacher_prefix = proj_rejected['teacher_prefix'].value_counts()

          approved_teac_prefix = {}
          rejected_teac_prefix = {}
```

```
for key, val in approved_teacher_prefix.iteritems():
    approved_teac_prefix[key] = val / all_teacher_prefix[key]

for key, val in rejected_teacher_prefix.iteritems():
    rejected_teac_prefix[key] = val / all_teacher_prefix[key]


print('Approved Teacher Prefix: ')
print(approved_cat)
print('*'*100)

print('Rejected Teacher Prefix: ')
print(rejected_cat)
print('*'*100)

X_train['teacher_prefix_approved'] = X_train['teacher_prefix'].apply(lambda x: approv
X_train['teacher_prefix_rejected'] = X_train['teacher_prefix'].apply(lambda x: reject

X_cv['teacher_prefix_approved'] = X_cv['teacher_prefix'].apply(lambda x: approved_tea
X_cv['teacher_prefix_rejected'] = X_cv['teacher_prefix'].apply(lambda x: rejected_tea

X_test['teacher_prefix_approved'] = X_test['teacher_prefix'].apply(lambda x: approved
X_test['teacher_prefix_rejected'] = X_test['teacher_prefix'].apply(lambda x: rejected


X_test.head(2)
```

```
Approved Teacher Prefix:
{'Literacy_Language': 0.8676092544987146, 'Math_Science': 0.8144622240226859, 'Literacy_Languag
**********************************************************************************************
Rejected Teacher Prefix:
{'Literacy_Language': 0.13239074550128535, 'Math_Science': 0.18553777597731416, 'Literacy_Langu
**********************************************************************************************
```

Out[320]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_resource_summary	teacher_number_of_previously_posted_projects	price	...
39510	97629	p030866	51e1ea41970d4da12b26c8a9517198a0	Mrs	AL	2017-01-26 11:31:02	Grades_3_5	My students need one special needs swing to en...			
37058	110225	p029816	78563a0f693b77d5cad7216898d5b695	Ms	GA	2017-01-08 21:04:31	Grades_PreK_2	My students need Chromebooks in our classroom ...			

```
39510                                          12  447.29  ...
37058                                           5  242.29  ...

       essay_sent_neu essay_sent_compound categories_approved  \
39510           0.601              0.9847              0.806131
37058           0.707              0.9921              0.863268

       categories_rejected  sub_categories_approved sub_categories_rejected  \
39510             0.193869                 0.806131                 0.193869
37058             0.136732                 0.860329                 0.139671

      school_state_approved  school_state_rejected  teacher_prefix_approved  \
39510              0.843750               0.156250                 0.850938
37058              0.847257               0.152743                 0.842814

       teacher_prefix_rejected
39510                 0.149062
37058                 0.157186

[2 rows x 29 columns]
```

In [321]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['teacher_prefix_approved'].values.reshape(-1,1))
print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

# Now standardize the data with above mean and variance.

teacher_prefix_approved_train = standardizer.transform(X_train['teacher_prefix_approv
teacher_prefix_approved_cv = standardizer.transform(X_cv['teacher_prefix_approved'].v
teacher_prefix_approved_test = standardizer.transform(X_test['teacher_prefix_approve



print('Post Standardization')
print(teacher_prefix_approved_train.shape, y_train.shape)
print(teacher_prefix_approved_cv.shape, y_cv.shape)
print(teacher_prefix_approved_test.shape, y_test.shape)
print('*'*100)
```

```
Mean : 0.84575, Standard deviation : 0.007412981197679975

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

In [322]:
```
standardizer = StandardScaler(with_mean=False)
```

```
        standardizer.fit(X_train['teacher_prefix_rejected'].values.reshape(-1,1))
        print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

        # Now standardize the data with above mean and variance.

        teacher_prefix_rejected_train = standardizer.transform(X_train['teacher_prefix_reject
        teacher_prefix_rejected_cv = standardizer.transform(X_cv['teacher_prefix_rejected'].v
        teacher_prefix_rejected_test = standardizer.transform(X_test['teacher_prefix_rejected


        print('Post Standardization')
        print(teacher_prefix_rejected_train.shape, y_train.shape)
        print(teacher_prefix_rejected_cv.shape, y_cv.shape)
        print(teacher_prefix_rejected_test.shape, y_test.shape)
        print('*'*100)
```

```
Mean : 0.15428125, Standard deviation : 0.008749896495082489

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

E) Encoding project_grade_category

```
In [323]: all_project_grade_category = X_train['project_grade_category'].value_counts()
          approved_project_grade_category = proj_approved['project_grade_category'].value_count
          rejected_project_grade_category = proj_rejected['project_grade_category'].value_count

          approved_proj_grad_cat = {}
          rejected_proj_grad_cat = {}

          for key, val in approved_project_grade_category.iteritems():
              approved_proj_grad_cat[key] = val / all_project_grade_category[key]

          for key, val in rejected_project_grade_category.iteritems():
              rejected_proj_grad_cat[key] = val / all_project_grade_category[key]


          print('Approved Project grade category: ')
          print(approved_proj_grad_cat)
          print('*'*100)

          print('Rejected Project grade category: ')
          print(rejected_proj_grad_cat)
          print('*'*100)
```

```
X_train['proj_grade_cat_approved'] = X_train['project_grade_category'].apply(lambda x
X_train['proj_grade_cat_rejected'] = X_train['project_grade_category'].apply(lambda x

X_cv['proj_grade_cat_approved'] = X_cv['project_grade_category'].apply(lambda x: appr
X_cv['proj_grade_cat_rejected'] = X_cv['project_grade_category'].apply(lambda x: rejc

X_test['proj_grade_cat_approved'] = X_test['project_grade_category'].apply(lambda x:
X_test['proj_grade_cat_rejected'] = X_test['project_grade_category'].apply(lambda x:


X_test.head(2)
```

```
Approved Project grade category:
{'Grades_PreK_2': 0.8461776779490358, 'Grades_3_5': 0.8527053184625311, 'Grades_6_8': 0.838690
**********************************************************************************************
Rejected Project grade category:
{'Grades_PreK_2': 0.1538223220509643, 'Grades_3_5': 0.14729468153746889, 'Grades_6_8': 0.16130
**********************************************************************************************
```

Out[323]:

	Unnamed: 0	id	teacher_id	teacher_prefix	\
39510	97629	p030866	51e1ea41970d4da12b26c8a9517198a0	Mrs	
37058	110225	p029816	78563a0f693b77d5cad7216898d5b695	Ms	

	school_state	Date	project_grade_category	\
39510	AL	2017-01-26 11:31:02	Grades_3_5	
37058	GA	2017-01-08 21:04:31	Grades_PreK_2	

	project_resource_summary	\
39510	My students need one special needs swing to en...	
37058	My students need Chromebooks in our classroom ...	

	teacher_number_of_previously_posted_projects	price	...	\
39510	12	447.29	...	
37058	5	242.29	...	

	categories_approved	categories_rejected	sub_categories_approved	\
39510	0.806131	0.193869	0.806131	
37058	0.863268	0.136732	0.860329	

	sub_categories_rejected	school_state_approved	school_state_rejected	\
39510	0.193869	0.843750	0.156250	
37058	0.139671	0.847257	0.152743	

	teacher_prefix_approved	teacher_prefix_rejected	\
39510	0.850938	0.149062	
37058	0.842814	0.157186	

```
       proj_grade_cat_approved  proj_grade_cat_rejected
39510                 0.852705                 0.147295
37058                 0.846178                 0.153822

[2 rows x 31 columns]
```

In [324]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['proj_grade_cat_approved'].values.reshape(-1,1))
print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

# Now standardize the data with above mean and variance.

proj_grade_cat_approved_train = standardizer.transform(X_train['proj_grade_cat_approv
proj_grade_cat_approved_cv = standardizer.transform(X_cv['proj_grade_cat_approved'].v
proj_grade_cat_approved_test = standardizer.transform(X_test['proj_grade_cat_approved


print('Post Standardization')
print(proj_grade_cat_approved_train.shape, y_train.shape)
print(proj_grade_cat_approved_cv.shape, y_cv.shape)
print(proj_grade_cat_approved_test.shape, y_test.shape)
print('*'*100)
```

```
Mean : 0.8457187500000002, Standard deviation : 0.0067262540530419294

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
****************************************************************************************************
```

In [325]:
```
standardizer = StandardScaler(with_mean=False)
standardizer.fit(X_train['proj_grade_cat_rejected'].values.reshape(-1,1))
print(f"Mean : {standardizer.mean_[0]}, Standard deviation : {np.sqrt(standardizer.va

# Now standardize the data with above mean and variance.

proj_grade_cat_rejected_train = standardizer.transform(X_train['proj_grade_cat_reject
proj_grade_cat_rejected_cv = standardizer.transform(X_cv['proj_grade_cat_rejected'].v
proj_grade_cat_rejected_test = standardizer.transform(X_test['proj_grade_cat_rejected


print('Post Standardization')
print(proj_grade_cat_rejected_train.shape, y_train.shape)
print(proj_grade_cat_rejected_cv.shape, y_cv.shape)
print(proj_grade_cat_rejected_test.shape, y_test.shape)
print('*'*100)
```

```
Mean : 0.15428125, Standard deviation : 0.006726254053041953

Post Standardization
(32000, 1) (32000,)
(8000, 1) (8000,)
(10000, 1) (10000,)
**************************************************************************************************
```

2.2.3 Vectorizing Text features

A) Bag of Words (BOW)

1.13.1 Bag of Words - clean_essay (min_df=10)

In [326]:
```
# performing bow on essay field

# ngram_range : (min_n, max_n)
# ngram_range : (2, 2) for bi_grams


vectorizer_bow_essay = CountVectorizer(min_df=10)
vectorizer_bow_essay.fit(X_train['clean_essay'])

print(vectorizer_bow_essay.get_feature_names()[:20])

essay_bow_train = vectorizer_bow_essay.transform(X_train['clean_essay'])
essay_bow_cv = vectorizer_bow_essay.transform(X_cv['clean_essay'])
essay_bow_test = vectorizer_bow_essay.transform(X_test['clean_essay'])


print('Post Vectorization')

print("Shape of matrix after bow vectorization of essay on train data ",essay_bow_tra
print("Shape of matrix after bow vectorization of essay on cv data",essay_bow_cv.shap
print("Shape of matrix after bow vectorization of essay on test data",essay_bow_test

print('*'*100)
```

```
['00', '000', '10', '100', '1000', '100th', '105', '10th', '11', '110', '1100', '11th', '12',
Post Vectorization
Shape of matrix after bow vectorization of essay on train data  (32000, 10142)
Shape of matrix after bow vectorization of essay on cv data (8000, 10142)
Shape of matrix after bow vectorization of essay on test data (10000, 10142)
**************************************************************************************************
```

1.13.2 Bag of Words - clean_title (min_df=10)

In [327]:
```
final_df.head(2)
```

Out[327]:
```
   Unnamed: 0       id                         teacher_id teacher_prefix  \
0      100660  p234804  cbc0e38f522143b86d372f8b43d4cff3            Mrs
1       33679  p137682  06f6e62e17de34fcf81020c77549e1d5            Mrs

  school_state                 Date project_grade_category  \
0           GA  2016-04-27 00:53:00          Grades_PreK_2
1           WA  2016-04-27 01:05:25             Grades_3_5

                             project_resource_summary  \
0  My students need flexible seating in the class...
1  My students need copies of the New York Times ...

   teacher_number_of_previously_posted_projects  project_is_approved  ...  \
0                                             2                    1  ...
1                                             2                    1  ...

    clean_categories  clean_subcategories title_word_count essay_word_count  \
0    AppliedLearning     EarlyDevelopment                5              225
1  Literacy_Language             Literacy                7              184

                                       clean_essay  \
0  recently read article giving students choice l...
1  students crave challenge eat obstacles breakfa...

                          clean_title essay_sent_pos essay_sent_neg  \
0  flexible seating flexible learning         0.194          0.031
1       going deep art inner thinking         0.315          0.031

   essay_sent_neu  essay_sent_compound
0           0.775               0.9524
1           0.653               0.9873

[2 rows x 22 columns]
```

In [328]:
```
vectorizer_bow_title = CountVectorizer(min_df=10)
vectorizer_bow_title.fit(X_train['clean_title'])
print(vectorizer_bow_title.get_feature_names()[:20])

title_bow_train = vectorizer_bow_title.transform(X_train['clean_title'])
title_bow_cv = vectorizer_bow_title.transform(X_cv['clean_title'])
title_bow_test = vectorizer_bow_title.transform(X_test['clean_title'])


print('Post Vectorization: ')

print("Shape of matrix after bow vectorization of title on train data ",title_bow_tra
print("Shape of matrix after bow vectorization of title on cv data",title_bow_cv.shap
print("Shape of matrix after bow vectorization of title on test data",title_bow_test
```

```
        print('*'*100)
```

```
['05', '10', '100', '101', '16', '1st', '2016', '2017', '21st', '2nd', '3d', '3doodler', '3rd'
Post Vectorization:
Shape of matrix after bow vectorization of title on train data  (32000, 1513)
Shape of matrix after bow vectorization of title on cv data (8000, 1513)
Shape of matrix after bow vectorization of title on test data (10000, 1513)
**********************************************************************************************
```

B) TFIDF Vectorizer

1.13.3 TFIDF - clean_essay (min_df=10)

```
In [329]: vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
          vectorizer_tfidf_essay.fit(X_train['clean_essay'])
          print(vectorizer_tfidf_essay.get_feature_names()[:20])

          essay_tfidf_train = vectorizer_tfidf_essay.transform(X_train['clean_essay'])
          essay_tfidf_cv = vectorizer_tfidf_essay.transform(X_cv['clean_essay'])
          essay_tfidf_test = vectorizer_tfidf_essay.transform(X_test['clean_essay'])

          print('Post Vectorization: ')

          print("Shape of matrix after tfidf vectorization of essay on train data ",essay_tfidf
          print("Shape of matrix after tfidf vectorization of essay on cv data",essay_tfidf_cv
          print("Shape of matrix after tfidf vectorization of essay on test data",essay_tfidf_t
          print('*'*100)
```

```
['00', '000', '10', '100', '1000', '100th', '105', '10th', '11', '110', '1100', '11th', '12',
Post Vectorization:
Shape of matrix after tfidf vectorization of essay on train data  (32000, 10142)
Shape of matrix after tfidf vectorization of essay on cv data (8000, 10142)
Shape of matrix after tfidf vectorization of essay on test data (10000, 10142)
**********************************************************************************************
```

1.13.4 TFIDF - clean_title (min_df=10)

```
In [330]: vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
          vectorizer_tfidf_title.fit(X_train['clean_title'])
          print(vectorizer_tfidf_title.get_feature_names()[:20])

          title_tfidf_train = vectorizer_tfidf_title.transform(X_train['clean_title'])
          title_tfidf_cv = vectorizer_tfidf_title.transform(X_cv['clean_title'])
          title_tfidf_test = vectorizer_tfidf_title.transform(X_test['clean_title'])

          print('Post Vectorization')
```

```
print("Shape of matrix after tfidf vectorization of title on train data ",title_tfidi
print("Shape of matrix after tfidf vectorization of title on cv data",title_tfidf_cv
print("Shape of matrix after tfidf vectorization of title on test data",title_tfidf_t
print('*'*100)
```

```
['05', '10', '100', '101', '16', '1st', '2016', '2017', '21st', '2nd', '3d', '3doodler', '3rd'
Post Vectorization
Shape of matrix after tfidf vectorization of title on train data  (32000, 1513)
Shape of matrix after tfidf vectorization of title on cv data (8000, 1513)
Shape of matrix after tfidf vectorization of title on test data (10000, 1513)
**********************************************************************************************
```

C) Avg W2V

```
In [157]: # https://stackoverflow.com/questions/37793118/load-pretrained-glove-vectors-in-pyth

          import numpy as np
          def loadGloveModel(gloveFile):
              print("Loading Glove Model")
              f = open(gloveFile,'r')
              model = {}
              for line in tqdm(f):
                  splitLine = line.split()
                  word = splitLine[0]
                  embedding = np.array([float(val) for val in splitLine[1:]])
                  model[word] = embedding
              print("Done.",len(model)," words loaded!")
              return model
```

```
In [158]: glove_model = loadGloveModel(res_base_path + 'glove.42B.300d.txt')
```

```
2033it [00:00, 10100.18it/s]

Loading Glove Model


1917495it [02:52, 11111.22it/s]


Done. 1917495  words loaded!
```

```
In [331]: from gensim.models import Word2Vec
          from gensim.models import KeyedVectors

          def perform_avg_w2v(list_sent, w2v_model, w2v_words):
              # average Word2Vec
```

```
    # compute average word2vec for each review.
    avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
    for sent in tqdm(list_sent): # for each review/sentence
        sent_vec = np.zeros(300) # as word vectors are of zero length 50, you might
        cnt_words =0; # num of words with a valid vector in the sentence/review
        for word in sent.split(): # for each word in a review/sentence
            if word in w2v_words:
                vec = w2v_model[word]
                sent_vec += vec
                cnt_words += 1
        if cnt_words != 0:
            sent_vec /= cnt_words
        avg_w2v.append(sent_vec)
    avg_w2v = np.array(avg_w2v)
    return avg_w2v
```

Avg W2V - clean_essay

```
In [332]: train_essays_words = []
          for i in X_train['clean_essay'] :
              train_essays_words.extend(i.split(' '))

          # Find the total number of words in the Train data of Essays.
          print("all the words in the X_train clean_essay", len(train_essays_words))

          # Find the unique words in this set of words
          train_essays_words = set(train_essays_words)
          print("the unique words in the X_train clean_essay", len(train_essays_words))


          common_words = set(glove_model.keys()).intersection(train_essays_words)
          print("The number of words that are present in both glove vectors and our X_train cl
                .format(len(common_words), np.round((float(len(common_words))/len(train_essays_
```

```
all the words in the X_train clean_essay 4418797
the unique words in the X_train clean_essay 34811
The number of words that are present in both glove vectors and our X_train clean_essay are 324
```

```
In [333]: corpus_train_essay_words = {}
          words_glove = set(glove_model.keys())
          for i in train_essays_words:
              if i in words_glove:
                  corpus_train_essay_words[i] = glove_model[i]
          print("word2vec length of our X_train clean_essay", len(corpus_train_essay_words))
```

```
word2vec length of our X_train clean_essay 32472
```

```
In [335]: # storing variables into pickle files python: http://www.jessicayung.com/how-to-use-p
          import pickle
          with open('glove_vectors_w2v_clean_essay', 'wb') as f:
              pickle.dump(corpus_train_essay_words, f)

In [336]: # loading stored vectors from pickle file
          with open('glove_vectors_w2v_clean_essay', 'rb') as f:
              model = pickle.load(f)
              glove_words_essay = set(model.keys())

In [337]: essay_avg_w2v_train = perform_avg_w2v(X_train['clean_essay'], glove_model, glove_word
          essay_avg_w2v_cv = perform_avg_w2v(X_cv['clean_essay'], glove_model, glove_words_essa
          essay_avg_w2v_test = perform_avg_w2v(X_test['clean_essay'], glove_model, glove_words_

          print('Post Vectorization: ')

          print("Shape of matrix after avg w2v vectorization of essay on train data ",essay_avg
          print("Shape of matrix after avg w2v vectorization of essay on cv data",essay_avg_w2v
          print("Shape of matrix after avg w2v vectorization of essay on test data",essay_avg_w
          print('*'*100)

100%|| 32000/32000 [00:07<00:00, 4017.17it/s]
100%|| 8000/8000 [00:01<00:00, 4269.87it/s]
100%|| 10000/10000 [00:02<00:00, 4370.62it/s]

Post Vectorization:
Shape of matrix after avg w2v vectorization of essay on train data  (32000, 300)
Shape of matrix after avg w2v vectorization of essay on cv data (8000, 300)
Shape of matrix after avg w2v vectorization of essay on test data (10000, 300)
****************************************************************************************************
```

Avg W2V - clean_title

```
In [338]: train_title_words = []
          for i in X_train['clean_title'] :
              train_title_words.extend(i.split(' '))

          # Find the total number of words in the Train data of Essays.
          print("all the words in the X_train clean_title", len(train_title_words))

          # Find the unique words in this set of words
          train_title_words = set(train_title_words)
          print("the unique words in the X_train clean_title", len(train_title_words))
```

```
        common_words = set(glove_model.keys()).intersection(train_title_words)
        print("The number of words that are present in both glove vectors and our X_train cle
              .format(len(common_words), np.round((float(len(common_words))/len(train_title_w
```

```
all the words in the X_train clean_title 118374
the unique words in the X_train clean_title 9407
The number of words that are present in both glove vectors and our X_train clean_essay are 904
```

```
In [339]: corpus_train_title_words = {}
          words_glove = set(glove_model.keys())
          for i in train_title_words:
              if i in words_glove:
                  corpus_train_title_words[i] = glove_model[i]
          print("word2vec length of our X_train clean_title", len(corpus_train_title_words))
```

```
word2vec length of our X_train clean_title 9047
```

```
In [340]: # storing variables into pickle files python: http://www.jessicayung.com/how-to-use-
          import pickle
          with open('glove_vectors_w2v_clean_title', 'wb') as f:
              pickle.dump(corpus_train_title_words, f)
```

```
In [341]: # loading stored vectors from pickle file
          with open('glove_vectors_w2v_clean_title', 'rb') as f:
              model = pickle.load(f)
              glove_words_title = set(model.keys())
```

```
In [342]: title_avg_w2v_train = perform_avg_w2v(X_train['clean_title'], glove_model, glove_word
          title_avg_w2v_cv = perform_avg_w2v(X_cv['clean_title'], glove_model, glove_words_titl
          title_avg_w2v_test = perform_avg_w2v(X_test['clean_title'], glove_model, glove_words_


          print('Post Vectorization: ')

          print("Shape of matrix after avg w2v vectorization of title on train data ",title_avg
          print("Shape of matrix after avg w2v vectorization of title on cv data",title_avg_w2v
          print("Shape of matrix after avg w2v vectorization of title on test data",title_avg_w
          print('*'*100)
```

```
100%|| 32000/32000 [00:00<00:00, 74335.13it/s]
100%|| 8000/8000 [00:00<00:00, 78057.89it/s]
100%|| 10000/10000 [00:00<00:00, 74469.02it/s]
```

```
Post Vectorization:
Shape of matrix after avg w2v vectorization of title on train data  (32000, 300)
Shape of matrix after avg w2v vectorization of title on cv data (8000, 300)
Shape of matrix after avg w2v vectorization of title on test data (10000, 300)
****************************************************************************************
```

C) TF-IDF W2V

In [343]:
```
#https://colab.research.google.com/drive/1j0xJr80XlDZkOKNf14nvPZxArc9bo7zm#scrollTo=
```

```
def perform_tfidf_w2v(preprocessed_text, glove_words, dictionary, tfidf_words, model
    tfidf_w2v = [];
    for sentence in tqdm(preprocessed_text):
        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 review/sentence
            if (word in glove_words) and (word in tfidf_words):
#             if word in tfidf_words:
                vec = model[word] # getting the vector for each word
#                 vec = tfidf_model[word]
                # here we are multiplying idf value(dictionary[word]) and the tf val
                tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
                vector += (vec * tf_idf) # calculating tfidf weighted w2v
                tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        tfidf_w2v.append(vector)

    tfidf_w2v = np.array(tfidf_w2v)
    return tfidf_w2v
```

Tf-Idf W2V - clean_essay

In [344]:
```
# performing tfidf_w2v on essay field
```

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_essay'])

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

In [345]:
```
essay_tfidf_w2v_train = perform_tfidf_w2v(X_train['clean_essay'], glove_words_essay,
essay_tfidf_w2v_cv = perform_tfidf_w2v(X_cv['clean_essay'], glove_words_essay, dictio
essay_tfidf_w2v_test = perform_tfidf_w2v(X_test['clean_essay'], glove_words_essay, di

print('Post Vectorization: ')

print("Shape of matrix after tfidf w2v vectorization of essay on train data ",essay_t
print("Shape of matrix after tfidf w2v vectorization of essay on cv data",essay_tfidi
print("Shape of matrix after tfidf w2v vectorization of essay on test data",essay_tfi
print('*'*100)
```

```
100%|| 32000/32000 [01:01<00:00, 521.46it/s]
100%|| 8000/8000 [00:15<00:00, 527.10it/s]
100%|| 10000/10000 [00:18<00:00, 529.57it/s]

Post Vectorization:
Shape of matrix after tfidf w2v vectorization of essay on train data  (32000, 300)
Shape of matrix after tfidf w2v vectorization of essay on cv data (8000, 300)
Shape of matrix after tfidf w2v vectorization of essay on test data (10000, 300)
**********************************************************************************************
```

Tf-Idf W2V - clean_title

```
In [346]: # performing tfidf_w2v on title field

          tfidf_model = TfidfVectorizer()
          tfidf_model.fit(X_train['clean_title'])

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

In [347]: title_tfidf_w2v_train = perform_tfidf_w2v(X_train['clean_title'], glove_words_title,
          title_tfidf_w2v_cv = perform_tfidf_w2v(X_cv['clean_title'], glove_words_title, dictio
          title_tfidf_w2v_test = perform_tfidf_w2v(X_test['clean_title'], glove_words_title, di


          print('Post Vectorization: ')

          print("Shape of matrix after tfidf w2v vectorization of title on train data ",title_t
          print("Shape of matrix after tfidf w2v vectorization of title on cv data",title_tfidi
          print("Shape of matrix after tfidf w2v vectorization of title on test data",title_tfi
          print('*'*100)
```

```
100%|| 32000/32000 [00:00<00:00, 36004.77it/s]
100%|| 8000/8000 [00:00<00:00, 35050.05it/s]
100%|| 10000/10000 [00:00<00:00, 36147.79it/s]

Post Vectorization:
Shape of matrix after tfidf w2v vectorization of title on train data  (32000, 300)
Shape of matrix after tfidf w2v vectorization of title on cv data (8000, 300)
Shape of matrix after tfidf w2v vectorization of title on test data (10000, 300)
**********************************************************************************************
```

2 Assignment 9: RF and GBDT

> The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

Apply both Random Forrest and GBDT on these feature sets

Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)

Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)

Set 3: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)

Set 4: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)

Consider the following range for hyperparameters n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000], max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]

Find the best hyper parameter which will give the maximum AUC value

find the best hyper paramter using k-fold cross validation/simple cross validation data

use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

Representation of results

You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure with X-axis as n_estimators, Y-axis as max_depth, and Z-axis as AUC Score , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive 3d_scatter_plot.ipynb

```
    <p style="text-align:center;font-size:30px;color:red;"><strong>or</strong></p> <br>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='heat_map.JPG' width=300px> <a href='https://seaborn.pydata.org/generated/seaborn.heat
<li>You can choose either of the plotting techniques: 3d plot or heat map</li>
<li>Once after you found the best hyper parameter, you need to train your model with it, and fi
<img src='train_test_auc.JPG' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.c
<img src='confusion_matrix.png' width=300px></li>
        </ul>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table for
    <img src='summary.JPG' width=400px>
</li>
    </ul>
```

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.

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

3 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

3 Applying Random Forest

Apply Random Forest on different kind of featurization as mentioned in the instructions For Every model that you work on make sure you do the step 2 and step 3 of instrucations

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

```
In [ ]: import matplotlib.pyplot as plt
        from sklearn.neighbors import KNeighborsClassifier
        from sklearn.metrics import accuracy_score
        from sklearn.model_selection import cross_val_score
        from collections import Counter
        from sklearn.metrics import accuracy_score
        from scipy.sparse import hstack
        from sklearn.model_selection import GridSearchCV
        from sklearn.ensemble import RandomForestClassifier
        from sklearn.ensemble import GradientBoostingClassifier
        from sklearn.metrics import roc_curve, auc, roc_auc_score
        import chart_studio
        import IPython
        from plotly.offline import init_notebook_mode
        import seaborn as sns
        sns.set()


        chart_studio.tools.set_credentials_file(username='rohit_singh0049', api_key='9Jp4mC66H8

        py.sign_in('rohit_singh0049', '9Jp4mC66H8zPBPCTDIwC')


        #https://stackoverflow.com/questions/46247758/set-multiple-parameters-from-gridsearch-

        parameters = {'n_estimators': [10, 50, 100, 300, 500, 1000], 'max_depth':[2, 3, 5,
         8, 9, 10]}


        def batch_predict(clf, data):
            # not the predicted outputs
            y_data_pred = []
            tr_loop = data.shape[0] - data.shape[0]%3000
            # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 =
```

```
        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[tr_loop:].shape[0] != 0:
            y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])
        return y_data_pred


    def find_best_params(model, X_tr, y_tr, X_cv, y_cv):
        clf = GridSearchCV(model, param_grid=parameters, cv=3, scoring='roc_auc',return_tra
        clf.fit(X_tr, y_tr)
        return clf


    def plot_heat_maps(clf):
        #https://qiita.com/bmj0114/items/8009f282c99b777780563
        max_scores1 = pd.DataFrame(clf.cv_results_).groupby(['param_n_estimators', 'param_
        fig, ax = plt.subplots(1,2, figsize=(20,6))
        sns.heatmap(max_scores1.mean_train_score, annot = True)
        sns.heatmap(max_scores1.mean_test_score, annot = True)
        ax[0].set_title('Train Set')
        ax[1].set_title('CV Set')
        plt.show()
```

In [361]:
```
import itertools

  def plot_confusion_matrix(cm, classes,
                            normalize=False,
                            title='Confusion matrix',
                            cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
```

```
    thresh = (cm.max() / 2) + 100
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.tight_layout()
```

In [362]:
```
def predict(proba, threshold, fpr, tpr):
    t = threshold[np.argmax(fpr*(1-tpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions


def compute_confusion_matrix(y_actual, y_pred, threshold, fpr, tpr):
    '''
     This func will compute and plot confusion matrix on test data
    '''

    class_names = [0, 1]
    cnf_matrix = confusion_matrix(y_actual, predict(y_pred, threshold, fpr, tpr))
    np.set_printoptions(precision=2)

    # Plot non-normalized confusion matrix
    plt.figure()
    plot_confusion_matrix(cnf_matrix,classes=class_names,
                          title='Confusion matrix, without normalization')

    # Plot normalized confusion matrix
    plt.figure()
    plot_confusion_matrix(cnf_matrix, classes=class_names, normalize=True,
                          title='Normalized confusion matrix')
    plt.show()
    print('*'*70)
```

3.0.1 Set 1: categorical (`response coding`), numerical features + project_title(BOW) + preprocessed_eassay

2.4.1 Applying Random Forest on BOW, SET 1

In [363]:
```
# Please write all the code with proper documentation

X_train_set1 = hstack((categories_approved_train, categories_rejected_train, sub_cate
            school_state_approved_train, school_state_rejected_train, teacher_prefix_a
            proj_grade_cat_approved_train,proj_grade_cat_rejected_train, price_train,
            prev_teacher_proj_train, title_word_count_train, essay_word_count_train,
            essay_sent_pos_train, essay_sent_neu_train, essay_sent_neu_train, essay_se
            essay_bow_train, title_bow_train)).tocsr()

X_cv_set1 = hstack((categories_approved_cv, categories_rejected_cv, sub_categories_ap
                    sub_categories_rejected_cv, school_state_approved_cv, school_stat
                    teacher_prefix_approved_cv, teacher_prefix_rejected_cv, proj_grad
                    proj_grade_cat_rejected_cv, price_cv, quantity_cv,prev_teacher_pr
                    title_word_count_cv, essay_word_count_cv,essay_sent_pos_cv, essay
                    essay_sent_neu_cv, essay_sent_compound_cv, essay_bow_cv, title_bo

X_test_set1 = hstack((categories_approved_test, categories_rejected_test, sub_categor
                      sub_categories_rejected_test,school_state_approved_test, school
                      teacher_prefix_approved_test, teacher_prefix_rejected_test, pro
                      proj_grade_cat_rejected_test, price_test, quantity_test,prev_te
                      title_word_count_test, essay_word_count_test,essay_sent_pos_tes
                      essay_sent_neu_test, essay_sent_compound_test, essay_bow_test,
```

In [364]:
```
print("Final Data matrix for set1")
print(X_train_set1.shape, y_train.shape)
print(X_cv_set1.shape, y_cv.shape)
print(X_test_set1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set1
(32000, 11674) (32000,)
(8000, 11674) (8000,)
(10000, 11674) (10000,)
====================================================================================================
```

3.1 A) Finding best hyper-parameters using grid search

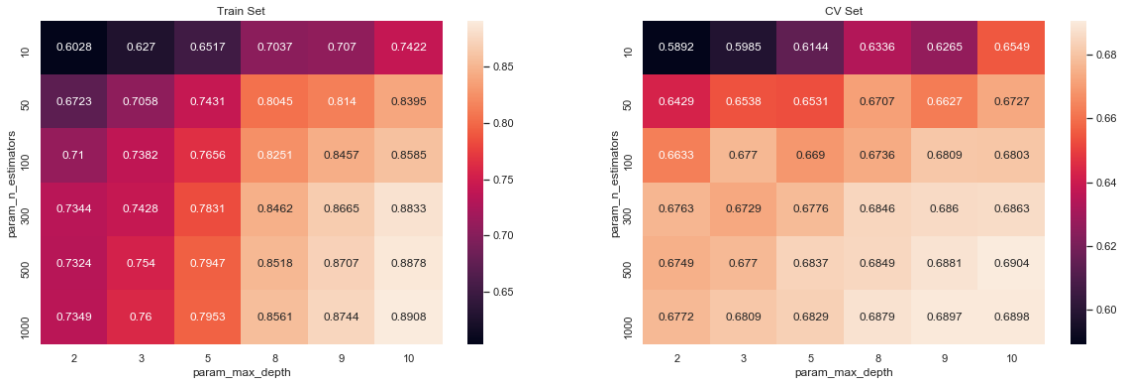
In [398]:
```
model = RandomForestClassifier()

clf = find_best_params( model, X_train_set1, y_train, X_cv_set1, y_cv)

train_auc = clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

```
        # clf.cv_results_
        rf_best_params_set1 = clf.best_params_
        rf_best_score_set1 = clf.best_score_
        print('Best Params: ', clf.best_params_)
        print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:   18.9s
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed:  2.0min finished


Best Params:  {'max_depth': 10, 'n_estimators': 500}
Best Score:  0.6904118860006099
```

3.2 Plot for Train and Cross Validation Data

```
In [399]: plot_heat_maps(clf)
```



3.3 Observations:

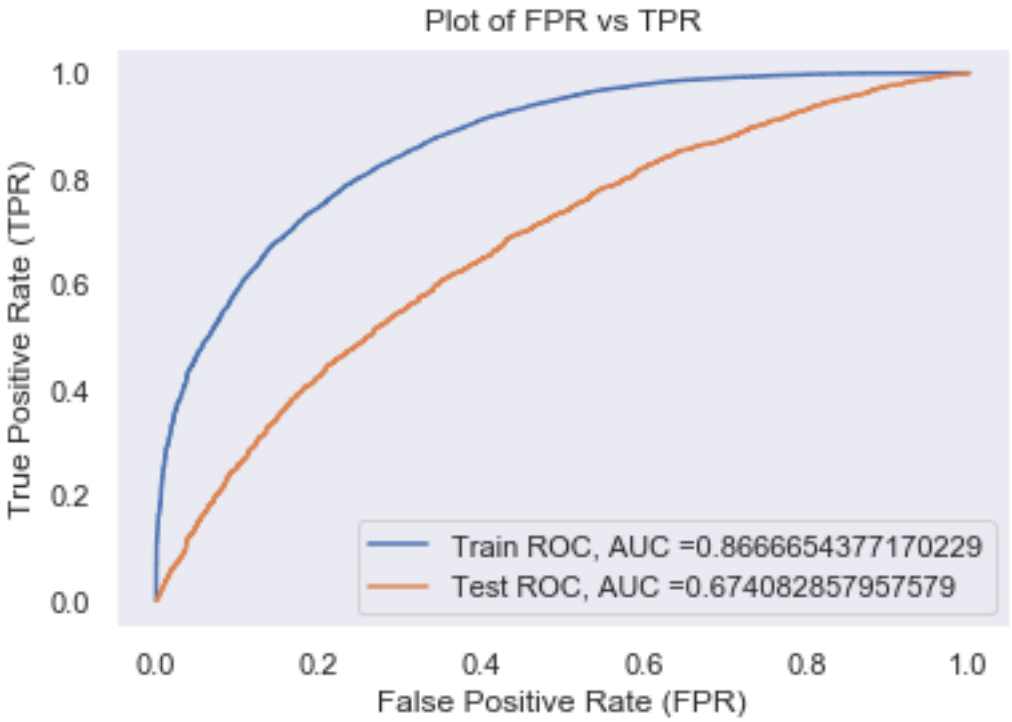
- On train data we achieve AUC score 0f 0.868 (max_depth: 10, n_estimators: 500) as best number of base learner models.
- RF with max_depth above 3 and n_estimators bove 300 has better CV AUC

3.4 C) Train model with best hyper-parameter value

```
In [400]: clf = RandomForestClassifier(max_depth=rf_best_params_set1['max_depth'], n_estimators
          clf.fit(X_train_set1,y_train)
```

```
# print(X_test_set1)
y_train_pred = batch_predict( clf, X_train_set1)
y_test_pred = batch_predict( clf, X_test_set1)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

rf_test_auc_set1 = roc_auc_score(y_test, y_test_pred)
```

In [403]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.rcParams["axes.grid"] = False
plt.legend()
plt.show()
```



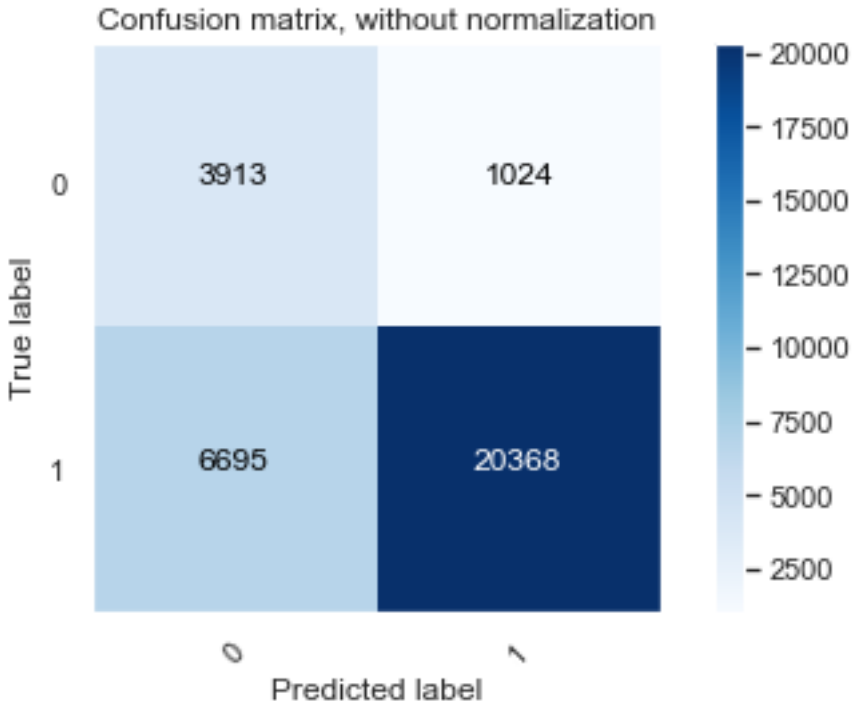
3.5 D) Confusion Matrix

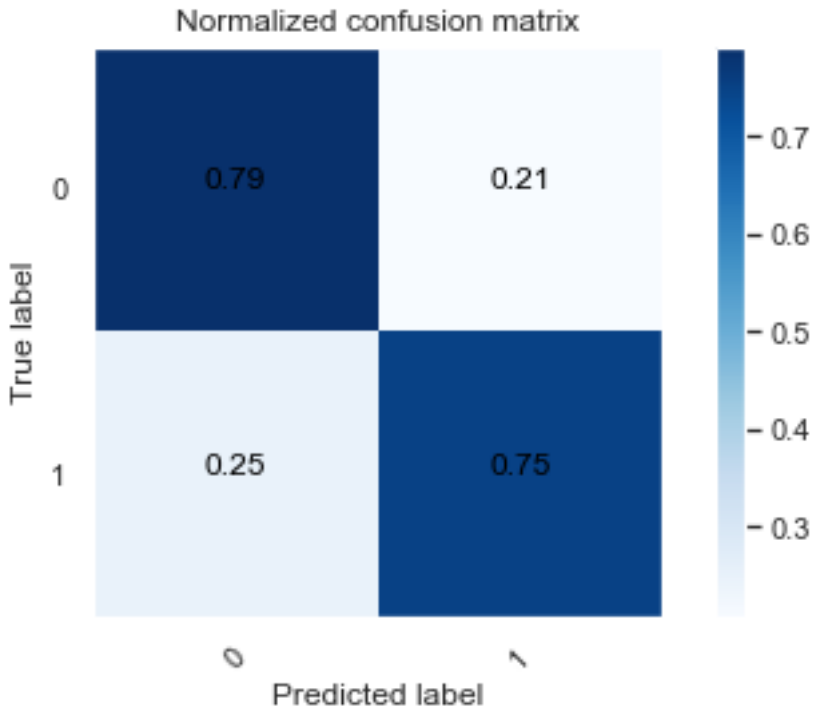
3.5.1 Train Set

In [404]:
```
# computa and plot confusion matrix for train data
print("="*100)
```

```
print("Train confusion matrix")

compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
==========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.6034784843362546 for threshold 0.84
Confusion matrix, without normalization
Normalized confusion matrix
```



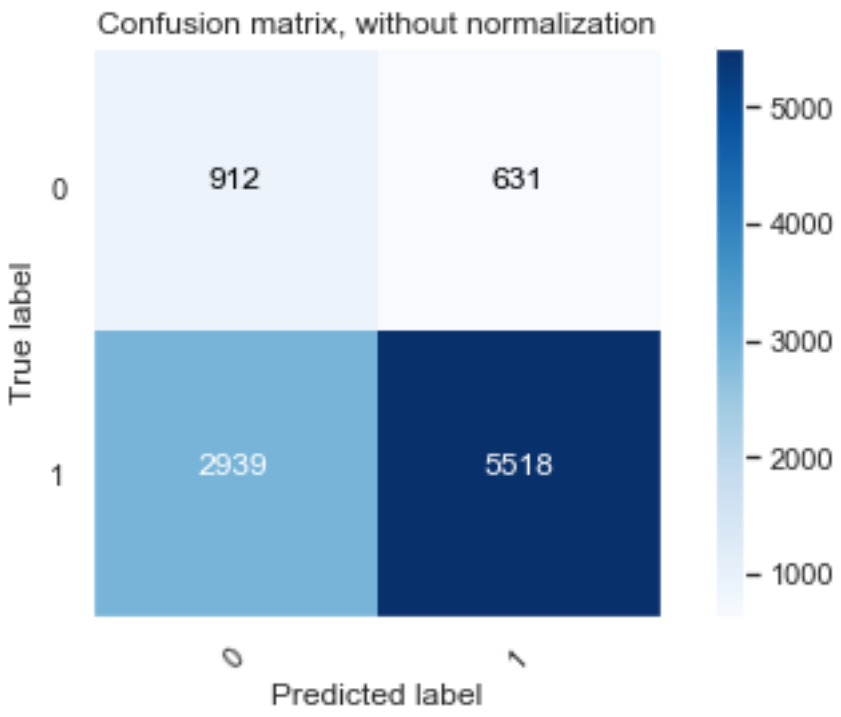


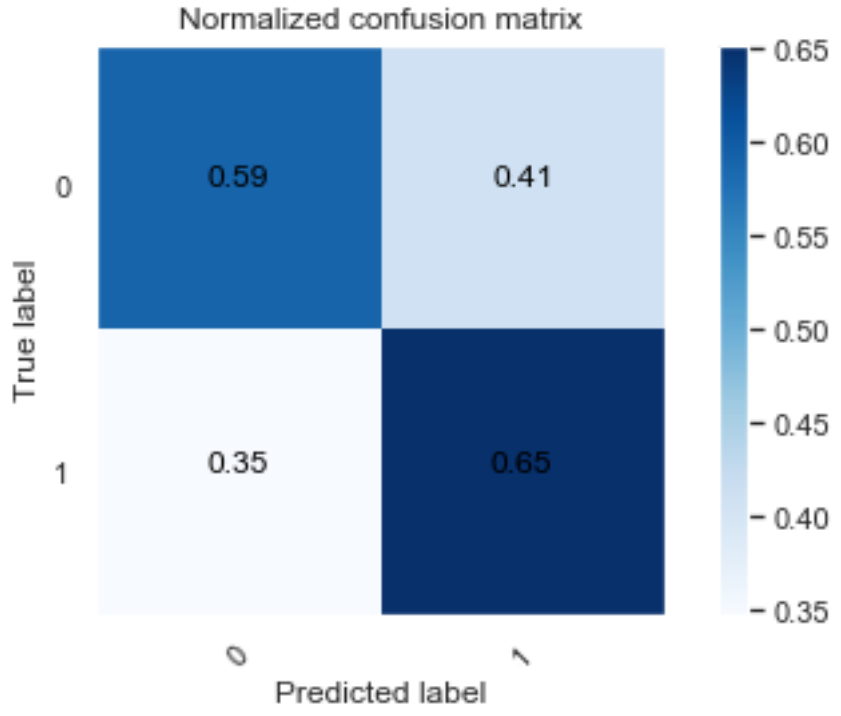
****

3.5.2 Test Set

```
In [405]: print("="*100)
          print("Test confusion matrix")
          # computa and plot confusion matrix for test data

          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3941456421187861 for threshold 0.843
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
912
631
2939
5518
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.59
0.41
0.35
0.65
0
1
True label
0
1
Predicted label
0.65
0.60
0.55
0.50
0.45
0.40
0.35

****

Observations

- On train data we achieve AUC score 0f 0.86 (max_depth: 10, n_estimators: 500) as best number of base learner models.
- While on test data we achieve an AUC score of 0.67 which is much better than any random model

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

3.5.4 2.4.2 Applying Random Forest on TFIDF, SET 2

In [406]:
```
# Please write all the code with proper documentation

X_train_set2 = hstack((categories_approved_train, categories_rejected_train, sub_cate
                       sub_categories_rejected_train,school_state_approved_train, sch
                       teacher_prefix_approved_train, teacher_prefix_rejected_train,
                       proj_grade_cat_rejected_train, price_train, quantity_train,pre
                       title_word_count_train, essay_word_count_train, essay_sent_pos
                       essay_sent_neu_train, essay_sent_compound_train,essay_tfidf_tr

X_cv_set2 = hstack((categories_approved_cv, categories_rejected_cv, sub_categories_ap
                    sub_categories_rejected_cv, school_state_approved_cv, school_stat
                    teacher_prefix_approved_cv, teacher_prefix_rejected_cv, proj_grad
                    proj_grade_cat_rejected_cv, price_cv, quantity_cv, prev_teacher_p
                    title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essa
                    essay_sent_neu_cv, essay_sent_compound_cv, essay_tfidf_cv, title_

X_test_set2 = hstack((categories_approved_test, categories_rejected_test, sub_categor
                      sub_categories_rejected_test,school_state_approved_test, school
                      teacher_prefix_approved_test, teacher_prefix_rejected_test, pre
                      proj_grade_cat_rejected_test, price_test, quantity_test, prev_t
                      title_word_count_test, essay_word_count_test, essay_sent_pos_te
                      essay_sent_neu_test, essay_sent_compound_test, essay_tfidf_test
```

In [407]:
```
print("Final Data matrix for set2")
print(X_train_set2.shape, y_train.shape)
print(X_cv_set2.shape, y_cv.shape)
print(X_test_set2.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set2
(32000, 11674) (32000,)
(8000, 11674) (8000,)
(10000, 11674) (10000,)
====================================================================================================
```

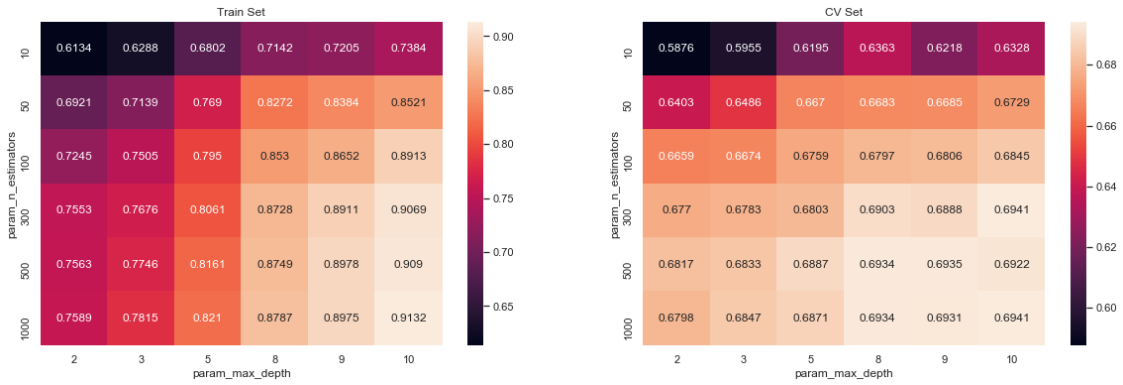
3.6 A) Finding best hyper-parameters using grid search

In [408]:
```
## A) Finding best hyper-parameters using grid search

        model = RandomForestClassifier()
        clf = find_best_params(model, X_train_set2, y_train, X_cv_set2, y_cv)
        train_auc = clf.cv_results_['mean_train_score']
        cv_auc = clf.cv_results_['mean_test_score']

        # clf.cv_results_
        rf_best_params_set2 = clf.best_params_
        rf_best_score_set2 = clf.best_score_
        print('Best Params: ', clf.best_params_)
        print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:   18.4s
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed:  2.5min finished


Best Params:  {'max_depth': 10, 'n_estimators': 300}
Best Score:  0.6941119338863232
```

3.7 Plot for Train and CrossValidation Data

In [410]:
```
plot_heat_maps(clf)
```



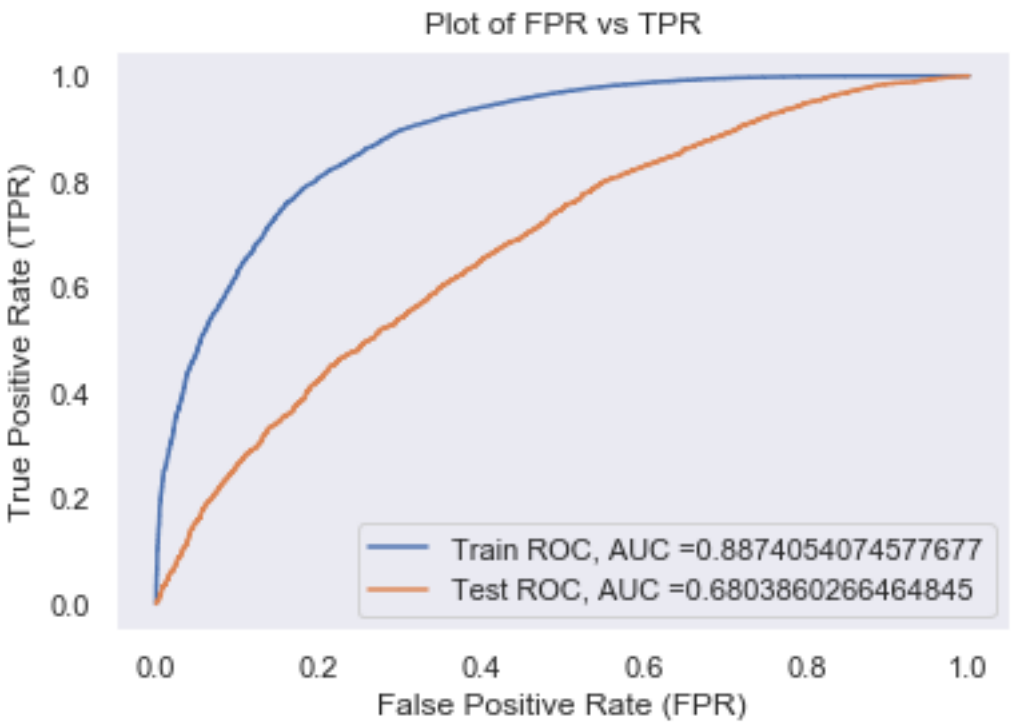
3.8 Observations:

- On train data we achieve AUC score 0f 0.88 (max_depth: 10, n_estimators: 300) as best number of base learner models.

3.9 C) Train model with best hyper-parameter value

In [412]:
```
# best hyper parameters = Best Params:  {'max_depth': 5, 'min_samples_split': 100}
# best_params = clf.best_params_

clf = RandomForestClassifier(max_depth=rf_best_params_set2['max_depth'], n_estimators

clf.fit(X_train_set2,y_train)

# print(X_test_set2)
y_train_pred = batch_predict( clf, X_train_set2)
y_test_pred = batch_predict( clf, X_test_set2)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

rf_test_auc_set2 = roc_auc_score(y_test, y_test_pred)
```

In [413]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.legend()
plt.show()
```

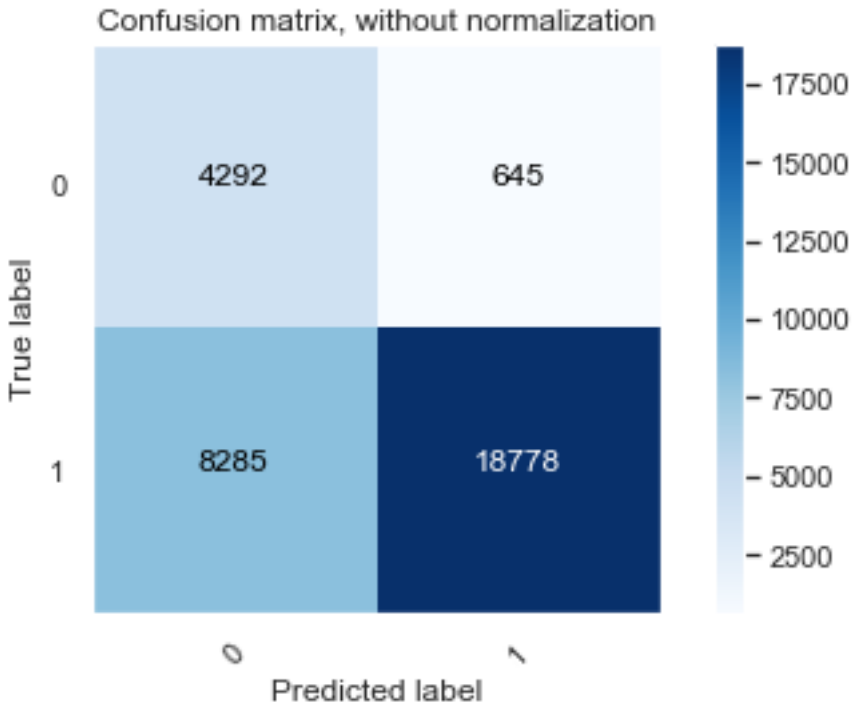


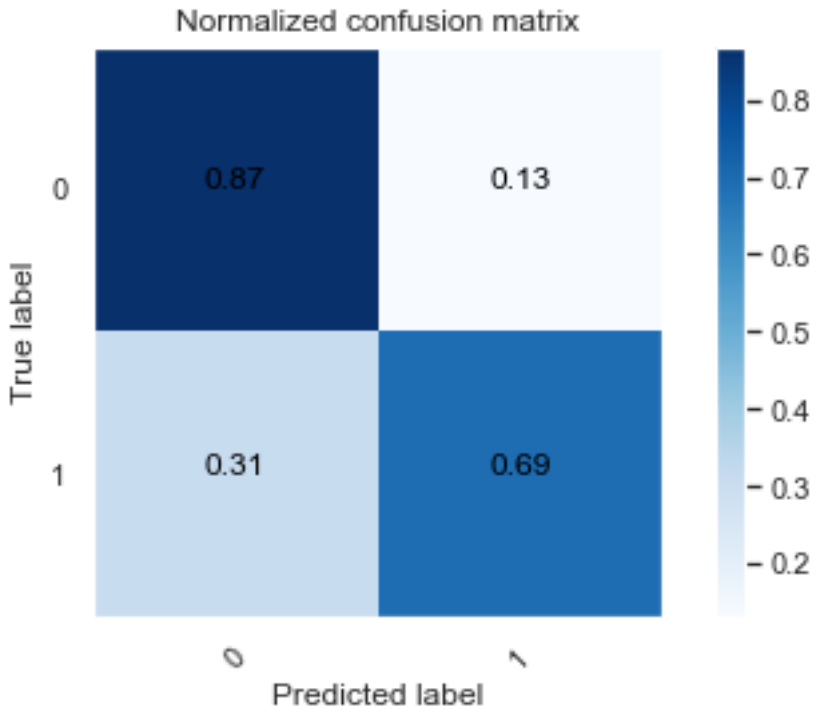
3.10 D) Confusion Matrix

3.10.1 Train Set

```
In [414]: # computa and plot confusion matrix for train data
          print("="*100)
          print("Train confusion matrix")
          compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.6465934732101065 for threshold 0.846
Confusion matrix, without normalization
Normalized confusion matrix
```



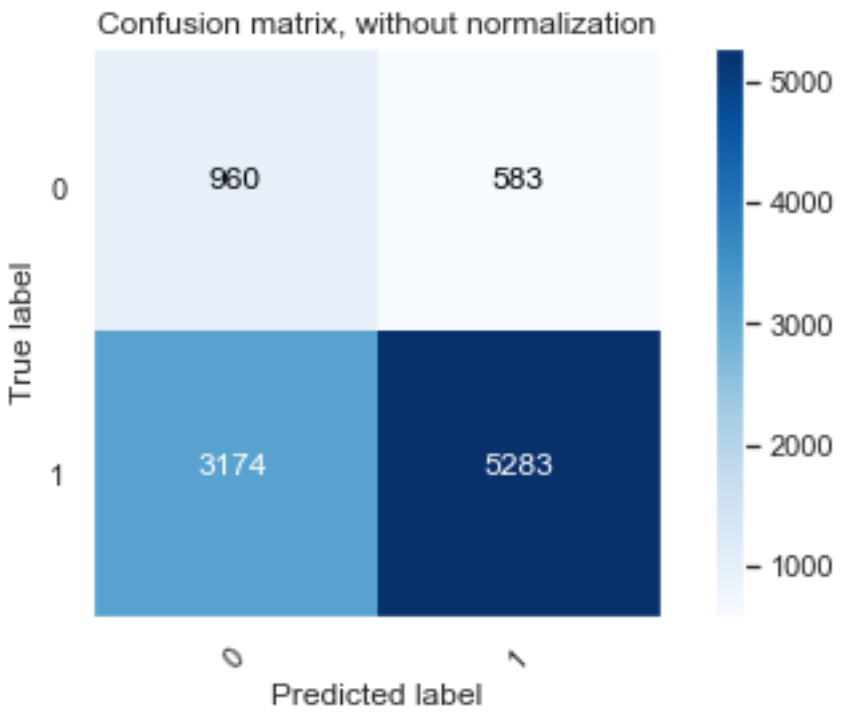


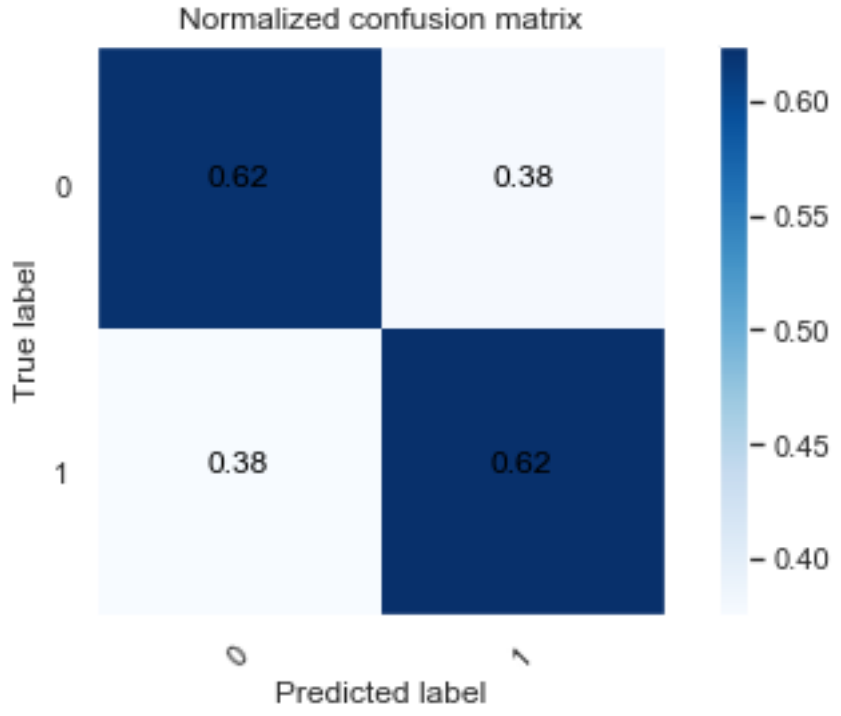
****

3.10.2 Test Set

```
In [415]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3917165185689092 for threshold 0.845
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
960
583
3174
5283
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.62
0.38
0.38
0.62
0
1
True label
0
1
Predicted label
0.60
0.55
0.50
0.45
0.40

****

3.11 Observations

- On train data we achieve AUC score 0f 0.88 (max_depth: 10, n_estimators: 300) as best number of base learner models.
- While on test data we achieve an AUC score of 0.68 which is much better than any random model

3.12 Set 3: categorical (response coding), numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)

3.12.1 4.3 Applying Random Forest on AVG W2V, SET 3

In [416]:
```
# Please write all the code with proper documentation

X_train_set3 = np.hstack((categories_approved_train, categories_rejected_train, sub_c
                          sub_categories_rejected_train, school_state_approved_train, sc
                          teacher_prefix_approved_train, teacher_prefix_rejected_train,
                          proj_grade_cat_rejected_train, price_train, quantity_train, pr
                          title_word_count_train, essay_word_count_train, essay_sent_pos
                          essay_sent_neu_train, essay_sent_compound_train, essay_avg_w2v

X_cv_set3 = np.hstack((categories_approved_cv, categories_rejected_cv, sub_categories
                       sub_categories_rejected_cv, school_state_approved_cv, school_stat
                       teacher_prefix_approved_cv, teacher_prefix_rejected_cv, proj_grad
                       proj_grade_cat_rejected_cv, price_cv, quantity_cv, prev_teacher_p
                       essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_
                       essay_sent_compound_cv, essay_avg_w2v_cv, title_avg_w2v_cv))

X_test_set3 = np.hstack((categories_approved_test, categories_rejected_test, sub_categ
                         sub_categories_rejected_test,school_state_approved_test, school
                         teacher_prefix_approved_test, teacher_prefix_rejected_test, pro
                         proj_grade_cat_rejected_test, price_test, quantity_test, prev_t
                         title_word_count_test, essay_word_count_test, essay_sent_pos_te
                         essay_sent_neu_test, essay_sent_compound_test, essay_avg_w2v_te
```

In [417]:
```
print("Final Data matrix for set3")
print(X_train_set3.shape, y_train.shape)
print(X_cv_set3.shape, y_cv.shape)
print(X_test_set3.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set3
(32000, 619) (32000,)
(8000, 619) (8000,)
(10000, 619) (10000,)
====================================================================================================
```

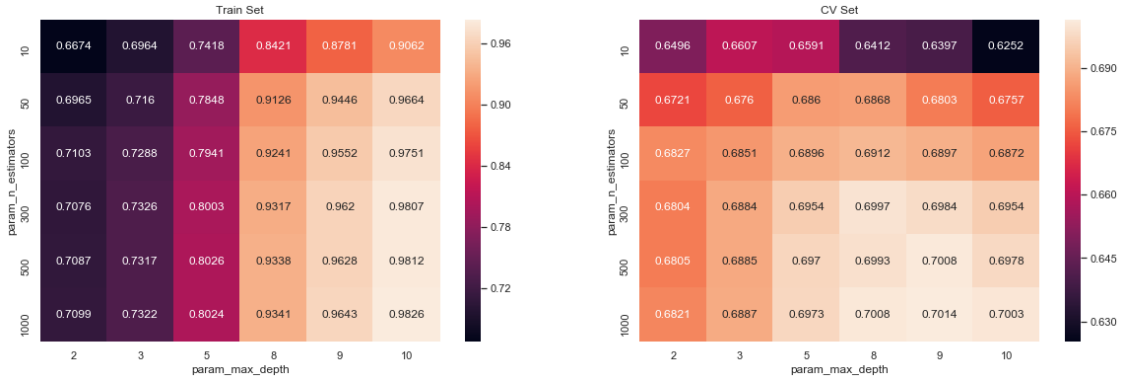
3.13 A) Finding best hyper-parameters using grid search

```
In [418]: model = RandomForestClassifier()

          clf = find_best_params(model, X_train_set3, y_train, X_cv_set3, y_cv)
          train_auc = clf.cv_results_['mean_train_score']
          cv_auc = clf.cv_results_['mean_test_score']

          # clf.cv_results_
          rf_best_params_set3 = clf.best_params_
          rf_best_score_set3 = clf.best_score_
          print('Best Params: ', clf.best_params_)
          print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:  1.9min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 20.9min finished


Best Params:  {'max_depth': 9, 'n_estimators': 1000}
Best Score:  0.7014031223037037
```

3.14 Plot for Train and CrossValidation Data

```
In [419]: plot_heat_maps(clf)
```



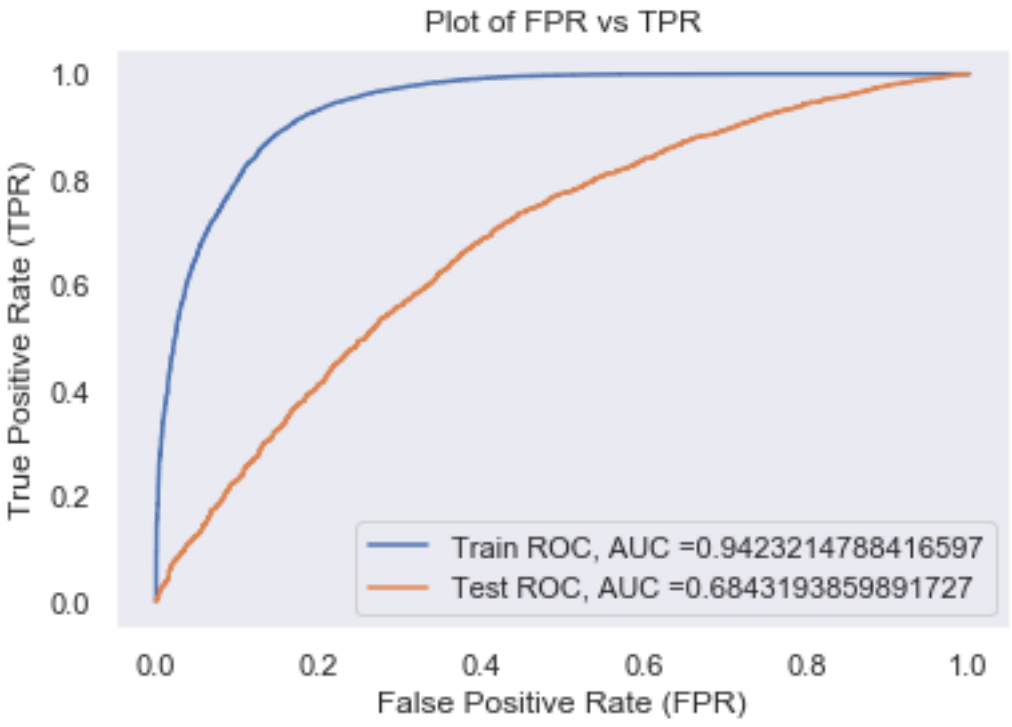
3.15 Observations

- On train data we achieve AUC score 0f 0.96 (max_depth: 9, n_estimators: 1000) as best number of base learner models.
- Best AUC on V data is 0.70 which is better than above models

3.16 C) Train model with best hyper-parameter value

In [420]:
```
clf = RandomForestClassifier(max_depth=rf_best_params_set3['max_depth'], n_estimators

clf.fit(X_train_set3,y_train)

y_train_pred = batch_predict( clf, X_train_set3)
y_test_pred = batch_predict( clf, X_test_set3)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

rf_test_auc_set3 = roc_auc_score(y_test, y_test_pred)
```

In [421]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.legend()
plt.show()
```

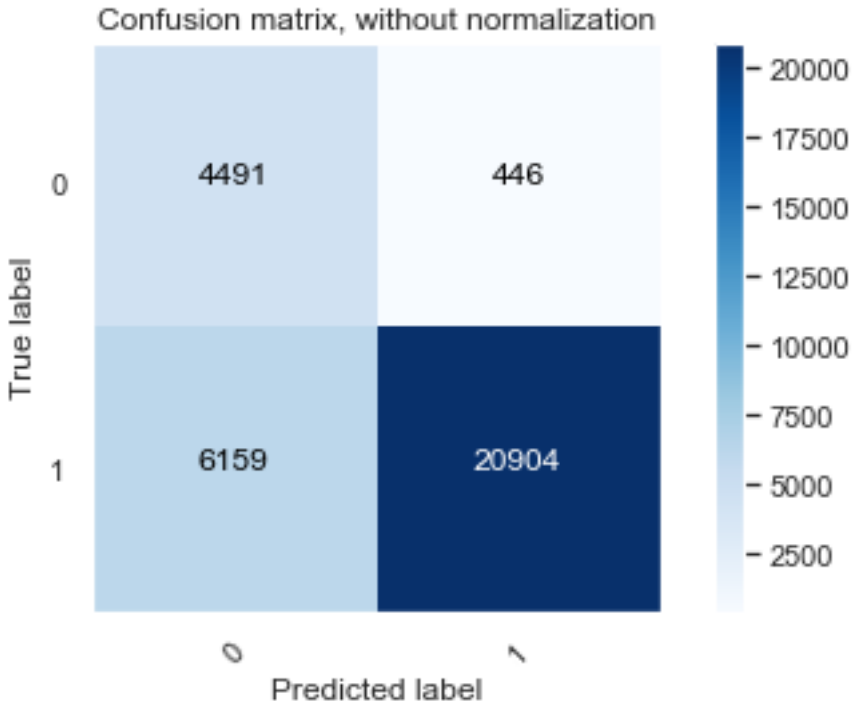


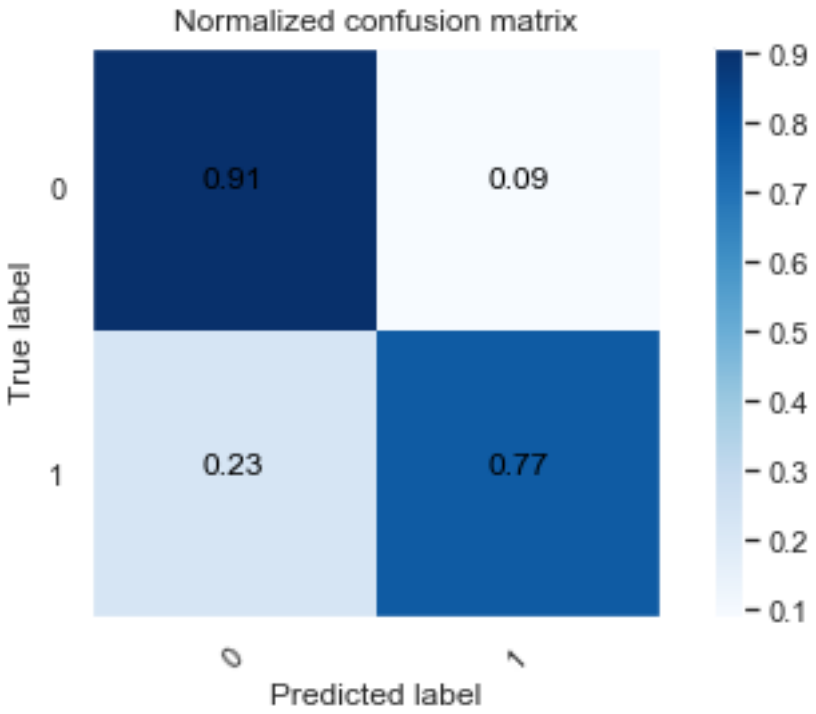
3.17 D) Confusion Matrix

3.17.1 Train Set

```
In [422]: # computa and plot confusion matrix for train data
          print("="*100)
          print("Train confusion matrix")
          compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.7551573728771906 for threshold 0.847
Confusion matrix, without normalization
Normalized confusion matrix
```



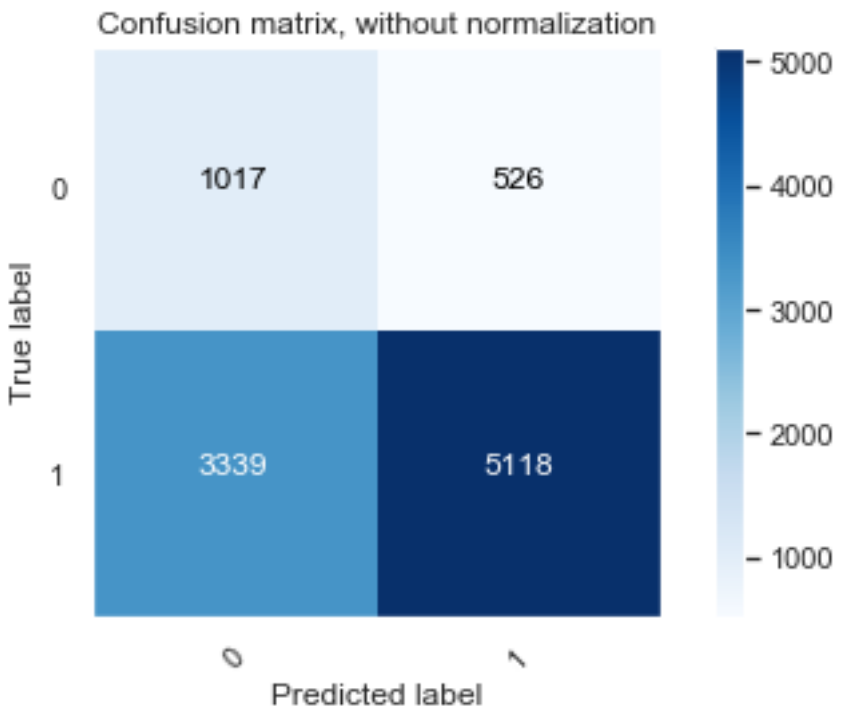


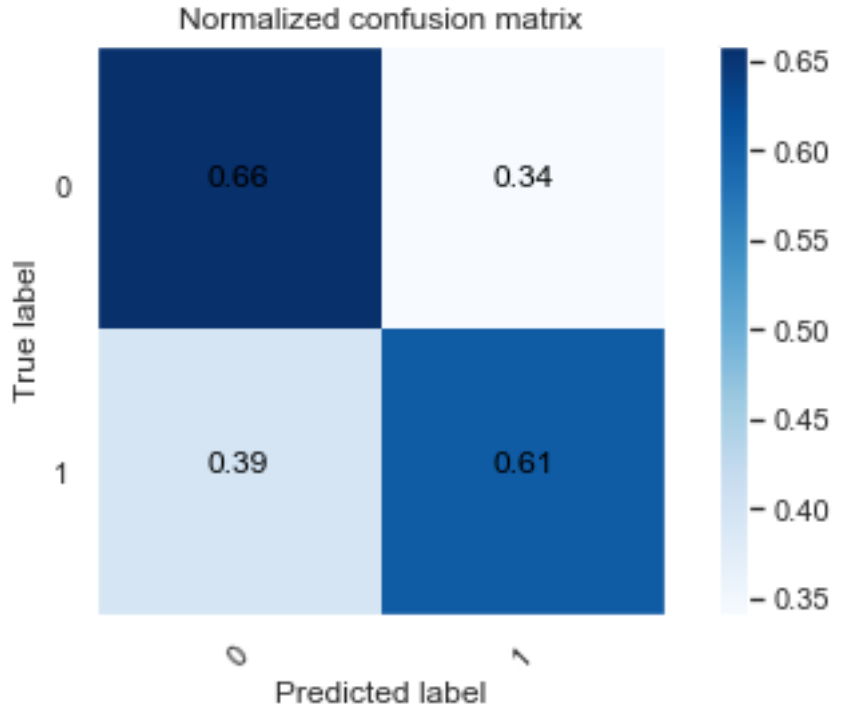
****

3.17.2 Test Set

```
In [423]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.41260308812427726 for threshold 0.85
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
1017
526
3339
5118
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.66
0.34
0.39
0.61
0
1
True label
0
1
Predicted label
0.65
0.60
0.55
0.50
0.45
0.40
0.35

****

Observations

- On train data we achieve AUC score 0f 0.94 (max_depth: 9, n_estimators: 1000) as best number of base learner models.
- While on test data we achieve an AUC score of 0.68 which is much better than any random model

3.18 Set 4: categorical (response coding), numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

3.18.1 4.4 Applying Random Forest on TFIDF W2V, SET 4

In [424]:
```
# Please write all the code with proper documentation

X_train_set4 = np.hstack((categories_approved_train, categories_rejected_train, sub_
                          sub_categories_rejected_train,school_state_approved_train, sc
                          teacher_prefix_approved_train, teacher_prefix_rejected_train,
                          proj_grade_cat_rejected_train, price_train, quantity_train, p
                          title_word_count_train, essay_word_count_train, essay_sent_pos
                          essay_sent_neu_train, essay_sent_compound_train, essay_tfidf_

X_cv_set4 = np.hstack((categories_approved_cv, categories_rejected_cv, sub_categories
                       school_state_approved_cv, school_state_rejected_cv, teacher_pref
                       teacher_prefix_rejected_cv, proj_grade_cat_approved_cv, proj_gra
                       price_cv, quantity_cv, prev_teacher_proj_cv, title_word_count_cv
                       essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_neu_cv, essay_s

X_test_set4 = np.hstack((categories_approved_test, categories_rejected_test, sub_cate
                         sub_categories_rejected_test,school_state_approved_test, schoo
                         teacher_prefix_approved_test, teacher_prefix_rejected_test, pr
                         proj_grade_cat_rejected_test, price_test, quantity_test, prev_
                         title_word_count_test, essay_word_count_test, essay_sent_pos_t
                         essay_sent_neu_test, essay_sent_compound_test, essay_tfidf_w2v_
```

In [425]:
```
print("Final Data matrix for set4")
print(X_train_set4.shape, y_train.shape)
print(X_cv_set4.shape, y_cv.shape)
print(X_test_set4.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set4
(32000, 619) (32000,)
(8000, 619) (8000,)
(10000, 619) (10000,)
====================================================================================================
```

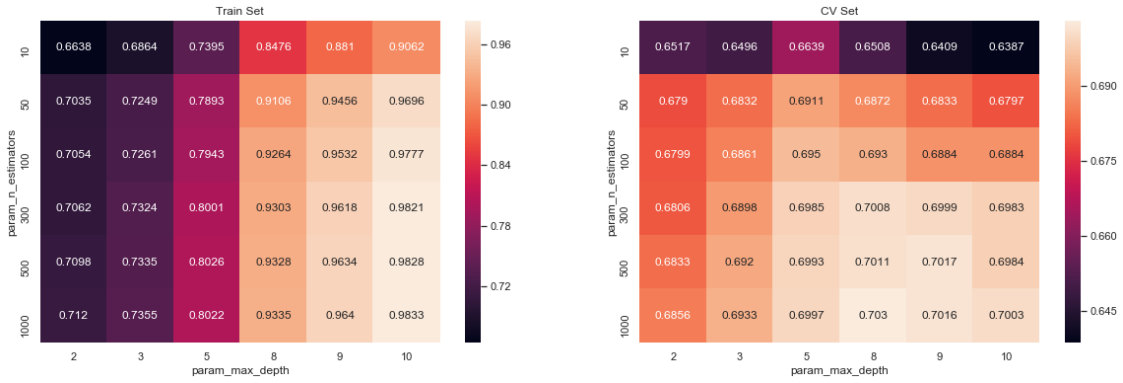
3.19 A) Finding best hyper-parameters using grid search

In [426]:
```
model = RandomForestClassifier()

        clf = find_best_params(model, X_train_set4, y_train, X_cv_set4, y_cv)
        train_auc = clf.cv_results_['mean_train_score']
        cv_auc = clf.cv_results_['mean_test_score']

        # clf.cv_results_
        rf_best_params_set4 = clf.best_params_
        rf_best_score_set4 = clf.best_score_
        print('Best Params: ', clf.best_params_)
        print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:  1.8min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 21.7min finished


Best Params:  {'max_depth': 8, 'n_estimators': 1000}
Best Score:  0.7029532527694392
```

3.20 Plot for Train and Cross Validation Data

In [427]:
```
plot_heat_maps(clf)
```



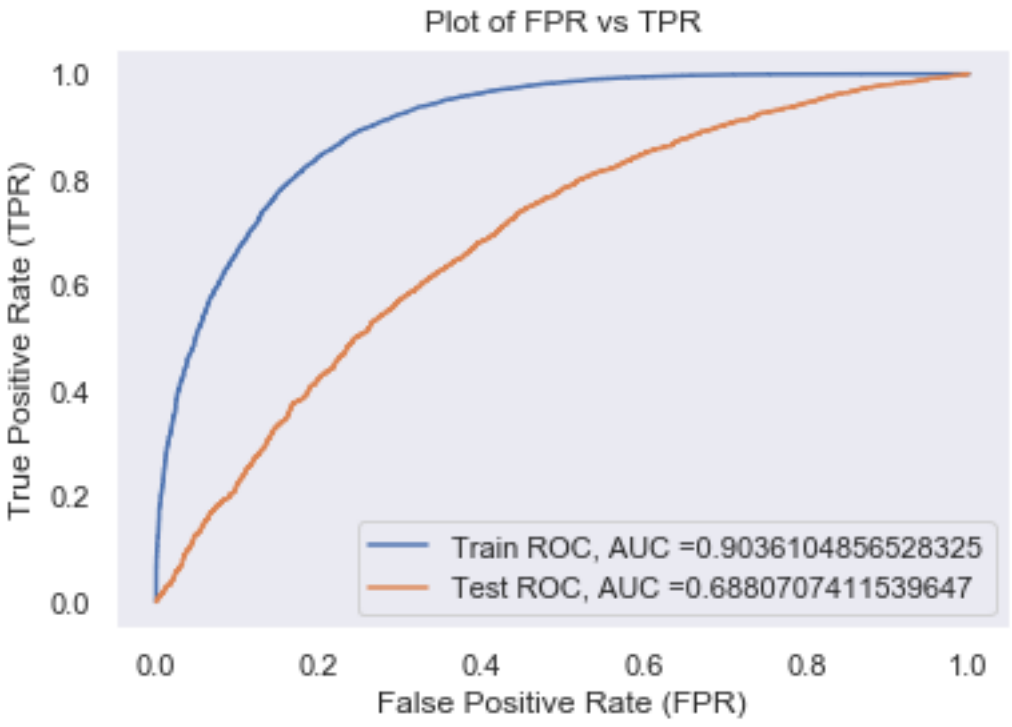
3.21 Observations

- On train data we achieve AUC score 0f 0.90 (max_depth: 8, n_estimators: 1000) as best number of base learner models.

3.22 C) Train model with best hyper-parameter value

In [428]:
```
clf = RandomForestClassifier(max_depth=rf_best_params_set4['max_depth'], n_estimators
clf.fit(X_train_set4,y_train)

# print(X_test_set2)
y_train_pred = batch_predict( clf, X_train_set4)
y_test_pred = batch_predict( clf, X_test_set4)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

rf_test_auc_set4 = roc_auc_score(y_test, y_test_pred)
```

In [429]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.legend()
plt.show()
```

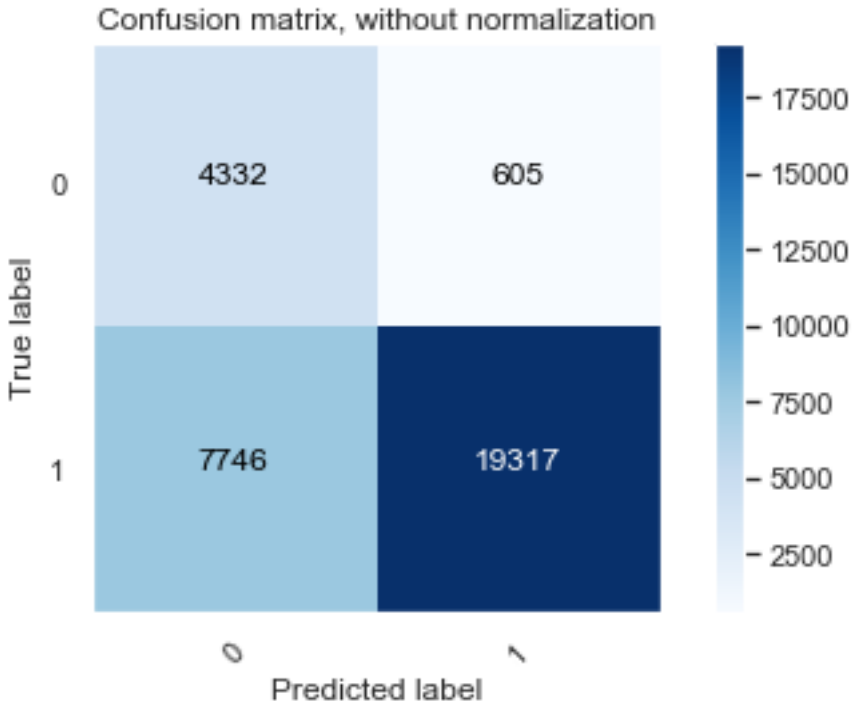


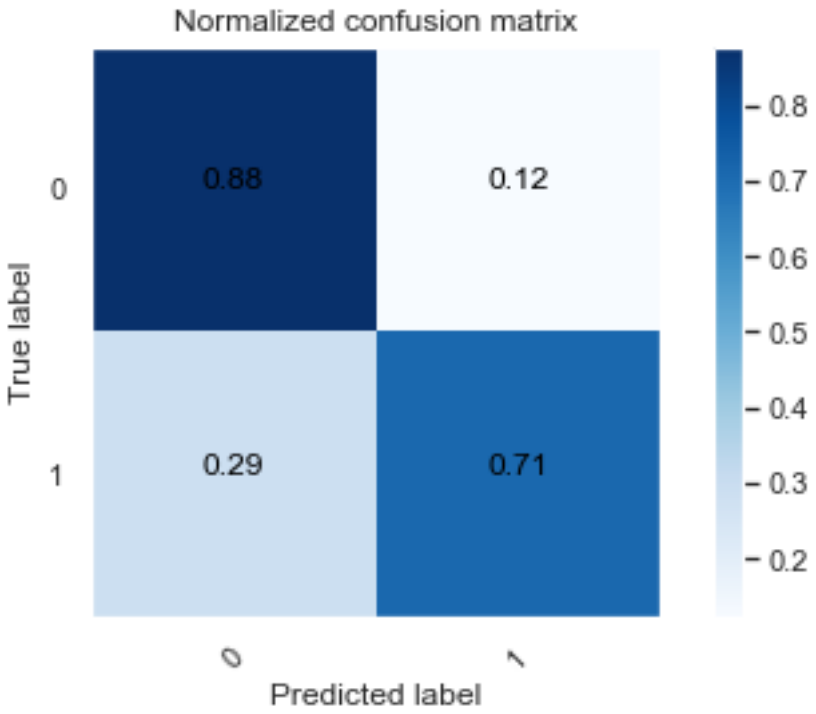
3.23 D) Confusion Matrix

3.23.1 Train Set

In [430]:
```
# computa and plot confusion matrix for train data
print("="*100)
print("Train confusion matrix")
compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.675093496535451 for threshold 0.844
Confusion matrix, without normalization
Normalized confusion matrix
```



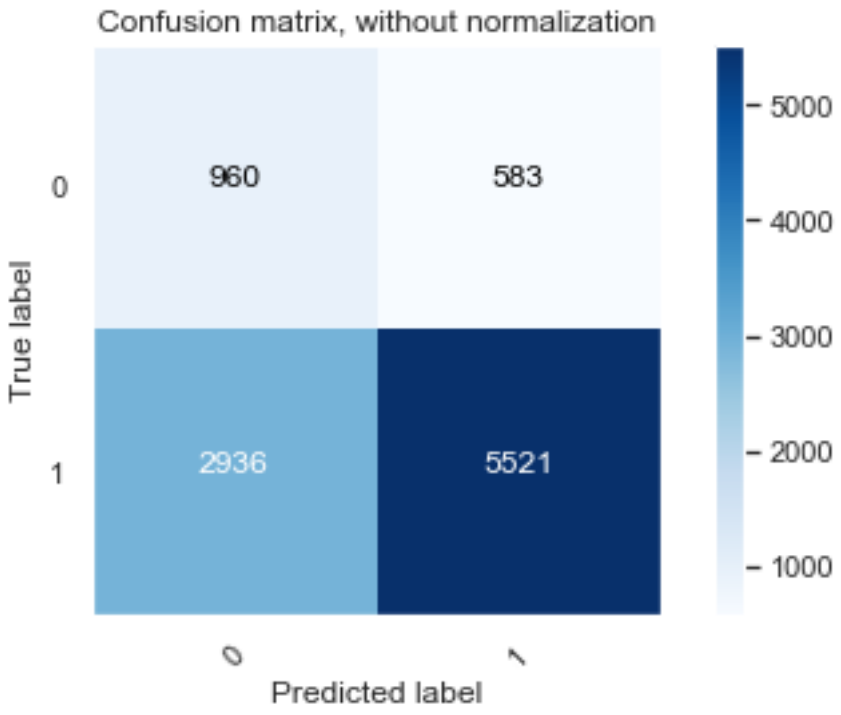


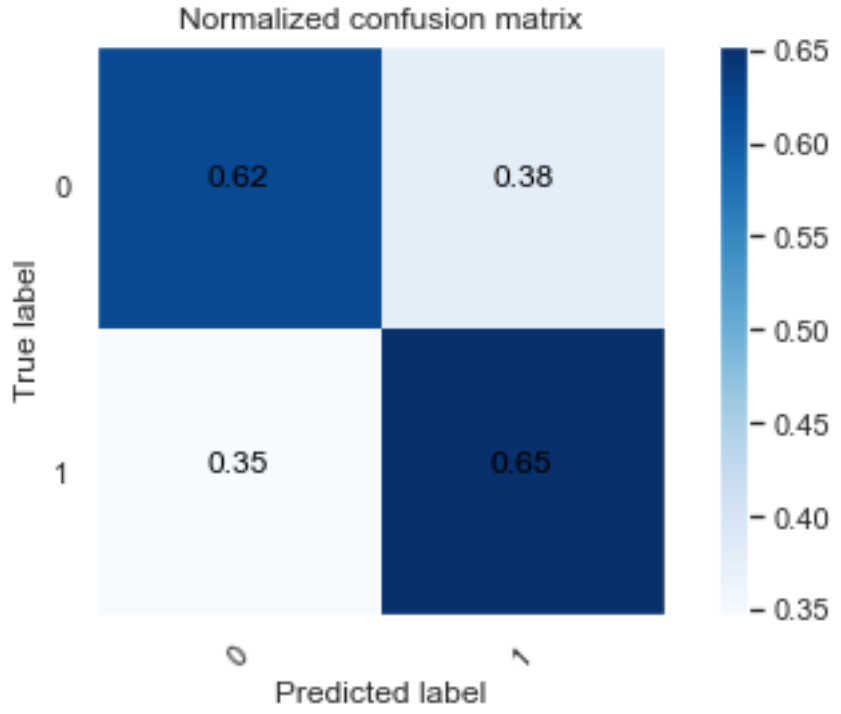
****

3.23.2 Test Set

```
In [431]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4105756765325192 for threshold 0.84
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
960
583
2936
5521
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.62
0.38
0.35
0.65
0
1
True label
0
1
Predicted label
0.65
0.60
0.55
0.50
0.45
0.40
0.35

****

Observations

- On train data we achieve AUC score 0f 0.90 (max_depth: 8, n_estimators: 1000) as best number of base learner models.
- While on test data we achieve an AUC score of 0.68 which is roughly same as above models

4 Applying GBDT

Apply GBDT on different kind of featurization as mentioned in the instructions For Every model that you work on make sure you do the step 2 and step 3 of instrucations

3.23.3 Set 1: categorical (response coding), numerical features + project_title(BOW) + preprocessed_eassay

4.1 Applying GBDT on BOW, SET 1

In [432]:
```
# Please write all the code with proper documentation

print("Final Data matrix for set1")
print(X_train_set1.shape, y_train.shape)
print(X_cv_set1.shape, y_cv.shape)
print(X_test_set1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set1
(32000, 11674) (32000,)
(8000, 11674) (8000,)
(10000, 11674) (10000,)
====================================================================================================
```

3.24 A) Finding best hyper-parameters using grid search

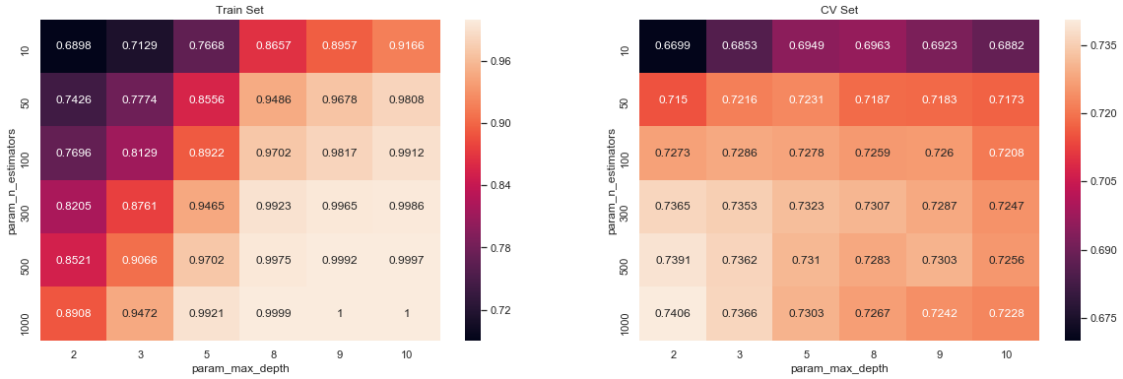
In [433]:
```
model = GradientBoostingClassifier()

clf = find_best_params( model, X_train_set1, y_train, X_cv_set1, y_cv)
train_auc = clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']

# clf.cv_results_
gbdt_best_params_set1 = clf.best_params_
gbdt_best_score_set1 = clf.best_score_
print('Best Params: ', clf.best_params_)
print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:  4.9min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 62.5min finished


Best Params:  {'max_depth': 2, 'n_estimators': 1000}
Best Score:  0.7405856481114766
```

3.25 Plot for Train and Cross Validation Data

```
In [434]: plot_heat_maps(clf)
```



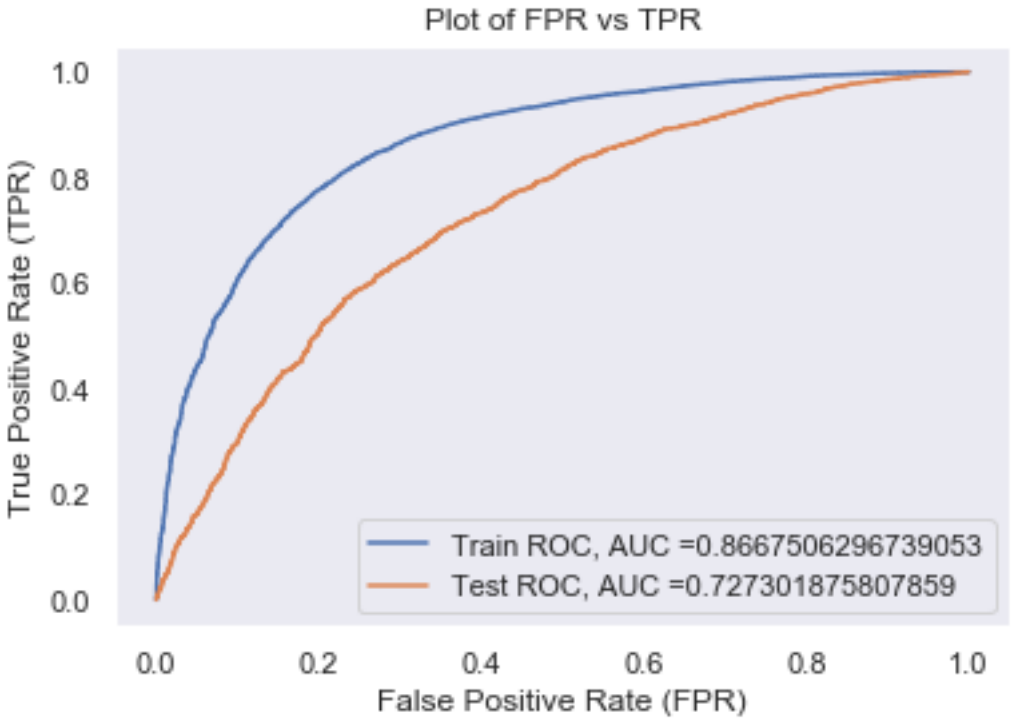
3.26 Observations:

- On train data we achieve AUC score 0f 0.86 (max_depth: 2, n_estimators: 1000) as best number of base learner models.

3.27 C) Train model with best hyper-parameter value

```
In [435]: clf = GradientBoostingClassifier(max_depth=gbdt_best_params_set1['max_depth'], n_esti
          clf.fit(X_train_set1,y_train)

          # print(X_test_set1)
          y_train_pred = batch_predict( clf, X_train_set1)
          y_test_pred = batch_predict( clf, X_test_set1)


          fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
          fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

          gbdt_test_auc_set1 = roc_auc_score(y_test, y_test_pred)
```

```
In [436]: plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
          plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
          plt.xlabel('False Positive Rate (FPR)')
          plt.ylabel("True Positive Rate (TPR)")
          plt.title('Plot of FPR vs TPR')
          plt.legend()
          plt.show()
```

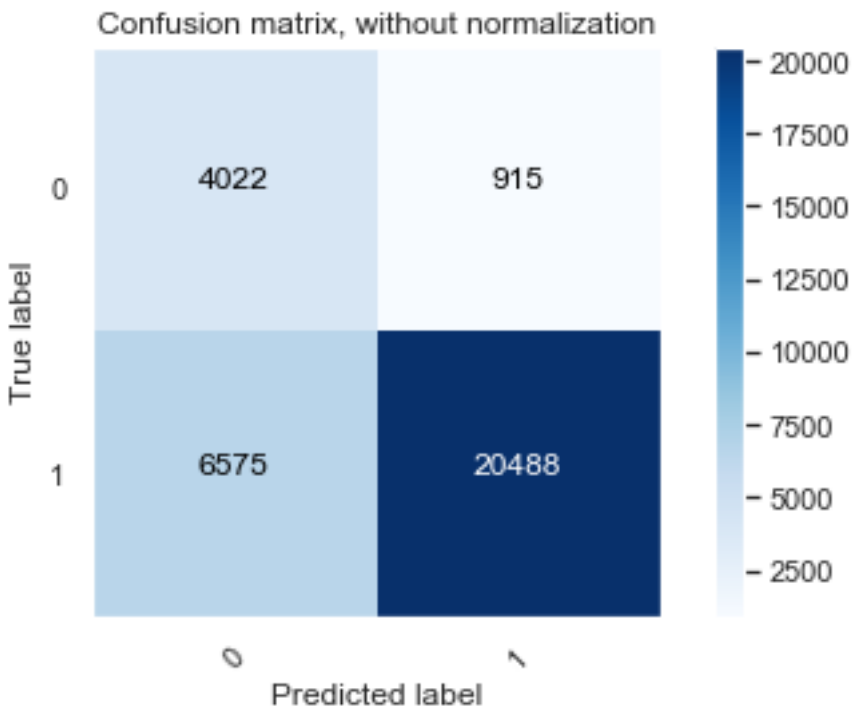


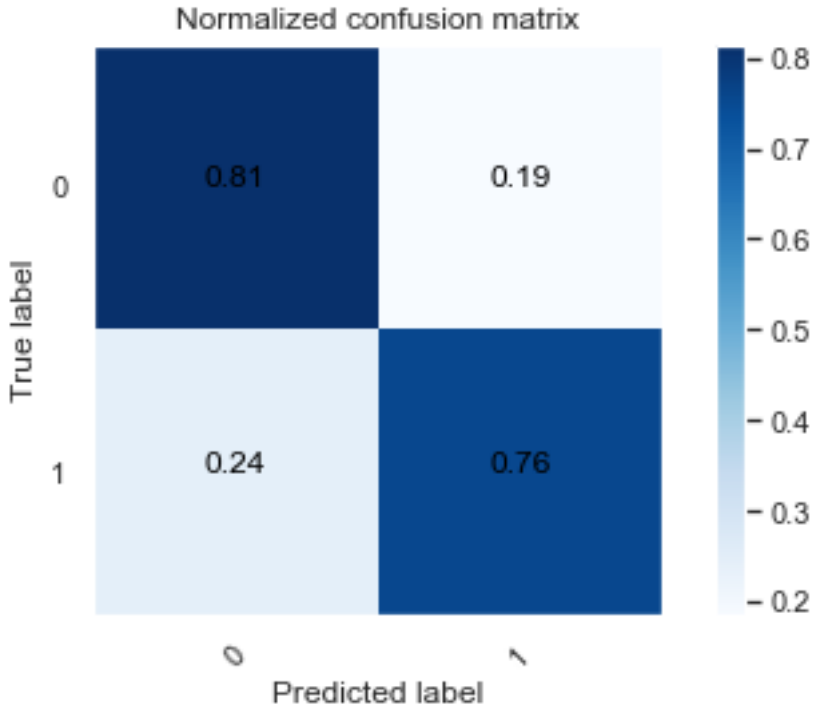
3.28 D) Confusion Matrix

3.28.1 Train Set

```
In [437]: # computa and plot confusion matrix for train data
          print("="*100)
          print("Train confusion matrix")

          compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.6236621186024572 for threshold 0.833
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
4022
915
6575
20488
0
1
True label
0
1
Predicted label
20000
17500
15000
12500
10000
7500
5000
2500

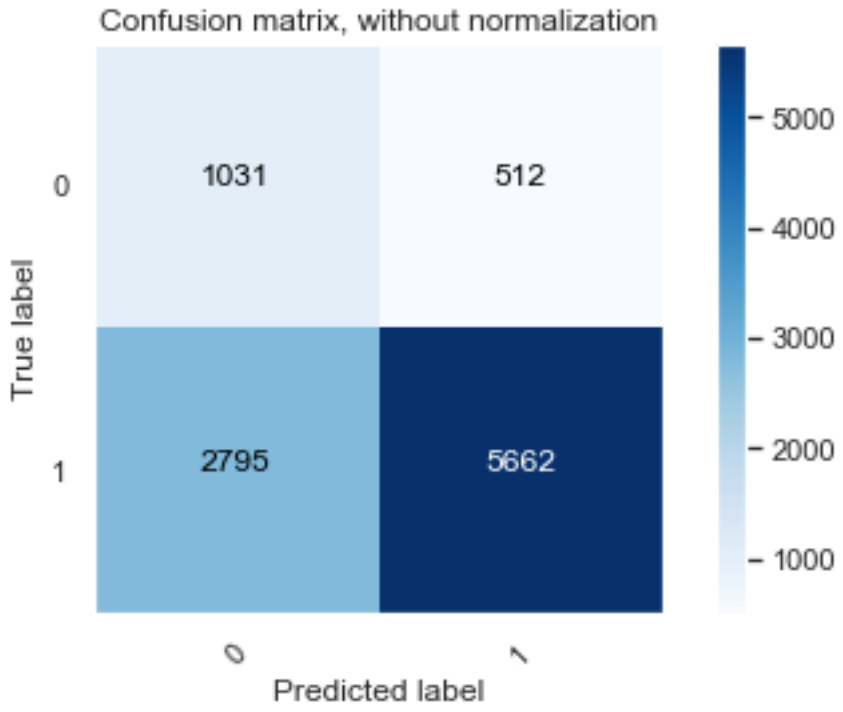

Normalized confusion matrix
0.81
0.19
0.24
0.76
0
1
True label
0
1
Predicted label
0.8
0.7
0.6
0.5
0.4
0.3
0.2

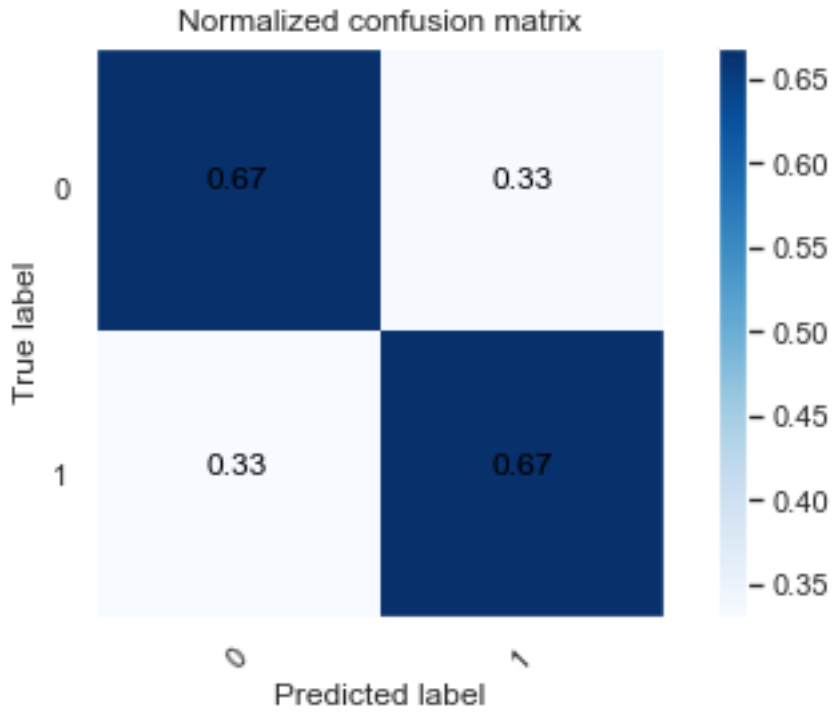
****

3.28.2 Test Set

```
In [438]: print("="*100)
          print("Test confusion matrix")
          # computa and plot confusion matrix for test data

          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.45222045480200207 for threshold 0.851
Confusion matrix, without normalization
Normalized confusion matrix
```





****

Observations

- On train data we achieve AUC score 0f 0.86 and test AUC = 0.72 which is very good compared to Random Forest Models.

3.28.3 Set 2: categorical (response coding), numerical features + project_title(TFIDF)+ preprocessed_eassay

3.28.4 4.2 Applying GBDT on TFIDF, SET 2

```
In [439]: # Please write all the code with proper documentation
          print("Final Data matrix for set2")
          print(X_train_set2.shape, y_train.shape)
          print(X_cv_set2.shape, y_cv.shape)
          print(X_test_set2.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix for set2
(32000, 11674) (32000,)
(8000, 11674) (8000,)
(10000, 11674) (10000,)
====================================================================================================
```

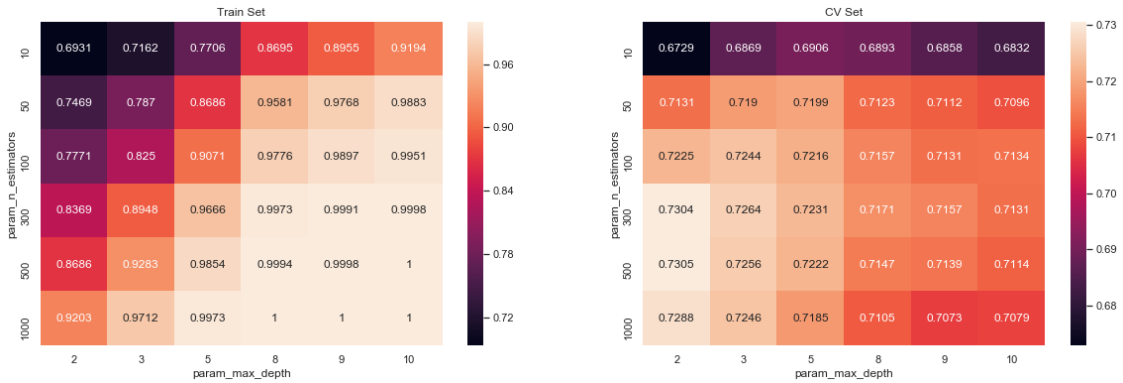
3.29 A) Finding best hyper-parameters using grid search

```
In [440]: model = GradientBoostingClassifier()
          clf = find_best_params(model, X_train_set2, y_train, X_cv_set2, y_cv)
          train_auc = clf.cv_results_['mean_train_score']
          cv_auc = clf.cv_results_['mean_test_score']

          # clf.cv_results_
          gbdt_best_params_set2 = clf.best_params_
          gbdt_best_score_set2 = clf.best_score_
          print('Best Params: ', clf.best_params_)
          print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed: 12.6min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 152.4min finished


Best Params:  {'max_depth': 2, 'n_estimators': 500}
Best Score:  0.7305156832904822
```

3.30 Plot for Train and CrossValidation Data

```
In [441]: plot_heat_maps(clf)
```



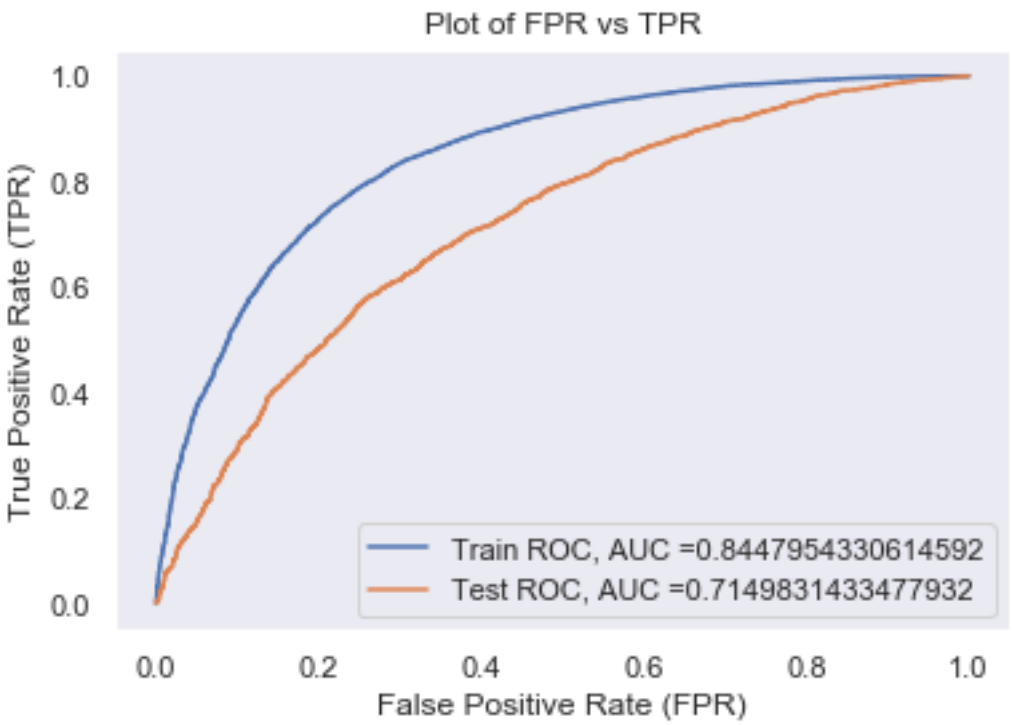
3.31 Observations:

- On train data we achieve AUC score 0f 0.90 and test AUC = 0.79 which is very good compared to Random Forest Models.

3.32 C) Train model with best hyper-parameter value

In [442]:
```
# best hyper parameters = Best Params:  {'max_depth': 5, 'min_samples_split': 100}
# best_params = clf.best_params_

clf = GradientBoostingClassifier(max_depth=gbdt_best_params_set2['max_depth'], n_esti

clf.fit(X_train_set2,y_train)

# print(X_test_set2)
y_train_pred = batch_predict( clf, X_train_set2)
y_test_pred = batch_predict( clf, X_test_set2)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

gbdt_test_auc_set2 = roc_auc_score(y_test, y_test_pred)
```

In [443]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.legend()
plt.show()
```

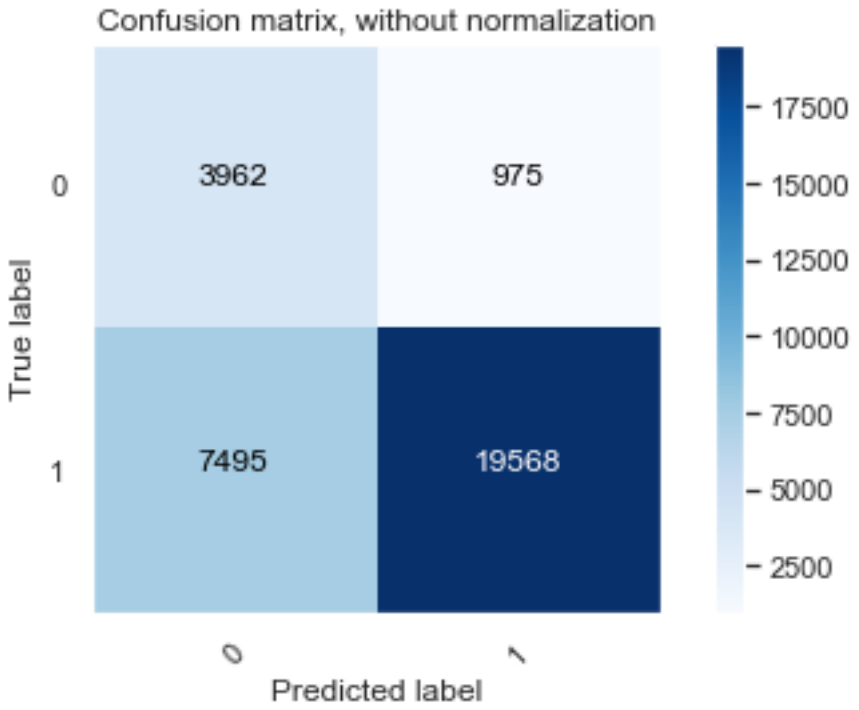


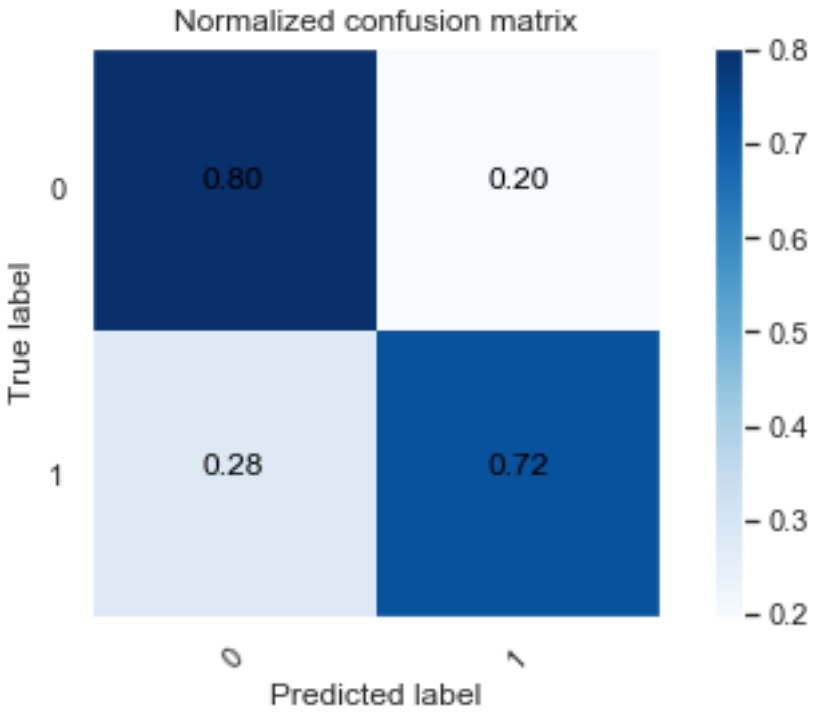
3.33 D) Confusion Matrix

3.33.1 Train Set

```
In [444]: # computa and plot confusion matrix for train data
          print("="*100)
          print("Train confusion matrix")
          compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5917592220302681 for threshold 0.843
Confusion matrix, without normalization
Normalized confusion matrix
```



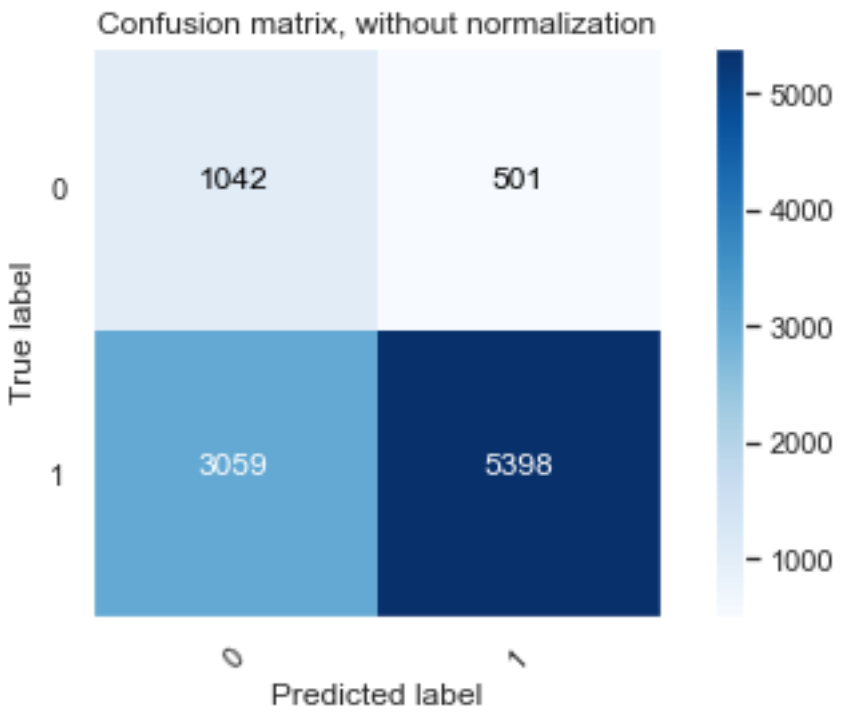


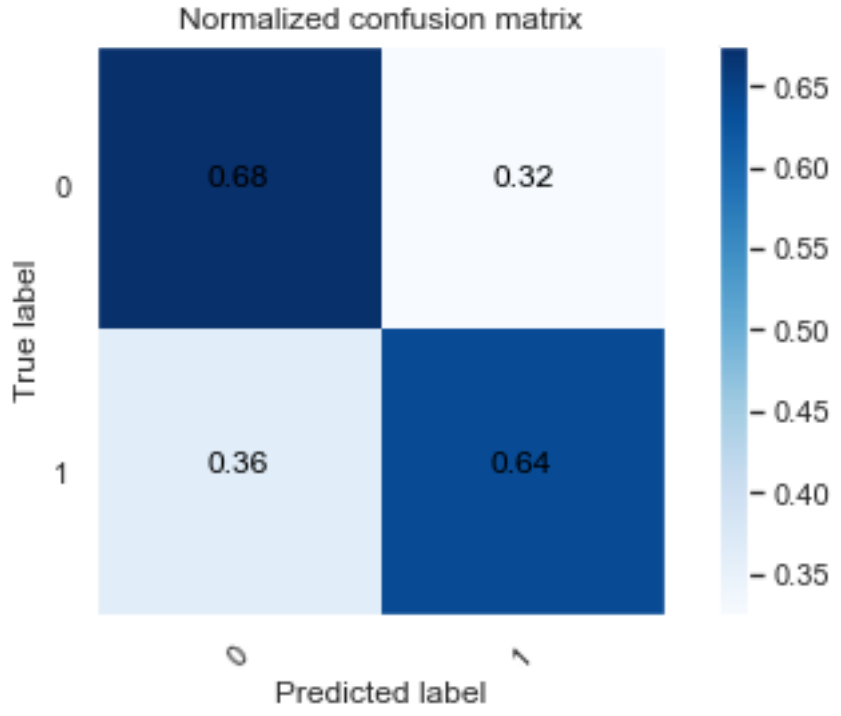
****

3.33.2 Test Set

```
In [445]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.43651728759978325 for threshold 0.859
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
1042
501
3059
5398
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.68
0.32
0.36
0.64
0
1
True label
0
1
Predicted label
0.65
0.60
0.55
0.50
0.45
0.40
0.35

****

3.34 Observations:

- On train data we achieve AUC score 0f 0.84 (max_depth: 2, n_estimators: 500) as best number of base learner models.
- Out Test AUC score is 0.714 which is good.

3.35 Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)

3.35.1 4.3 Applying GBDT on AVG W2V, SET 3

In [446]:
```
# Please write all the code with proper documentation

print("Final Data matrix for set3")
print(X_train_set3.shape, y_train.shape)
print(X_cv_set3.shape, y_cv.shape)
print(X_test_set3.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix for set3
(32000, 619) (32000,)
(8000, 619) (8000,)
(10000, 619) (10000,)
====================================================================================================
```

3.36 A) Finding best hyper-parameters using grid search

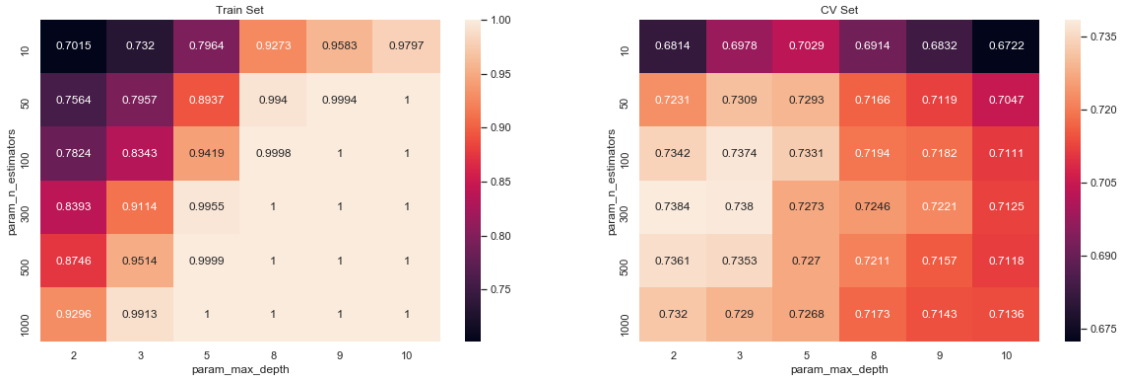
In [447]:
```
model = GradientBoostingClassifier()

clf = find_best_params(model, X_train_set3, y_train, X_cv_set3, y_cv)
train_auc = clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']

# clf.cv_results_
gbdt_best_params_set3 = clf.best_params_
gbdt_best_score_set3 = clf.best_score_
print('Best Params: ', clf.best_params_)
print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed: 37.0min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 1004.7min finished
```

```
Best Params:  {'max_depth': 2, 'n_estimators': 300}
Best Score:  0.7384379381482543
```

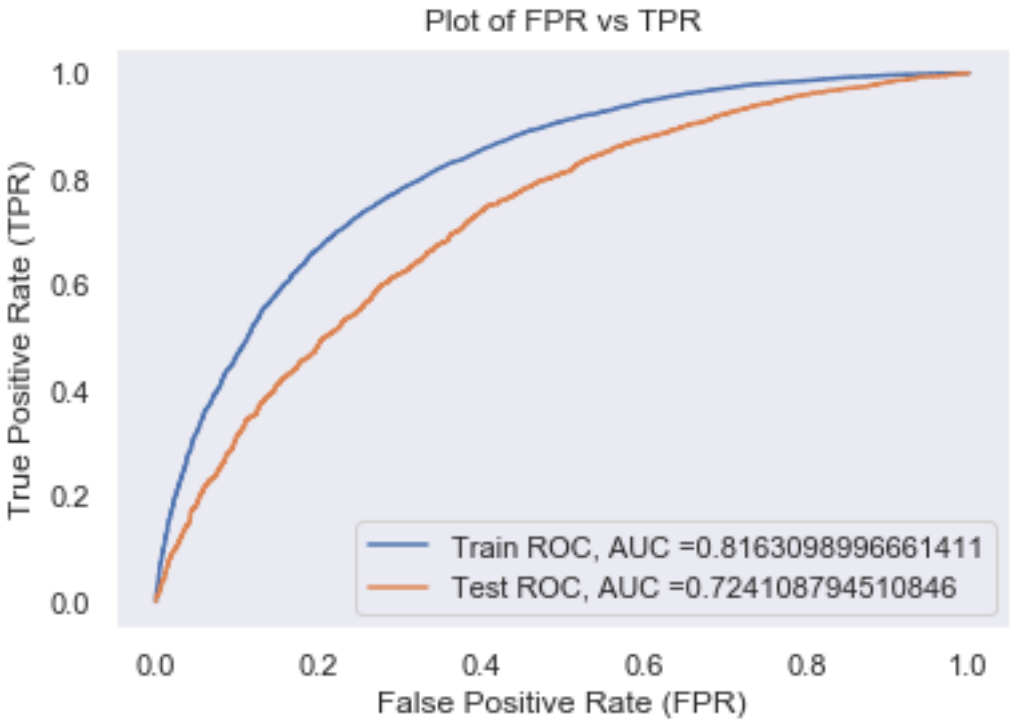
3.37 Plot for Train and CrossValidation Data

```
In [448]: plot_heat_maps(clf)
```



3.38 C) Train model with best hyper-parameter value

```
In [449]: clf = GradientBoostingClassifier(max_depth=gbdt_best_params_set3['max_depth'], n_esti

          clf.fit(X_train_set3,y_train)

          y_train_pred = batch_predict( clf, X_train_set3)
          y_test_pred = batch_predict( clf, X_test_set3)


          fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
          fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

          gbdt_test_auc_set3 = roc_auc_score(y_test, y_test_pred)

In [450]: plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
          plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
          plt.xlabel('False Positive Rate (FPR)')
          plt.ylabel("True Positive Rate (TPR)")
          plt.title('Plot of FPR vs TPR')
          plt.legend()
          plt.show()
```

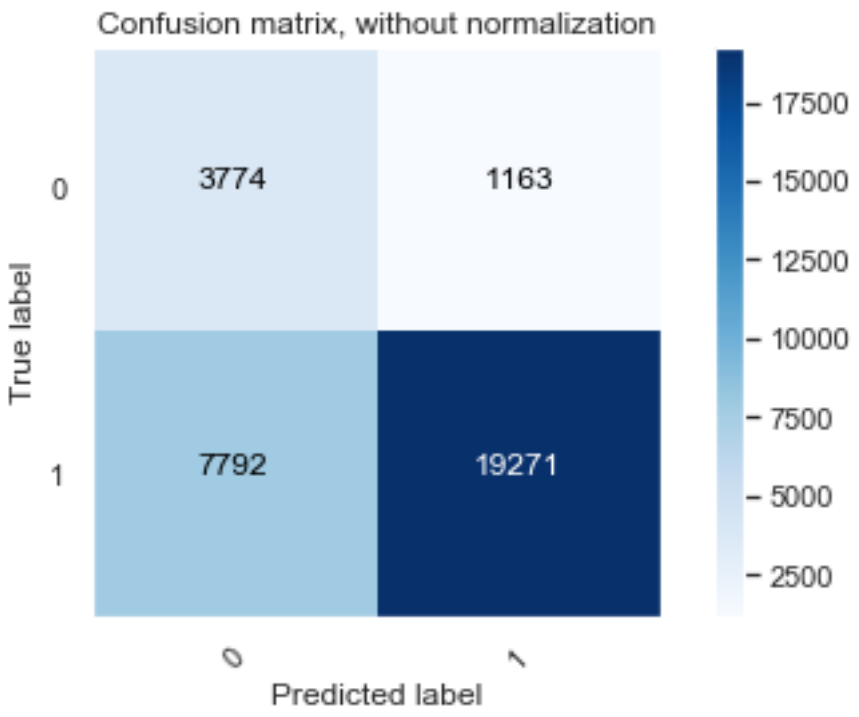


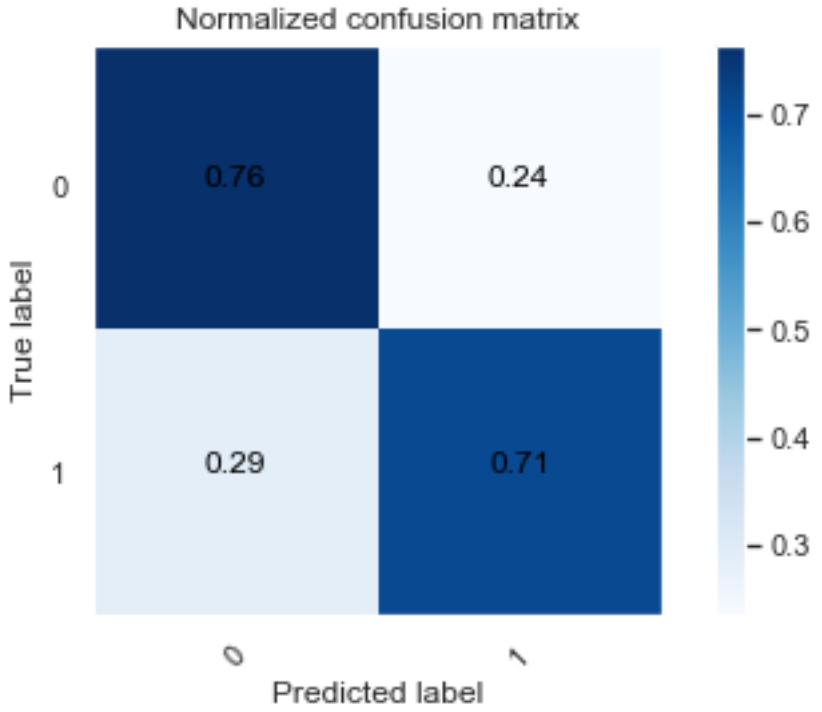
3.39 D) Confusion Matrix

3.39.1 Train Set

```
In [451]: # computa and plot confusion matrix for train data
          print("="*100)
          print("Train confusion matrix")
          compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5494361647143096 for threshold 0.846
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
3774
1163
7792
19271
0
1
True label
0
1
Predicted label
17500
15000
12500
10000
7500
5000
2500

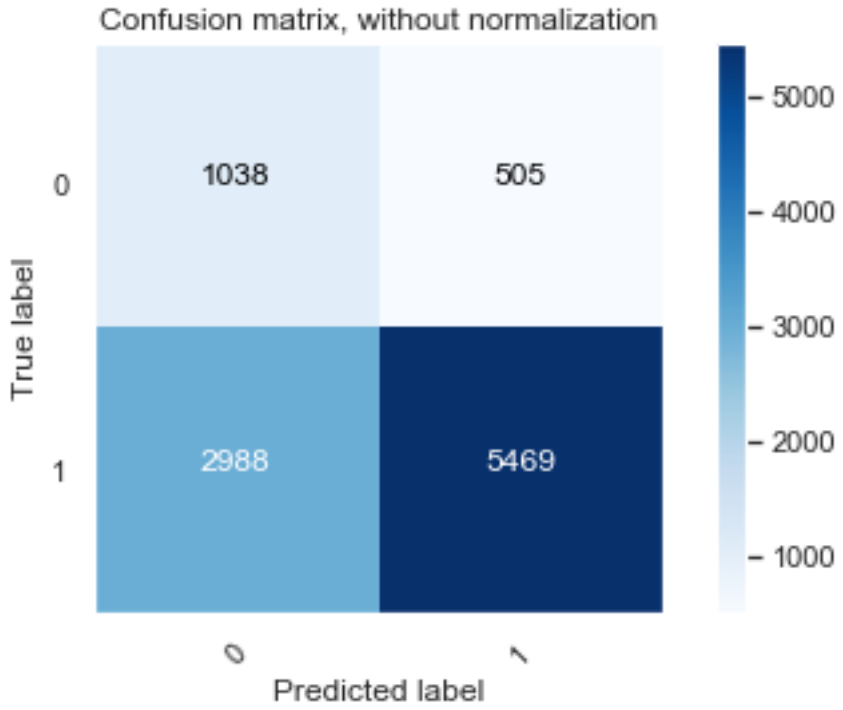

Normalized confusion matrix
0.76
0.24
0.29
0.71
0
1
True label
0
1
Predicted label
0.7
0.6
0.5
0.4
0.3

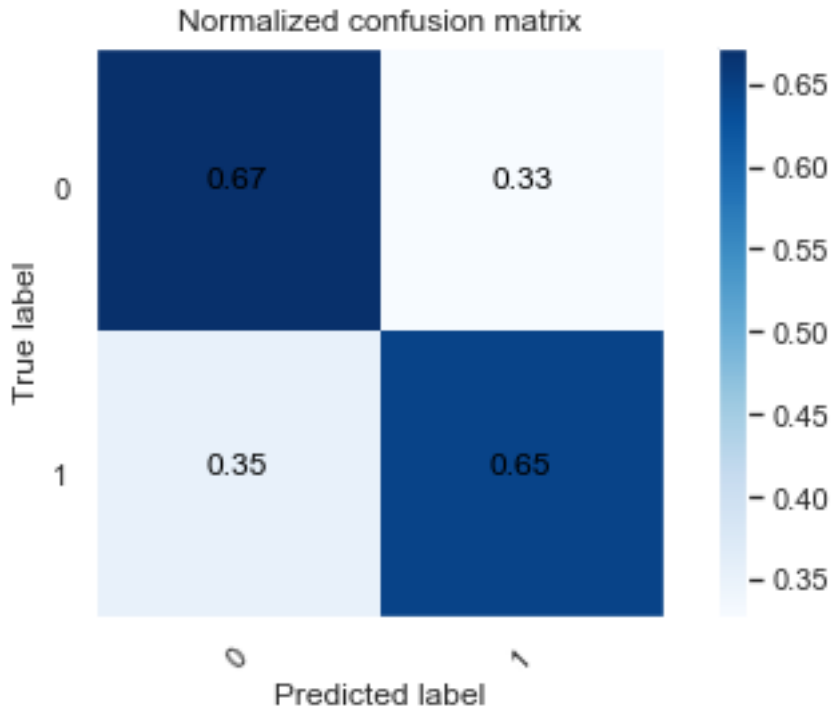
****

3.39.2 Test Set

```
In [452]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.44458984343119334 for threshold 0.857
Confusion matrix, without normalization
Normalized confusion matrix
```





****

Observations

- We get our Best Params as {'max_depth': 2, 'num_estimators': 300}.
- Test AUC on Avg W2V is almost same as that on BOW and TFIDF features.

3.40 Set 4: categorical (response coding), numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

3.40.1 4.4 Applying GBDT on TFIDF W2V, SET 4

```
In [453]: print("Final Data matrix for set4")
          print(X_train_set4.shape, y_train.shape)
          print(X_cv_set4.shape, y_cv.shape)
          print(X_test_set4.shape, y_test.shape)
          print("="*100)

Final Data matrix for set4
(32000, 619) (32000,)
(8000, 619) (8000,)
(10000, 619) (10000,)
====================================================================================================
```

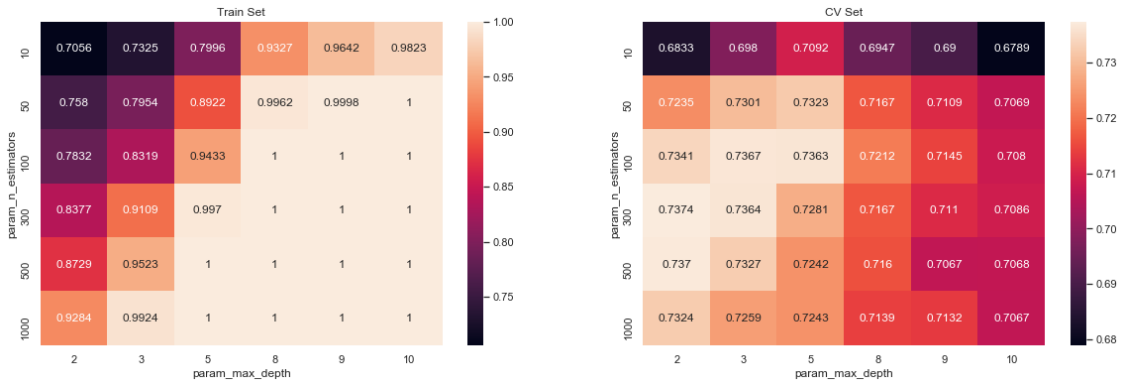
3.41 A) Finding best hyper-parameters using grid search

In [454]:
```
model = GradientBoostingClassifier()

clf = find_best_params(model, X_train_set4, y_train, X_cv_set4, y_cv)
train_auc = clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']

# clf.cv_results_
gbdt_best_params_set4 = clf.best_params_
gbdt_best_score_set4 = clf.best_score_
print('Best Params: ', clf.best_params_)
print('Best Score: ', clf.best_score_)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits


[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed: 37.4min
[Parallel(n_jobs=-1)]: Done 108 out of 108 | elapsed: 562.8min finished


Best Params:  {'max_depth': 2, 'n_estimators': 300}
Best Score:  0.7373795983459962
```

3.42 Plot for Train and Cross Validation Data

In [455]:
```
plot_heat_maps(clf)
```

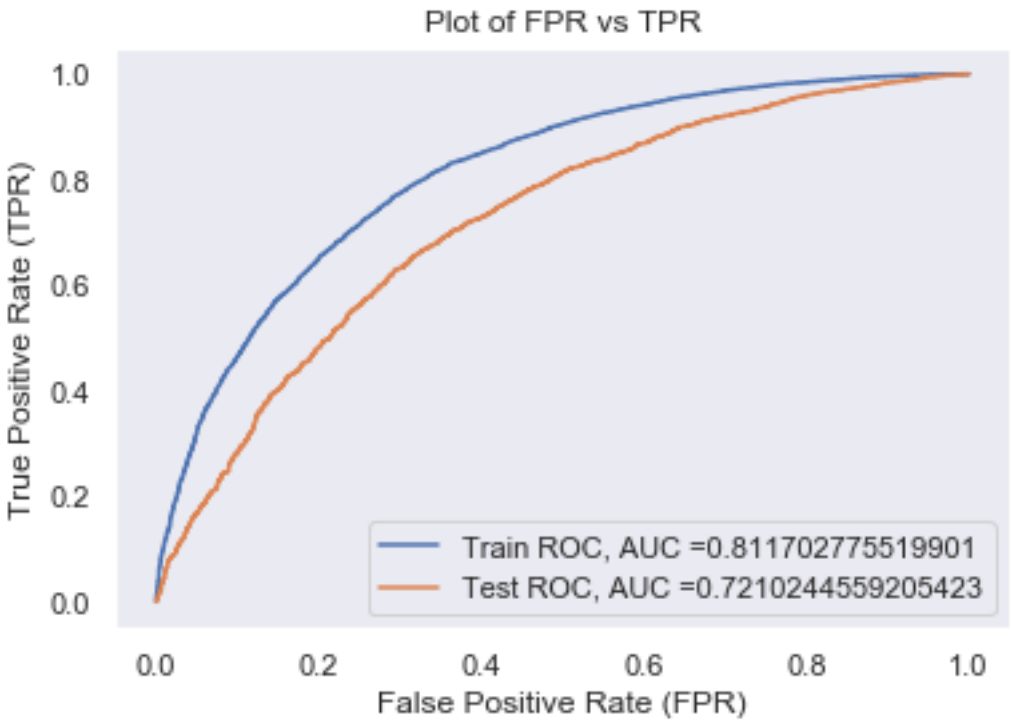


3.43 C) Train model with best hyper-parameter value

In [456]:
```
clf = GradientBoostingClassifier(max_depth=gbdt_best_params_set4['max_depth'], n_esti
clf.fit(X_train_set4,y_train)
```

```
# print(X_test_set2)
y_train_pred = batch_predict( clf, X_train_set4)
y_test_pred = batch_predict( clf, X_test_set4)


fpr_train, tpr_train, thresh1 = roc_curve(y_train, y_train_pred)
fpr_test, tpr_test, thresh = roc_curve(y_test, y_test_pred)

gbdt_test_auc_set4 = roc_auc_score(y_test, y_test_pred)
```

In [457]:
```
plt.plot(fpr_train,tpr_train, label='Train ROC, AUC ='+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test,tpr_test, label='Test ROC, AUC ='+str(auc(fpr_test, tpr_test)))
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel("True Positive Rate (TPR)")
plt.title('Plot of FPR vs TPR')
plt.legend()
plt.show()
```



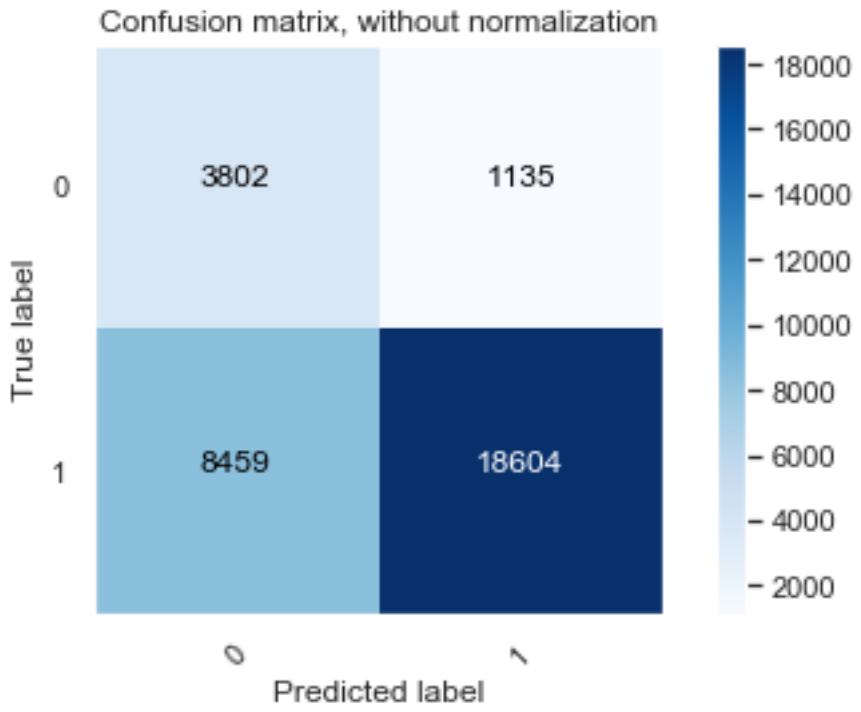
3.44 D) Confusion Matrix

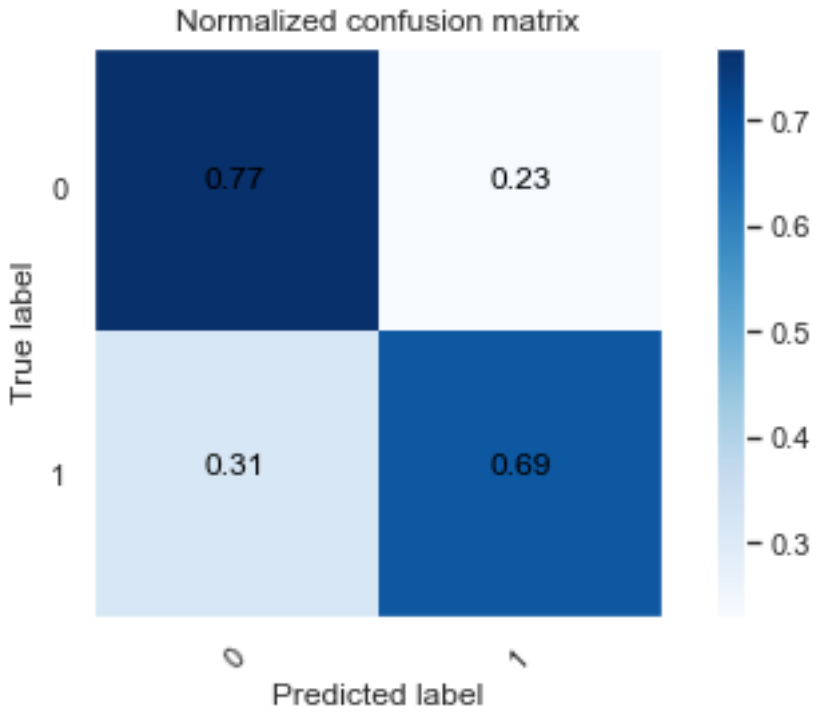
3.44.1 Train Set

In [458]:
```
# computa and plot confusion matrix for train data
print("="*100)
```

```
print("Train confusion matrix")
compute_confusion_matrix(y_train, y_train_pred, thresh1, fpr_train, tpr_train)
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.543433830952408 for threshold 0.849
Confusion matrix, without normalization
Normalized confusion matrix
```



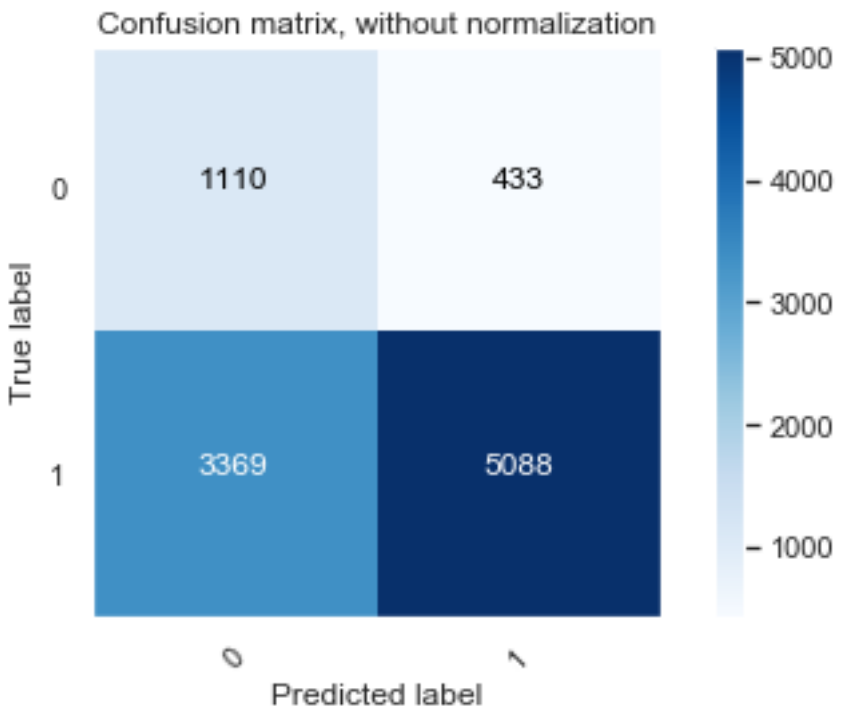


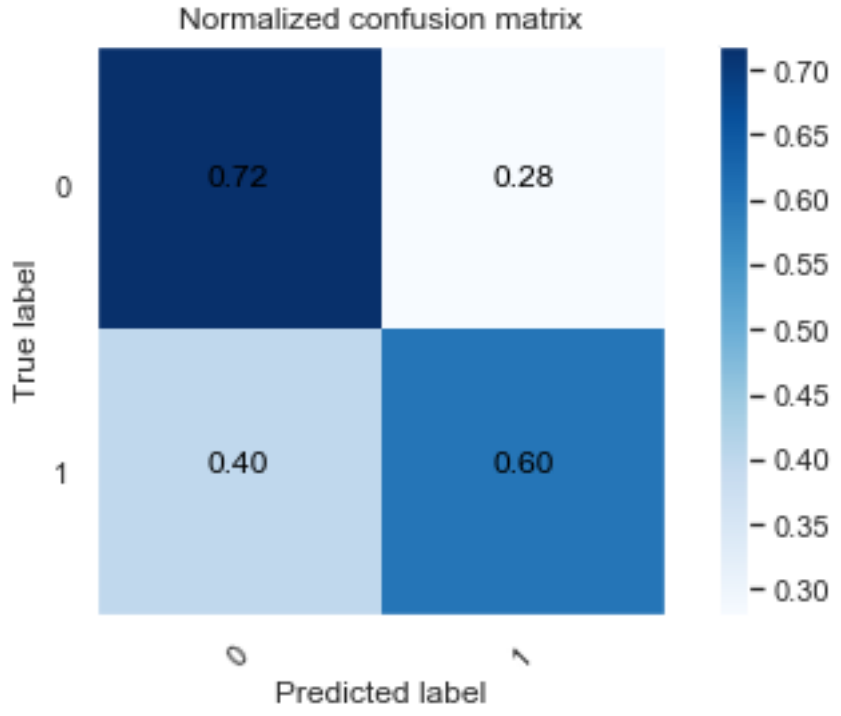
****

3.44.2 Test Set

```
In [459]: print("="*100)
          print("Test confusion matrix")
          compute_confusion_matrix(y_test, y_test_pred, thresh, fpr_test, tpr_test)
```

```
====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.44789887096869374 for threshold 0.866
Confusion matrix, without normalization
Normalized confusion matrix
```


Confusion matrix, without normalization
1110
433
3369
5088
0
1
True label
0
1
Predicted label
5000
4000
3000
2000
1000


Normalized confusion matrix
0.72
0.28
0.40
0.60
0
1
True label
0
1
Predicted label
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30

****

Observations

- We get our Best Params as {'max_depth': 2, 'n_estimators': 300} and best Test AUC as 0.71.
- Test AUC on TFIDF W2V is same as that of Agv W2V.

4. Conclusions

In [460]:
```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyper Parameter", "AUC"]

x.add_row(["BOW", 'RF', rf_best_params_set1, rf_test_auc_set1])
x.add_row(["TFIDF", 'RF', rf_best_params_set2, rf_test_auc_set2])
x.add_row(["Avg W2V", 'RF', rf_best_params_set3, rf_test_auc_set3])
x.add_row(["TFIDF W2V", 'RF', rf_best_params_set4, rf_test_auc_set4])
x.add_row(["BOW", 'GBDT', gbdt_best_params_set1, gbdt_test_auc_set1])
x.add_row(["TFIDF", 'GBDT', gbdt_best_params_set2, gbdt_test_auc_set2])
x.add_row(["Avg W2V", 'GBDT', gbdt_best_params_set3, gbdt_test_auc_set3])
x.add_row(["TFIDF W2V", 'GBDT', gbdt_best_params_set4, gbdt_test_auc_set4])


print(x)
```

```
+------------+-------+-----------------------------------------+--------------------+
| Vectorizer | Model |            Hyper Parameter              |        AUC         |
+------------+-------+-----------------------------------------+--------------------+
|    BOW     |   RF  | {'max_depth': 10, 'n_estimators': 500} | 0.674082857957579  |
|   TFIDF    |   RF  | {'max_depth': 10, 'n_estimators': 300} | 0.6803860266464845 |
|  Avg W2V   |   RF  | {'max_depth': 9, 'n_estimators': 1000} | 0.6843193859891727 |
| TFIDF W2V  |   RF  | {'max_depth': 8, 'n_estimators': 1000} | 0.6880707411539647 |
|    BOW     |  GBDT | {'max_depth': 2, 'n_estimators': 1000} | 0.727301875807859  |
|   TFIDF    |  GBDT | {'max_depth': 2, 'n_estimators': 500}  | 0.7149831433477932 |
|  Avg W2V   |  GBDT | {'max_depth': 2, 'n_estimators': 300}  | 0.724108794510846  |
| TFIDF W2V  |  GBDT | {'max_depth': 2, 'n_estimators': 300}  | 0.7210244559205423 |
+------------+-------+-----------------------------------------+--------------------+
```

Observations

- Random Forest performs better on deep trees while GBDT performs better in shallow trees.
- Best Test AUC value is achieved using GBDT and is 0.7241
- Overall GBDT performs better than Random Forest.

In [ ]: