Assignment 9: GBDT

In [1]:

```
import time
time_start = time.time()

import re
import pickle

import numpy as np
import pandas as pd
import seaborn as sns
import missingno as msno

from statistics import mode
from tqdm import tqdm
from scipy.sparse import hstack
import matplotlib.pyplot as plt
from prettytable import PrettyTable

from sklearn.metrics import auc
from sklearn.metrics import roc_curve
from sklearn.preprocessing import Normalizer
from sklearn.metrics import confusion_matrix

from sklearn.model_selection import train_test_split
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import GradientBoostingClassifier

from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer

import nltk
# nltk.download('vader_lexicon')

from nltk.corpus import stopwords
from nltk.sentiment.vader import SentimentIntensityAnalyzer

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

In [2]:

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

In [3]:

```
print(f'Number of data points in train data : {project_data.shape}')
print('\nColumn names : \n', project_data.columns)

project_data.head(2)
```

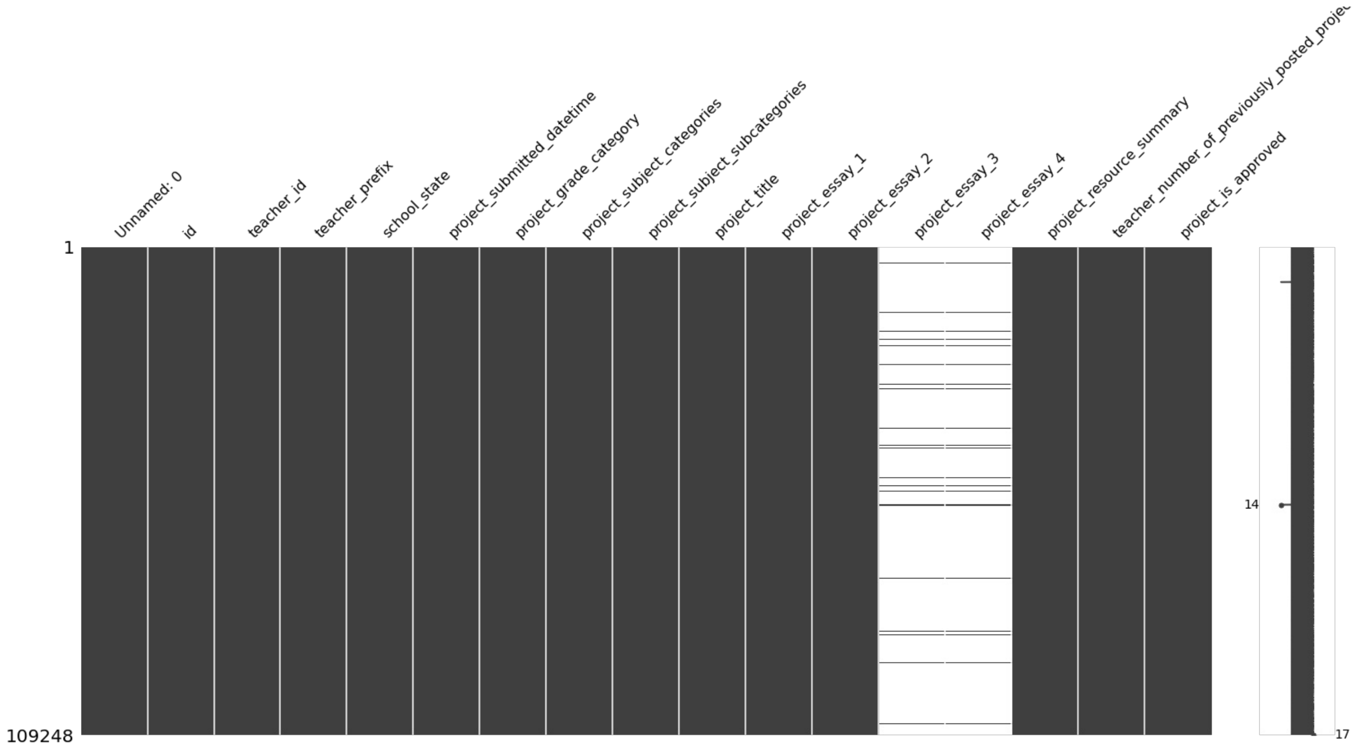
```
Number of data points in train data : (109248, 17)

Column names :
 Index(['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'],
      dtype='object')
```

Out[3]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades 6-8	

In [4]:

```
# https://www.geeksforgeeks.org/python-visualize-missing-values-nan-values-using-missingno-library/

msno.matrix(project_data)
plt.show()
```



Observation

- There are missing values in `teacher_prefix`, `project_essay_3` and `project_essay_4`.
- Except these 3, there are no missing values available.

In [5]:

```
print(f'Number of data points in train data : {resource_data.shape}')
print('Column names : \n', resource_data.columns)
resource_data.head(3)
```

```
Number of data points in train data : (1541272, 4)
Column names :
 Index(['id', 'description', 'quantity', 'price'], dtype='object')
```

Out[5]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95
2	p069063	Cory Stories: A Kid's Book About Living With Adhd	1	8.45

Preprocessing Categorical Features

We need to remove the spaces, and special characters

- Remove additional spaces
- Remove dots : '.'
- Replace '-' with '_'
- Replace ' The ' with ''
- Replace '&' with '_'
- Replace ',' with '_'
- Convert all the characters to small case

project_grade_category

In [6]:

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

Out[6]:

```
Grades PreK-2    44225
Grades 3-5       37137
Grades 6-8       16923
Grades 9-12      10963
Name: project_grade_category, dtype: int64
```

In [7]:

```
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[7]:

```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

project_subject_categories

In [8]:

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

Out[8]:

```
Literacy & Language                           23655
Math & Science                                17072
Literacy & Language, Math & Science           14636
Health & Sports                               10177
Music & The Arts                               5180
Special Needs                                  4226
Literacy & Language, Special Needs             3961
Applied Learning                               3771
Math & Science, Literacy & Language            2289
Applied Learning, Literacy & Language          2191
History & Civics                               1851
Math & Science, Special Needs                  1840
Literacy & Language, Music & The Arts          1757
Math & Science, Music & The Arts               1642
Applied Learning, Special Needs                1467
History & Civics, Literacy & Language          1421
Health & Sports, Special Needs                 1391
Warmth, Care & Hunger                          1309
Math & Science, Applied Learning               1220
Applied Learning, Math & Science               1052
Literacy & Language, History & Civics           809
Health & Sports, Literacy & Language            803
Applied Learning, Music & The Arts              758
Math & Science, History & Civics                652
Literacy & Language, Applied Learning           636
Applied Learning, Health & Sports               608
Math & Science, Health & Sports                 414
History & Civics, Math & Science                322
History & Civics, Music & The Arts              312
Special Needs, Music & The Arts                 302
Health & Sports, Math & Science                 271
History & Civics, Special Needs                 252
Health & Sports, Applied Learning               192
Applied Learning, History & Civics              178
Health & Sports, Music & The Arts               155
Music & The Arts, Special Needs                 138
Literacy & Language, Health & Sports             72
Health & Sports, History & Civics                43
History & Civics, Applied Learning               42
Special Needs, Health & Sports                   42
Special Needs, Warmth, Care & Hunger             23
Health & Sports, Warmth, Care & Hunger           23
Music & The Arts, Health & Sports                19
Music & The Arts, History & Civics               18
History & Civics, Health & Sports                13
Math & Science, Warmth, Care & Hunger            11
Music & The Arts, Applied Learning               10
Applied Learning, Warmth, Care & Hunger          10
Literacy & Language, Warmth, Care & Hunger        9
Music & The Arts, Warmth, Care & Hunger           2
History & Civics, Warmth, Care & Hunger           1
Name: project_subject_categories, dtype: int64
```

In [9]:

```
project_data['clean_categories'] = project_data['project_subject_categories'].str.replace(' The ','')
project_data['clean_categories'] = project_data['clean_categories'].str.replace(' ','')
project_data['clean_categories'] = project_data['clean_categories'].str.replace('&','_')
project_data['clean_categories'] = project_data['clean_categories'].str.replace(',','_')
project_data['clean_categories'] = project_data['clean_categories'].str.lower()
project_data['clean_categories'].value_counts()
```

Out[9]:

```
literacy_language                       23655
math_science                            17072
literacy_language_math_science          14636
```

```
health_sports                            10177
music_arts                                5180
specialneeds                              4226
literacy_language_specialneeds            3961
appliedlearning                           3771
math_science_literacy_language            2289
appliedlearning_literacy_language         2191
history_civics                            1851
math_science_specialneeds                 1840
literacy_language_music_arts              1757
math_science_music_arts                   1642
appliedlearning_specialneeds              1467
history_civics_literacy_language          1421
health_sports_specialneeds                1391
warmth_care_hunger                        1309
math_science_appliedlearning              1220
appliedlearning_math_science              1052
literacy_language_history_civics           809
health_sports_literacy_language            803
appliedlearning_music_arts                 758
math_science_history_civics                652
literacy_language_appliedlearning          636
appliedlearning_health_sports              608
math_science_health_sports                 414
history_civics_math_science                322
history_civics_music_arts                  312
specialneeds_music_arts                    302
health_sports_math_science                 271
history_civics_specialneeds                252
health_sports_appliedlearning              192
appliedlearning_history_civics             178
health_sports_music_arts                   155
music_arts_specialneeds                    138
literacy_language_health_sports             72
health_sports_history_civics                43
history_civics_appliedlearning              42
specialneeds_health_sports                  42
specialneeds_warmth_care_hunger             23
health_sports_warmth_care_hunger            23
music_arts_health_sports                    19
music_arts_history_civics                   18
history_civics_health_sports                13
math_science_warmth_care_hunger             11
music_arts_appliedlearning                  10
appliedlearning_warmth_care_hunger          10
literacy_language_warmth_care_hunger         9
music_arts_warmth_care_hunger                2
history_civics_warmth_care_hunger            1
Name: clean_categories, dtype: int64
```

teacher_prefix

In [10]:

```
project_data['teacher_prefix'].isnull().sum()
```

Out[10]:

```
3
```

In [11]:

```
project_data['teacher_prefix'].fillna('Mrs.', inplace = True)
project_data['teacher_prefix'].isnull().sum()
```

Out[11]:

```
0
```

In [12]:

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

Out[12]:

```
Mrs.       57272
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

In [13]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('.','')
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

```
mrs        57272
```

Out[13]:

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

project_subject_subcategories

In [14]:

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

Out[14]:

```
Literacy                             9486
Literacy, Mathematics                8325
Literature & Writing, Mathematics    5923
Literacy, Literature & Writing       5571
Mathematics                          5379
                                     ...
Community Service, Gym & Fitness        1
Parent Involvement, Team Sports         1
Gym & Fitness, Social Sciences          1
Community Service, Music                1
Economics, Foreign Languages            1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

In [15]:

```
project_data['clean_subcategories'] = \
                                project_data['project_subject_subcategories'].str.replace(' The ','')

project_data['clean_subcategories'] = \
                                project_data['clean_subcategories'].str.replace(' ','')

project_data['clean_subcategories'] = \
                                project_data['clean_subcategories'].str.replace('&','_')

project_data['clean_subcategories'] = \
                                project_data['clean_subcategories'].str.replace(',','_')

project_data['clean_subcategories'] = \
                                project_data['clean_subcategories'].str.lower()

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

Out[15]:

```
literacy                          9486
literacy_mathematics              8325
literature_writing_mathematics    5923
literacy_literature_writing       5571
mathematics                       5379
                                  ...
communityservice_gym_fitness         1
parentinvolvement_teamsports         1
gym_fitness_socialsciences           1
communityservice_music               1
economics_foreignlanguages           1
Name: clean_subcategories, Length: 401, dtype: int64
```

school_state

In [16]:

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

Out[16]:

```
CA    15388
TX     7396
NY     7318
FL     6185
NC     5091
IL     4350
GA     3963
SC     3936
MI     3161
PA     3109
IN     2620
MO     2576
OH     2467
LA     2394
MA     2389
WA     2334
OK     2276
NJ     2237
```

```
AZ     2147
VA     2045
WI     1827
AL     1762
UT     1731
TN     1688
CT     1663
MD     1514
NV     1367
MS     1323
KY     1304
OR     1242
MN     1208
CO     1111
AR     1049
ID      693
IA      666
KS      634
NM      557
DC      516
HI      507
ME      505
WV      503
NH      348
AK      345
DE      343
NE      309
SD      300
RI      285
MT      245
ND      143
WY       98
VT       80
Name: school_state, dtype: int64
```

In [17]:

```
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].unique()
```

Out[17]:

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

project_title

In [18]:

```
# https://stackoverflow.com/a/47091490/4084039

def decontracted(phrase):

    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)

    return phrase
```

In [19]:

```
# https://gist.github.com/sebleier/554280
# Removing the words from the stop words list: 'no', 'nor', 'not'

stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
            'himself', 'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they',
            'them', 'their', 'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that',
            "that'll", 'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have',
            'has', 'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if',
            'or', 'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'against',
            'between', 'into', 'through', 'during', 'before', 'after', 'above', 'below', 'to', 'from',
            'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further', 'then', 'once',
            'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', 's',
            't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm',
            'o', 're', 've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't",
            'doesn', "doesn't", 'hadn', "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't",
            'ma', 'mightn', "mightn't", 'mustn', "mustn't", 'needn', "needn't", 'shan', "shan't",
            'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "weren't", 'won', "won't", 'wouldn',
            "wouldn't"]
```

In [20]:

```
print('Random Review Texts')
print('=' *19)
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])
```

```
Random Review Texts
===================
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!
```

In [21]:

```
# https://gist.github.com/sebleier/554280
# Combining all the above stundents

def preprocess_title(text_data):

    preprocessed_text = []

    for sentance in tqdm(text_data):

        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)

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

        preprocessed_text.append(sent.lower().strip())

    return preprocessed_text
```

In [22]:

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

```
100%|███████████████████████████████| 109248/109248 [00:00<00:00, 117520.01it/s]
```

In [23]:

```
print('BEFORE Processing')
print('=' *19)
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])

print('\nAFTER Processing')
print('=' *16)
print(9, preprocessed_titles[9])
print(34, preprocessed_titles[34])
print(147, preprocessed_titles[147])
```

```
BEFORE Processing
===================
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!

AFTER Processing
================
9 just for the love of reading pure pleasure
34 have a ball
147 who needs a chromebook we do
```

title_word_count

- Adding a new feature

In [24]:

```
title_word_count = []
```

```
for title in tqdm(preprocessed_titles):
    title_length = len(title.split())
    title_word_count.append(title_length)

print(f'Length of `title_word_count` list : {len(title_word_count)}')
```

```
100%|██████████████████████████████| 109248/109248 [00:00<00:00, 1648947.13it/s]
```

```
Length of `title_word_count` list : 109248
```

essay

In [25]:

```
# https://gist.github.com/sebleier/554280
# Combining all the above stundents

def preprocess_text(text_data):

    preprocessed_text = []

    for sentance in tqdm(text_data):

        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)

        sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)

        preprocessed_text.append(sent.lower().strip())

    return preprocessed_text
```

In [26]:

```
# merge two column text dataframe:

project_data['essay'] = project_data['project_essay_1'].map(str) +\
                        project_data['project_essay_2'].map(str) + \
                        project_data['project_essay_3'].map(str) + \
                        project_data['project_essay_4'].map(str)
```

In [27]:

```
print('Random Essay Texts')
print('=' * 18)
print(9, project_data['essay'].values[9])
print('-' * 110)
print(34, project_data['essay'].values[34])
print('-' * 110)
print(147, project_data['essay'].values[147])
```

```
Random Essay Texts
==================
9 Over 95% of my students are on free or reduced lunch.  I have a few who are homeless, but despite that, they co
me to school with an eagerness to learn.  My students are inquisitive eager learners who  embrace the challenge o
f not having great books and other resources  every day.  Many of them are not afforded the opportunity to engage
with these big colorful pages of a book on a regular basis at home and they don't travel to the public library.
\r\nIt is my duty as a teacher to do all I can to provide each student an opportunity to succeed in every aspect
of life. \r\nReading is Fundamental! My students will read these books over and over again while boosting their c
omprehension skills. These books will be used for read alouds, partner reading and for Independent reading. \r\nT
hey will engage in reading to build their \"Love for Reading\" by reading for pure enjoyment. They will be introd
uced to some new authors as well as some old favorites. I want my students to be ready for the 21st Century and k
now the pleasure of holding a good hard back book in hand. There's nothing like a good book to read!  \r\nMy stud
ents will soar in Reading, and more because of your consideration and generous funding contribution. This will he
lp build stamina and prepare for 3rd grade. Thank you so much for reading our proposal!nannan
--------------------------------------------------------------------------------------------------------------
34 My students mainly come from extremely low-income families, and the majority of them come from homes where bot
h parents work full time. Most of my students are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm in the after
-school program), and they all receive free and reduced meals for breakfast and lunch. \r\n\r\n\r\nI want my stud
ents to feel  as comfortable in my classroom as they do at home. Many of my students take on multiple roles both
at home as well as in school. They are sometimes the caretakers of younger siblings, cooks, babysitters, academic
s, friends, and most of all, they are developing who they are going to become as adults.  I consider it an essent
ial part of my job to model helping others gain knowledge in a positive manner. As a result, I have a community o
f students who love helping each other in and outside of the classroom. They consistently look for opportunities
to support each other's learning in a kind and helpful way.I am excited to be experimenting with alternative seat
ing in my classroom this school year. Studies have shown that giving students the option of where they sit in a c
lassroom increases focus as well as motivation.  \r\n\r\nBy allowing students choice in the classroom, they are a
ble to explore and create in a welcoming environment. Alternative classroom seating has been experimented with mo
re frequently in recent years. I believe (along with many others), that every child learns differently. This does
not only apply to how multiplication is memorized, or a paper is written, but applies to the space in which they
are asked to work. I have had students in the past ask \"Can I work in the library? Can I work on the carpet?\" M
y answer was always, \"As long as you're learning, you can work wherever you want!\" \r\n\r\nWith the yoga balls
```

```
and the lap-desks, I will be able to increase the options for seating in my classroom and expand its imaginable s
pace.nannan
--------------------------------------------------------------------------------------------------------------
147 My students are eager to learn and make their mark on the world.\r\n\r\nThey come from a Title 1 school and n
eed extra love.\r\n\r\nMy fourth grade students are in a high poverty area and still come to school every day to
get their education. I am trying to make it fun and educational for them so they can get the most out of their sc
hooling. I created a caring environment for the students to bloom! They deserve the best.\r\nThank you!\r\nI am r
equesting 1 Chromebook to access online interventions, differentiate instruction, and get extra practice. The Chr
omebook will be used to supplement ELA and math instruction. Students will play ELA and math games that are engag
ing and fun, as well as participate in assignments online. This in turn will help my students improve their skill
s. Having a Chromebook in the classroom would not only allow students to use the programs at their own pace, but
would ensure more students are getting adequate time to use the programs. The online programs have been especiall
y beneficial to my students with special needs. They are able to work at their level as well as be challenged wit
h some different materials. This is making these students more confident in their abilities.\r\n\r\nThe Chromeboo
k would allow my students to have daily access to computers and increase their computing skills.\r\nThis will cha
nge their lives for the better as they become more successful in school. Having access to technology in the class
room would help bridge the achievement gap.nannan
```

In [28]:

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

```
100%|█████████████████████████████████| 109248/109248 [00:46<00:00, 2356.04it/s]
```

In [29]:

```
print('9 : BEFORE Processing')
print('=' * 21)
print(project_data['essay'].values[9])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_essays[9])

print('\n','-' * 110)

print('\n 34 : BEFORE Processing')
print('=' * 23)
print(project_data['essay'].values[34])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_essays[34])

print('\n','-' * 110)

print('\n147 : BEFORE Processing')
print('=' *23)
print(project_data['essay'].values[147])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_essays[147])
```

```
9 : BEFORE Processing
=====================
Over 95% of my students are on free or reduced lunch.  I have a few who are homeless, but despite that, they come
to school with an eagerness to learn.  My students are inquisitive eager learners who  embrace the challenge of n
ot having great books and other resources  every day.  Many of them are not afforded the opportunity to engage wi
th these big colorful pages of a book on a regular basis at home and they don't travel to the public library.  \r
\nIt is my duty as a teacher to do all I can to provide each student an opportunity to succeed in every aspect of
life. \r\nReading is Fundamental! My students will read these books over and over again while boosting their comp
rehension skills. These books will be used for read alouds, partner reading and for Independent reading. \r\nThey
will engage in reading to build their \"Love for Reading\" by reading for pure enjoyment. They will be introduced
to some new authors as well as some old favorites. I want my students to be ready for the 21st Century and know t
he pleasure of holding a good hard back book in hand. There's nothing like a good book to read!  \r\nMy students
will soar in Reading, and more because of your consideration and generous funding contribution. This will help bu
ild stamina and prepare for 3rd grade. Thank you so much for reading our proposal!nannan

AFTER Processing
================
95 students free reduced lunch homeless despite come school eagerness learn students inquisitive eager learners e
mbrace challenge not great books resources every day many not afforded opportunity engage big colorful pages book
regular basis home not travel public library duty teacher provide student opportunity succeed every aspect life r
eading fundamental students read books boosting comprehension skills books used read alouds partner reading indep
endent reading engage reading build love reading reading pure enjoyment introduced new authors well old favorites
want students ready 21st century know pleasure holding good hard back book hand nothing like good book read stude
nts soar reading consideration generous funding contribution help build stamina prepare 3rd grade thank much read
ing proposal nannan

 --------------------------------------------------------------------------------------------------------------

 34 : BEFORE Processing
=======================
My students mainly come from extremely low-income families, and the majority of them come from homes where both p
arents work full time. Most of my students are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm in the after-sc
hool program), and they all receive free and reduced meals for breakfast and lunch. \r\n\r\n\r\nI want my student
s to feel  as comfortable in my classroom as they do at home. Many of my students take on multiple roles both at
home as well as in school. They are sometimes the caretakers of younger siblings, cooks, babysitters, academics,
friends, and most of all, they are developing who they are going to become as adults.  I consider it an essential
part of my job to model helping others gain knowledge in a positive manner. As a result, I have a community of st
udents who love helping each other in and outside of the classroom. They consistently look for opportunities to s
upport each other's learning in a kind and helpful way.I am excited to be experimenting with alternative seating
in my classroom this school year. Studies have shown that giving students the option of where they sit in a class
room increases focus as well as motivation.  \r\n\r\nBy allowing students choice in the classroom, they are able
to explore and create in a welcoming environment. Alternative classroom seating has been experimented with more f
requently in recent years. I believe (along with many others), that every child learns differently. This does not
only apply to how multiplication is memorized, or a paper is written, but applies to the space in which they are
asked to work. I have had students in the past ask \"Can I work in the library? Can I work on the carpet?\" My an
swer was always, \"As long as you're learning, you can work wherever you want!\" \r\n\r\nWith the yoga balls and
the lap-desks, I will be able to increase the options for seating in my classroom and expand its imaginable space
.nannan

AFTER Processing
================
students mainly come extremely low income families majority come homes parents work full time students school 7 3
0 6 00 pm 2 30 6 00 pm school program receive free reduced meals breakfast lunch want students feel comfortable c
lassroom home many students take multiple roles home well school sometimes caretakers younger siblings cooks baby
sitters academics friends developing going become adults consider essential part job model helping others gain kn
owledge positive manner result community students love helping outside classroom consistently look opportunities
support learning kind helpful way excited experimenting alternative seating classroom school year studies shown g
iving students option sit classroom increases focus well motivation allowing students choice classroom able explo
re create welcoming environment alternative classroom seating experimented frequently recent years believe along
many others every child learns differently not apply multiplication memorized paper written applies space asked w
ork students past ask work library work carpet answer always long learning work wherever want yoga balls lap desk
s able increase options seating classroom expand imaginable space nannan

 --------------------------------------------------------------------------------------------------------------

147 : BEFORE Processing
=======================
My students are eager to learn and make their mark on the world.\r\n\r\nThey come from a Title 1 school and need
extra love.\r\n\r\nMy fourth grade students are in a high poverty area and still come to school every day to get
their education. I am trying to make it fun and educational for them so they can get the most out of their school
ing. I created a caring environment for the students to bloom! They deserve the best.\r\nThank you!\r\nI am reque
sting 1 Chromebook to access online interventions, differentiate instruction, and get extra practice. The Chromeb
ook will be used to supplement ELA and math instruction. Students will play ELA and math games that are engaging
and fun, as well as participate in assignments online. This in turn will help my students improve their skills. H
aving a Chromebook in the classroom would not only allow students to use the programs at their own pace, but woul
d ensure more students are getting adequate time to use the programs. The online programs have been especially be
neficial to my students with special needs. They are able to work at their level as well as be challenged with so
me different materials. This is making these students more confident in their abilities.\r\n\r\nThe Chromebook wo
uld allow my students to have daily access to computers and increase their computing skills.\r\nThis will change
their lives for the better as they become more successful in school. Having access to technology in the classroom
would help bridge the achievement gap.nannan

AFTER Processing
================
students eager learn make mark world come title 1 school need extra love fourth grade students high poverty area
still come school every day get education trying make fun educational get schooling created caring environment st
udents bloom deserve best thank requesting 1 chromebook access online interventions differentiate instruction get
extra practice chromebook used supplement ela math instruction students play ela math games engaging fun well par
ticipate assignments online turn help students improve skills chromebook classroom would not allow students use p
rograms pace would ensure students getting adequate time use programs online programs especially beneficial stude
nts special needs able work level well challenged different materials making students confident abilities chromeb
ook would allow students daily access computers increase computing skills change lives better become successful s
chool access technology classroom would help bridge achievement gap nannan
```

In [30]:

```python
preprocessed_project_resource_summary = preprocess_text(project_data['project_resource_summary'].values)
```

```
100%|████████████████████████████████| 109248/109248 [00:04<00:00, 24466.70it/s]
```

In [31]:

```python
print('9 : BEFORE Processing')
print('=' * 21)
print(project_data['project_resource_summary'].values[9])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_project_resource_summary[9])

print('\n','-' * 110)

print('\n34 : BEFORE Processing')
print('=' * 22)
print(project_data['project_resource_summary'].values[34])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_project_resource_summary[34])

print('\n','-' * 110)

print('\n147 : BEFORE Processing')
print('=' *23)
print(project_data['project_resource_summary'].values[147])
print('\nAFTER Processing')
print('=' *16)
print(preprocessed_project_resource_summary[147])
```

```
9 : BEFORE Processing
=====================
My students need great books to use during Independent Reading, Read Alouds, Partner Reading and Author Studies.

AFTER Processing
================
students need great books use independent reading read alouds partner reading author studies

 ----------------------------------------------------------------------------------------------------------------

34 : BEFORE Processing
======================
My students need alternative seating, to increase student choice, and add to mobility in the classroom.

AFTER Processing
================
students need alternative seating increase student choice add mobility classroom

 ----------------------------------------------------------------------------------------------------------------

147 : BEFORE Processing
=======================
My students need a chromebook to help with differentiation and extra practice!!!

AFTER Processing
================
students need chromebook help differentiation extra practice
```

Preprocessing Categorical Features

price_data

In [32]:

```
'''
https://stackoverflow.com/questions/22407798/how-to-reset-a-
dataframes-indexes-for-all-groups-in-one-step
'''

price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(3)
```

Out[32]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21
2	p000003	298.97	4

In [33]:

```
# Joining two dataframes `project_data` & `price_data` :

project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [34]:

```
project_data['price'].head()
```

Out[34]:

```
0    154.60
1    299.00
2    516.85
3    232.90
4     67.98
Name: price, dtype: float64
```

In [35]:

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

Out[35]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs	in	2016-12-05 13:43:57	grades_prek_2	

1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr	fl	2016-10-25 09:22:10	grades_6_8

2 rows × 22 columns

Appending new features to $project_data$

In [36]:

```
project_data['clean_essay'] = preprocessed_essays
project_data['clean_project_title'] = preprocessed_titles
project_data['clean_project_resource_summary'] = preprocessed_project_resource_summary
project_data['title_word_count'] = title_word_count

project_data.info()
```

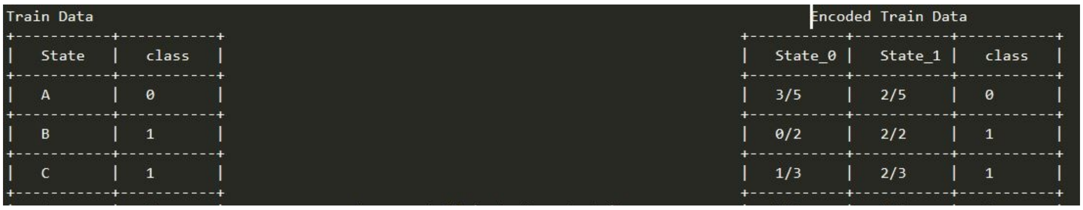
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 109248 entries, 0 to 109247
Data columns (total 26 columns):
 #   Column                                        Non-Null Count   Dtype  
---  ------                                        --------------   -----  
 0   Unnamed: 0                                    109248 non-null  int64  
 1   id                                            109248 non-null  object 
 2   teacher_id                                    109248 non-null  object 
 3   teacher_prefix                                109248 non-null  object 
 4   school_state                                  109248 non-null  object 
 5   project_submitted_datetime                    109248 non-null  object 
 6   project_grade_category                        109248 non-null  object 
 7   project_subject_categories                    109248 non-null  object 
 8   project_subject_subcategories                 109248 non-null  object 
 9   project_title                                 109248 non-null  object 
 10  project_essay_1                               109248 non-null  object 
 11  project_essay_2                               109248 non-null  object 
 12  project_essay_3                               3758 non-null    object 
 13  project_essay_4                               3758 non-null    object 
 14  project_resource_summary                      109248 non-null  object 
 15  teacher_number_of_previously_posted_projects  109248 non-null  int64  
 16  project_is_approved                           109248 non-null  int64  
 17  clean_categories                              109248 non-null  object 
 18  clean_subcategories                           109248 non-null  object 
 19  essay                                         109248 non-null  object 
 20  price                                         109248 non-null  float64
 21  quantity                                      109248 non-null  int64  
 22  clean_essay                                   109248 non-null  object 
 23  clean_project_title                           109248 non-null  object 
 24  clean_project_resource_summary                109248 non-null  object 
 25  title_word_count                              109248 non-null  int64  
dtypes: float64(1), int64(5), object(20)
memory usage: 22.5+ MB
```

Removing processed columns and saving the dataframe into `processed_data.csv`

In [37]:

```
drop_c = ['project_subject_categories', 'project_subject_subcategories', 'project_title',
          'project_essay_1', 'project_essay_2', 'project_essay_3', 'project_essay_4', 'essay',
          'Unnamed: 0', 'teacher_id', 'project_submitted_datetime', 'project_resource_summary', 'id']

final_project_data = project_data.drop(drop_c, axis=1)

final_project_data.to_csv('processed_data.csv', index=False)

time_processing = time.time()
```

Response Coding: Example

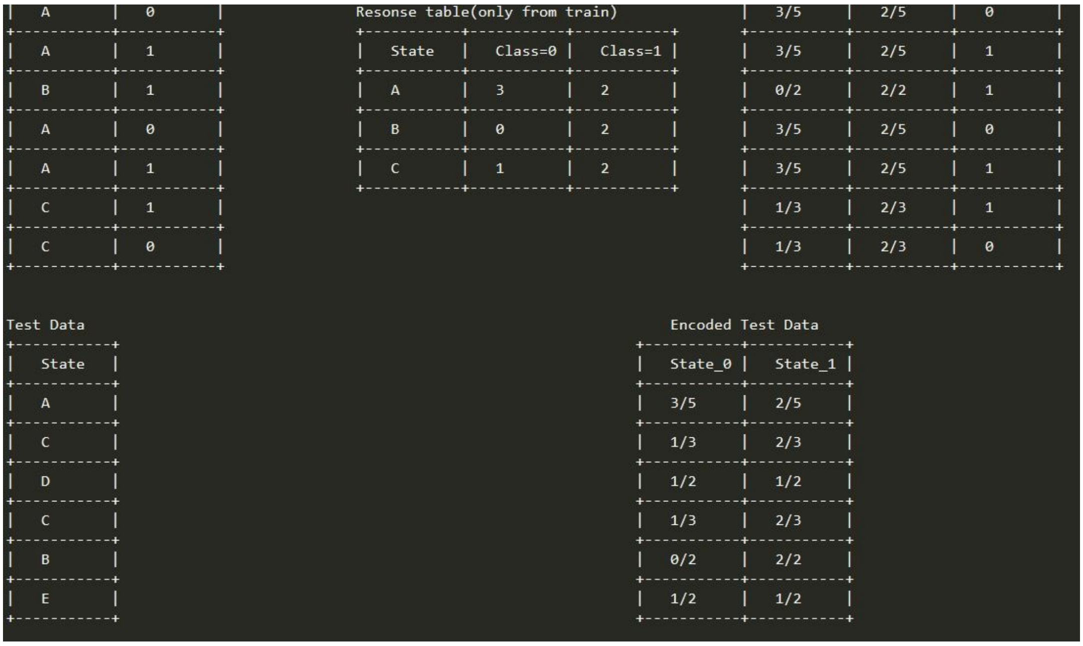


Train Data

State	class
A	0
B	1
C	1

Encoded Train Data

State_0	State_1	class
3/5	2/5	0
0/2	2/2	1
1/3	2/3	1



```
|   A      |   0      |              Resonse table(only from train)            |   3/5    |   2/5    |   0      |
+----------+----------+              +----------+----------+----------+        +----------+----------+----------+
|   A      |   1      |              |   State  |  Class=0 |  Class=1 |        |   3/5    |   2/5    |   1      |
+----------+----------+              +----------+----------+----------+        +----------+----------+----------+
|   B      |   1      |              |   A      |   3      |   2      |        |   0/2    |   2/2    |   1      |
+----------+----------+              +----------+----------+----------+        +----------+----------+----------+
|   A      |   0      |              |   B      |   0      |   2      |        |   3/5    |   2/5    |   0      |
+----------+----------+              +----------+----------+----------+        +----------+----------+----------+
|   A      |   1      |              |   C      |   1      |   2      |        |   3/5    |   2/5    |   1      |
+----------+----------+              +----------+----------+----------+        +----------+----------+----------+
|   C      |   1      |                                                        |   1/3    |   2/3    |   1      |
+----------+----------+                                                        +----------+----------+----------+
|   C      |   0      |                                                        |   1/3    |   2/3    |   0      |
+----------+----------+                                                        +----------+----------+----------+


Test Data                                                       Encoded Test Data
+----------+                                                 +----------+----------+
|   State  |                                                 |  State_0 |  State_1 |
+----------+                                                 +----------+----------+
|   A      |                                                 |  3/5     |  2/5     |
+----------+                                                 +----------+----------+
|   C      |                                                 |  1/3     |  2/3     |
+----------+                                                 +----------+----------+
|   D      |                                                 |  1/2     |  1/2     |
+----------+                                                 +----------+----------+
|   C      |                                                 |  1/3     |  2/3     |
+----------+                                                 +----------+----------+
|   B      |                                                 |  0/2     |  2/2     |
+----------+                                                 +----------+----------+
|   E      |                                                 |  1/2     |  1/2     |
+----------+                                                 +----------+----------+
```

> 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]

1. **Apply GBDT on these feature sets**
   - Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)+sentiment Score of eassay(check the bellow example, include all 4 values as 4 features)
   - Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
   - Here in response encoding you need to apply the **laplase smoothing** value for test set. Laplase smoothing means, If test point is present in test but not in train then you need to apply default 0.5 as probability value for that data point (Refer the Response Encoding Image from above cell)
   - Please use atleast **35k** data points
2. **The hyper paramter tuning (Consider any two hyper parameters)**
   - 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
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the

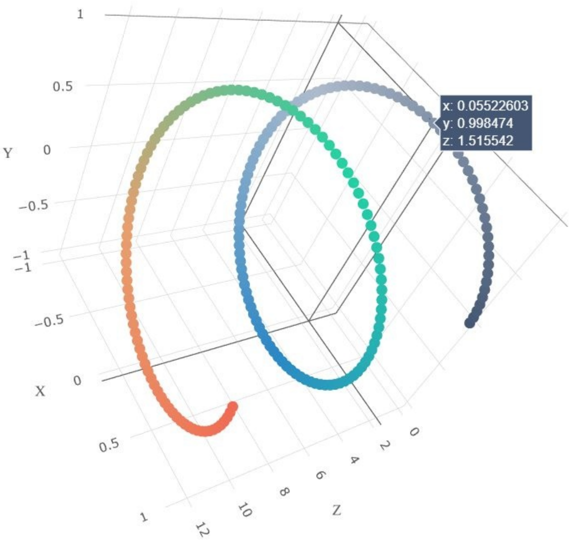
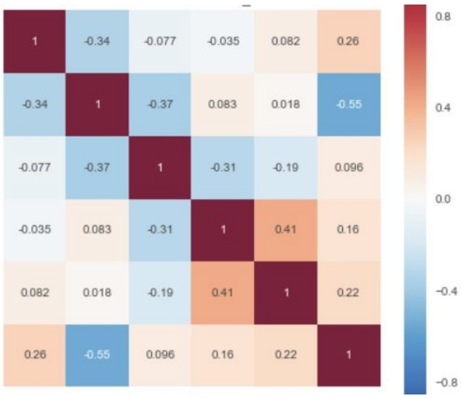


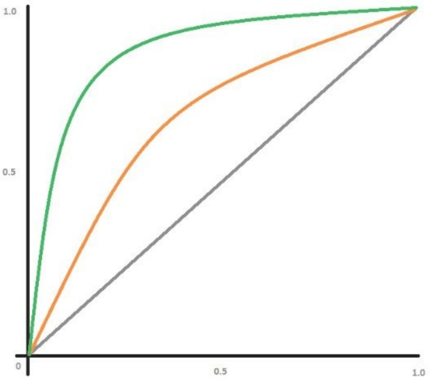
figure with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

or

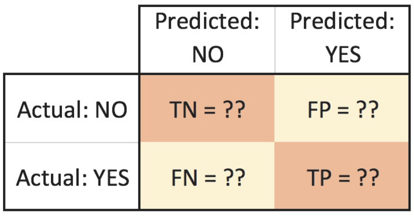
- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure seaborn heat maps with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**



- You choose either of the plotting techniques out of 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test. Make sure that you are using predict_proba method to calculate AUC curves, because AUC is calcualted on class probabilities and not on class labels.

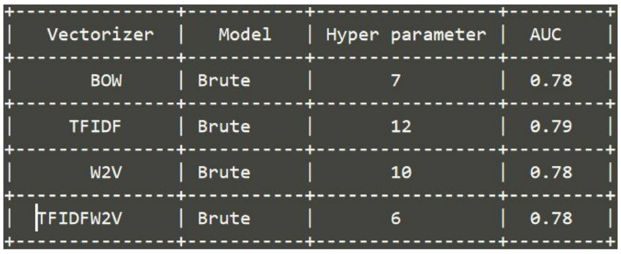


- Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points



	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

4. You need to summarize the results at the end of the notebook, summarize it in the table format



```
+---------------+----------+------------------+--------+
|  Vectorizer   |  Model   | Hyper parameter  |  AUC   |
+---------------+----------+------------------+--------+
|      BOW      | Brute    |        7         |  0.78  |
+---------------+----------+------------------+--------+
|    TFIDF      | Brute    |        12        |  0.79  |
+---------------+----------+------------------+--------+
|      W2V      | Brute    |        10        |  0.78  |
+---------------+----------+------------------+--------+
|  TFIDFW2V     | Brute    |        6         |  0.78  |
+---------------+----------+------------------+--------+
```

Few Notes

1. Use atleast 35k data points
2. Use classifier.Predict_proba() method instead of predict() method while calculating roc_auc scores
3. Be sure that you are using laplase smoothing in response encoding function. Laplase smoothing means applying the default (0.5) value to test data if the test data is not present in the train set

In [38]:

```
sid = SentimentIntensityAnalyzer()

sample_sentence_1='I am happy.'
ss_1 = sid.polarity_scores(sample_sentence_1)
print('sentiment score for sentence 1',ss_1)

sample_sentence_2='I am sad.'
ss_2 = sid.polarity_scores(sample_sentence_2)
print('sentiment score for sentence 2',ss_2)
```

```
sample_sentence_3='I am going to New Delhi tommorow.'
ss_3 = sid.polarity_scores(sample_sentence_3)
print('sentiment score for sentence 3',ss_3)

# sample_sentence_1 = 'I am going to New Delhi tommorow.'
# neg = sid.polarity_scores(sample_sentence_1)['neg']
# neu = sid.polarity_scores(sample_sentence_1)['neu']
# pos = sid.polarity_scores(sample_sentence_1)['pos']
# comp = sid.polarity_scores(sample_sentence_1)['compound']

# print(f"'neg': {neg}, 'neu': {neu}, 'pos': {pos}, 'compound': {comp}")
```

```
sentiment score for sentence 1 {'neg': 0.0, 'neu': 0.213, 'pos': 0.787, 'compound': 0.5719}
sentiment score for sentence 2 {'neg': 0.756, 'neu': 0.244, 'pos': 0.0, 'compound': -0.4767}
sentiment score for sentence 3 {'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound': 0.0}
```

1. GBDT (xgboost/lightgbm)

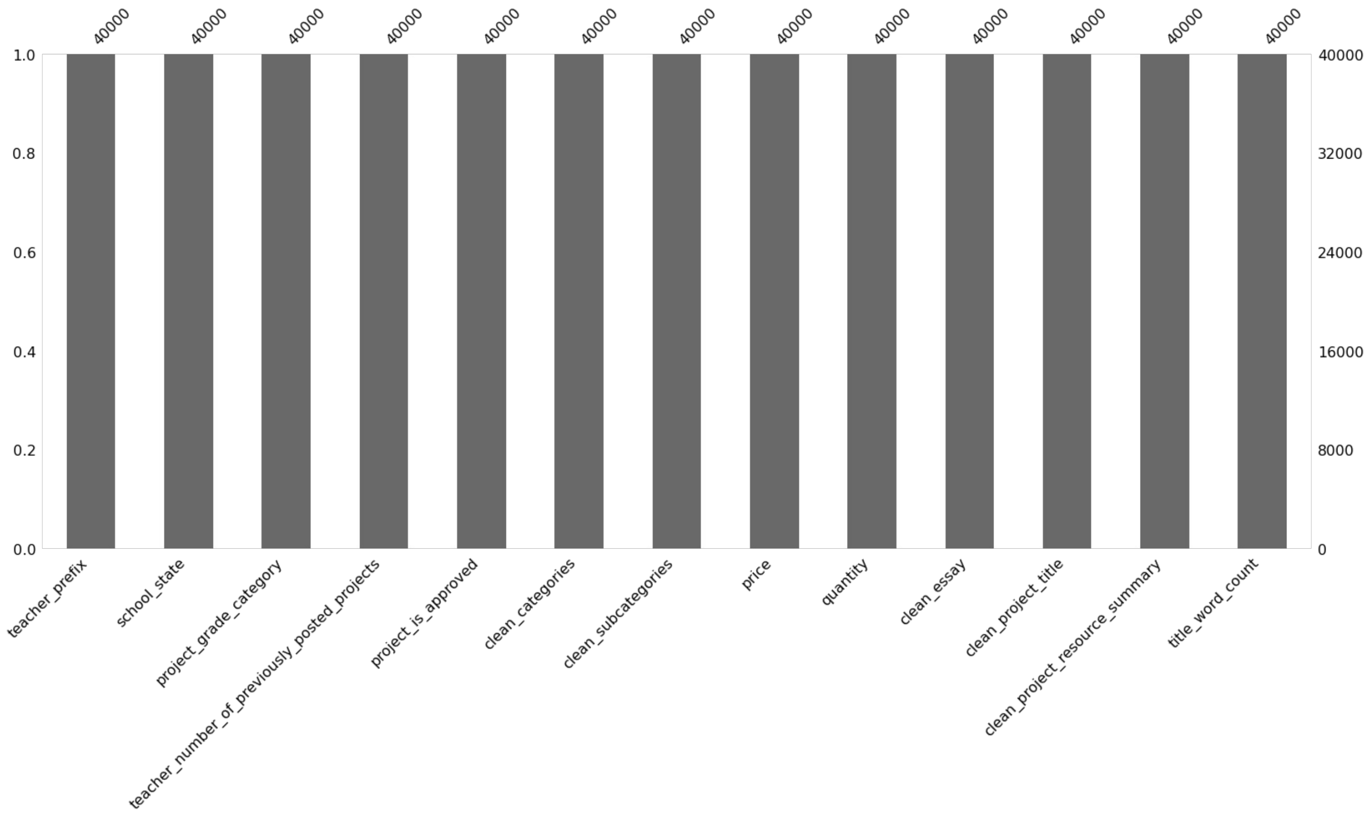
1.1 Loading Data

In [39]:

```
nrows_ = 40000

data = pd.read_csv('processed_data.csv', nrows = nrows_)
```

In [40]:

```
msno.bar(data)
plt.show()
```



Observation

- It is clearly visible that we don't have any missing values in the data frame.
- We have 40,000 (40K) data points and 13 features (columns)

In [41]:

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

In [42]:

```
print(f'Number of data points in train data : {data.shape}')
print('\nColumn names : \n', data.columns)
```

```
Number of data points in train data : (40000, 13)
Number of data points in train data : (40000, 13)

Column names :
 Index(['teacher_prefix', 'school_state', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'price', 'quantity',
       'clean_essay', 'clean_project_title', 'clean_project_resource_summary',
       'title_word_count'],
      dtype='object')
```

In [43]:

```
data.head(3)
```

Out[43]:

	teacher_prefix	school_state	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_categ
0	mrs	in	grades_prek_2	0	0	literacy_lang
1	mr	fl	grades_6_8	7	1	history_civics_health_s
2	ms	az	grades_6_8	1	0	health_s

In [44]:

```
# Generating sentiment scores using NLTK SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

negative = []
neutral  = []
positive = []
compound = []

print('Shape before adding Sentiment Scores : ', data.shape)

for a in tqdm(data['clean_essay']) :
    neg = sid.polarity_scores(a)['neg']
    neu = sid.polarity_scores(a)['neu']
    pos = sid.polarity_scores(a)['pos']
    comp = sid.polarity_scores(a)['compound']

    negative.append(neg)
    neutral.append(neu)
    positive.append(pos)
    compound.append(comp)

data['negative'] = negative
data['positive'] = positive
data['neutral'] = neutral
data['compound'] = compound

print('Shape after adding Sentiment Scores : ', data.shape)
```

```
Shape before adding Sentiment Scores :  (40000, 13)
```

```
100%|████████████████████████████████████| 40000/40000 [03:11<00:00, 209.34it/s]
```

```
Shape after adding Sentiment Scores :  (40000, 17)
```

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

In [45]:

```
data.head(3)
```

Out[45]:

	teacher_prefix	school_state	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_categ
0	mrs	in	grades_prek_2	0	0	literacy_lang

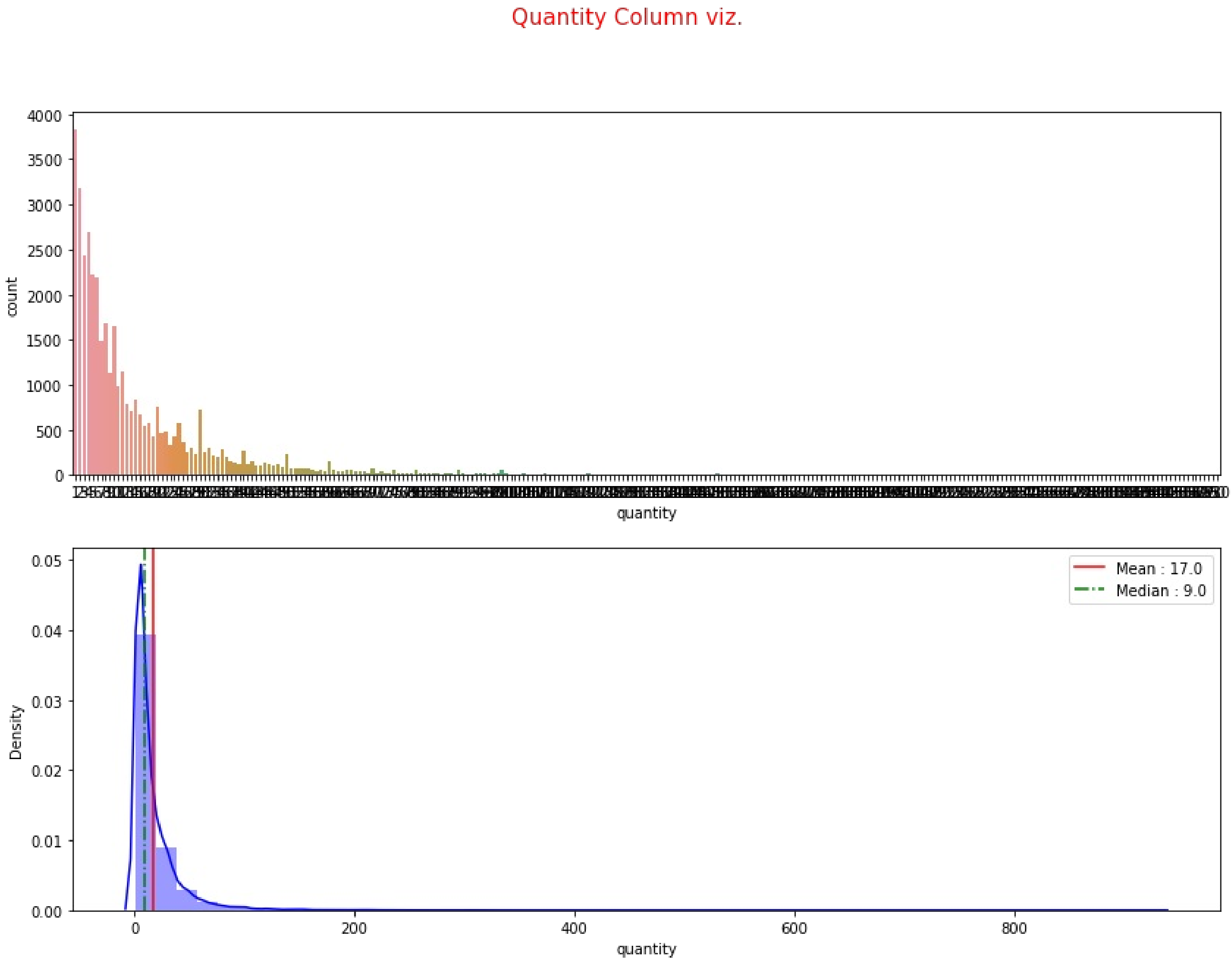
1	mr	fl	grades_6_8	7	1	history_civics_health_s
2	ms	az	grades_6_8	1	0	health_s

Exploring Data

quantity
column

In [46]:

```
mean_q = round(data.quantity.mean(), 2)
median_q = round(data.quantity.median(), 2)

fig, axes = plt.subplots(2, 1, figsize = (14,10))

fig.suptitle('Quantity Column viz.', fontsize = 15, color = 'r')
fig_1 = sns.countplot(data.quantity, ax = axes[0])

fig_2 = sns.distplot(data.quantity, color = 'b', ax = axes[1])
plt.axvline(mean_q, c = 'r', label = f'Mean : {mean_q}')
plt.axvline(median_q, c = 'g', linestyle = '-.', label = f'Median : {median_q}')

plt.legend()
plt.show()
```


Quantity Column viz.

Observation

- Its clearly visible the `quantity` column is **Right Skewed**.

- Majority of the data points lies within `mean score 17`.
- Most frequent quantity requested by teachers is **10**.

$tit \leq_w$ or $d_{c}ount$
column

In [47]:

```python
data.title_word_count.value_counts(ascending = True)
```

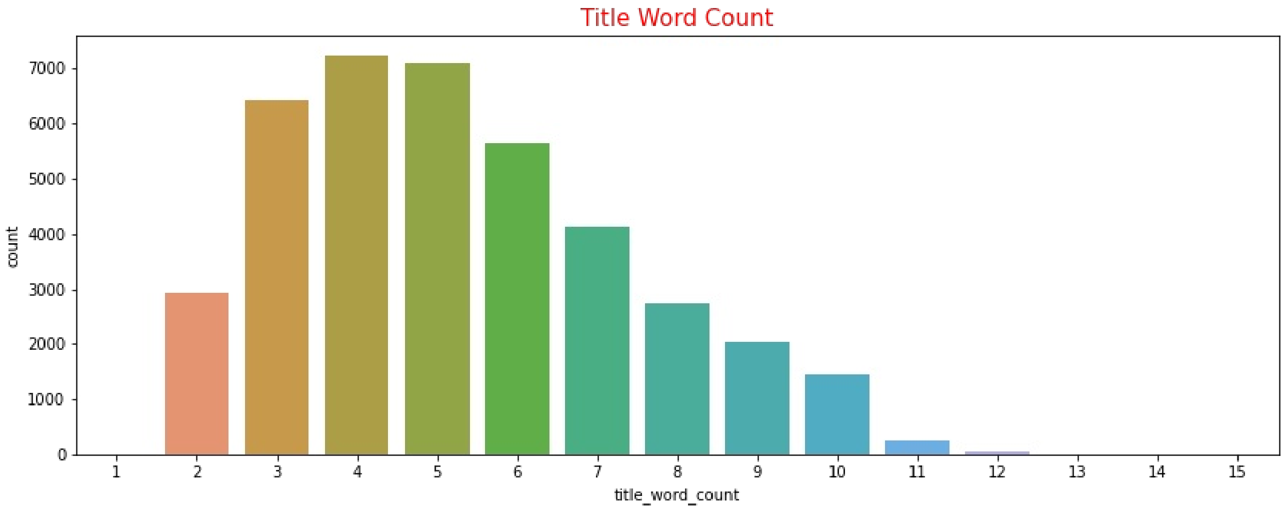
Out[47]:

```
14       1
15       1
1       11
13      11
12      49
11     261
10    1450
9     2043
8     2738
2     2929
7     4126
6     5636
3     6418
5     7094
4     7232
Name: title_word_count, dtype: int64
```

In [48]:

```python
mean_twc = round(data.title_word_count.mean(), 2)
median_twc = round(data.title_word_count.median(), 2)

plt.figure(figsize = (14,5))

fig = sns.countplot(data.title_word_count)
plt.title('Title Word Count', fontsize = 15, color = 'r')

print(f'title_word_count  :::  Mean = {mean_twc}  &  Median = {median_twc}')

plt.show()
```

```
title_word_count  :::  Mean = 5.27  &  Median = 5.0
```



Observation

- Majority of the projects contains 2 to 8 words (after preprocessing).
- Projects with 4 & 5 words are those mostly submitted.
- The `median` and `mean` value lies in close to **5** words.
- 65% of the projects contains 3 to 6 words in its title

Converting into
$tra \in_t est_{s}plit$

In [49]:

```python
y_data = data['project_is_approved'].values
# x_data = data.drop(['project_is_approved'], axis =1)
x_train, x_test, y_train, y_test = train_test_split(data, y_data, test_size = 0.3 ,stratify = y_data)
```

```
x_train.head(3)
```

Out[49]:

	teacher_prefix	school_state	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_c
26478	ms	md	grades_3_5	24	1	math_science_r
29006	mrs	mo	grades_prek_2	8	1	hea
19993	mrs	sc	grades_3_5	4	0	health_sports_spe

1.3 Make Data Model Ready: encoding eassay, and project_title

clean_project_title

TF-IDF

In [50]:

```
tfidf_vectorizor = TfidfVectorizer(min_df = 5, ngram_range = (1,3), max_features = 10000)
tfidf_vectorizor.fit(x_train['clean_project_title'].values)
x_tr_title_tfidf = tfidf_vectorizor.transform(x_train['clean_project_title'].values)
x_te_title_tfidf = tfidf_vectorizor.transform(x_test['clean_project_title'].values)

print(f"Shape of matrix before TF-IDF Vectorizor : {x_train.shape}  {x_test.shape}")
print(f"Shape of matrix after TF-IDF Vectorizor  : {x_tr_title_tfidf.shape} {x_te_title_tfidf.shape}")
```

```
Shape of matrix before TF-IDF Vectorizor : (28000, 17)  (12000, 17)
Shape of matrix after TF-IDF Vectorizor  : (28000, 6974) (12000, 6974)
```

TF-IDF W2V

In [51]:

```
# Converting a dictionary with word as a key, and the idf as a value

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

tfidf_w2v_title_x_tr = []

# clean_project_title

for sentence in tqdm(x_train['clean_project_title']):
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0

    for word in sentence.split():
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf

    if tf_idf_weight != 0:
        vector /= tf_idf_weight

    tfidf_w2v_title_x_tr.append(vector)

print(f'x_train TF-IDF-W2V shape is {len(tfidf_w2v_title_x_tr) , len(tfidf_w2v_title_x_tr[0])}')

tfidf_w2v_title_x_te = []

for sentence in tqdm(x_test['clean_project_title']):
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0

    for word in sentence.split():
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf

    if tf_idf_weight != 0:
        vector /= tf_idf_weight

    tfidf_w2v_title_x_te.append(vector)

print(f'x_test TF-IDF-W2V shape is {len(tfidf_w2v_title_x_te) , len(tfidf_w2v_title_x_te[0])}')
```

```
100%|██████████████████████████████████| 28000/28000 [00:00<00:00, 35034.69it/s]

x_train TF-IDF-W2V shape is (28000, 300)

100%|██████████████████████████████████| 12000/12000 [00:00<00:00, 33191.14it/s]

x_test TF-IDF-W2V shape is (12000, 300)
```

clean_essay

TF-IDF

In [52]:

```
tfidf_vectorizor = TfidfVectorizer(min_df = 20, ngram_range = (1,3), max_features = 15000)
tfidf_vectorizor.fit(x_train['clean_essay'].values)
x_tr_essay_tfidf = tfidf_vectorizor.transform(x_train['clean_essay'].values)
x_te_essay_tfidf = tfidf_vectorizor.transform(x_test['clean_essay'].values)

print(f"Shape of matrix before TF-IDF Vectorizor : {x_train.shape}   {x_test.shape}")
print(f"Shape of matrix after TF-IDF Vectorizor  : {x_tr_essay_tfidf.shape} {x_te_essay_tfidf.shape}")
```

```
Shape of matrix before TF-IDF Vectorizor : (28000, 17)   (12000, 17)
Shape of matrix after TF-IDF Vectorizor  : (28000, 15000) (12000, 15000)
```

TF-IDF W2V

In [53]:

```
# Converting a dictionary with word as a key, and the idf as a value

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

tfidf_w2v_essay_x_tr = []

for sentence in tqdm(x_train['clean_essay']):
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0

    for word in sentence.split():
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf

    if tf_idf_weight != 0:
        vector /= tf_idf_weight

    tfidf_w2v_essay_x_tr.append(vector)

print(f'x_train TF-IDF-W2V shape is {len(tfidf_w2v_essay_x_tr) , len(tfidf_w2v_essay_x_tr[0])}')

tfidf_w2v_essay_x_te = []

for sentence in tqdm(x_test['clean_essay']):
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0

    for word in sentence.split():
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf

    if tf_idf_weight != 0:
        vector /= tf_idf_weight

    tfidf_w2v_essay_x_te.append(vector)

print(f'x_test TF-IDF-W2V shape is {len(tfidf_w2v_essay_x_te) , len(tfidf_w2v_essay_x_te[0])}')
```

```
100%|████████████████████████████████████| 28000/28000 [00:39<00:00, 714.65it/s]
x_train TF-IDF-W2V shape is (28000, 300)

100%|████████████████████████████████████| 12000/12000 [00:16<00:00, 739.77it/s]
x_test TF-IDF-W2V shape is (12000, 300)
```

TF-IDF : clean_project_resource_summary

In [54]:

```
tfidf_vectorizor = TfidfVectorizer(min_df = 10, ngram_range = (1,3), max_features = 10000)
tfidf_vectorizor.fit(x_train['clean_project_resource_summary'].values)
x_tr_rs_sum_tfidf = tfidf_vectorizor.transform(x_train['clean_project_resource_summary'].values)
x_te_rs_sum_tfidf = tfidf_vectorizor.transform(x_test['clean_project_resource_summary'].values)

print(f"Shape of matrix before TF-IDF Vectorizor : {x_train.shape}  {x_test.shape}")
print(f"Shape of matrix after TF-IDF Vectorizor  : {x_tr_rs_sum_tfidf.shape} {x_te_rs_sum_tfidf.shape}")
```

```
Shape of matrix before TF-IDF Vectorizor : (28000, 17)  (12000, 17)
Shape of matrix after TF-IDF Vectorizor  : (28000, 7366) (12000, 7366)
```

1.4 Make Data Model Ready: encoding numerical, categorical features

Categorical ----------- 'teacher_prefix', 'school_state', 'project_grade_category', 'clean_categories','clean_subcategories', Numerical --------- 'teacher_number_of_previously_posted_projects', 'price', 'quantity', 'title_word_count' 'negative', 'positive', 'neutral', 'compound' Text ---- 'clean_essay', 'clean_project_title', 'clean_project_resource_summary',

Processing Numerical features

In [55]:

```
print('Shape of matrix after encodig :')
print('(Numerical features)')
print('='*40)

# price
price_normalizer = Normalizer()
price_normalizer.fit(x_train['price'].values.reshape(-1, 1))

x_train_price = price_normalizer.transform(x_train['price'].values.reshape(-1, 1))
x_test_price = price_normalizer.transform(x_test['price'].values.reshape(-1, 1))

print('Price\t\t\t: ', x_train_price.shape,',',x_test_price.shape)

# quantity
quantity_normalizer = Normalizer()
quantity_normalizer.fit(x_train['quantity'].values.reshape(-1, 1))

x_train_quantity = quantity_normalizer.transform(x_train['quantity'].values.reshape(-1, 1))
x_test_quantity = quantity_normalizer.transform(x_test['quantity'].values.reshape(-1, 1))

print('Quantity\t\t: ', x_train_quantity.shape,',',x_test_quantity.shape)


# teacher_number_of_previously_posted_projects
pervious_project_normalizer = Normalizer()
pervious_project_normalizer.fit(x_train['teacher_number_of_previously_posted_projects'].\
                                                values.reshape(-1, 1))
x_train_previous_projects = pervious_project_normalizer.transform(
                x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))

x_test_previous_projects = pervious_project_normalizer.transform(
                x_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))

print('Previous Projects\t: ', x_train_previous_projects.shape,',',x_test_previous_projects.shape)

# negative
negative_normalizer = Normalizer()
negative_normalizer.fit(x_train['negative'].values.reshape(-1, 1))

x_train_negative = negative_normalizer.transform(x_train['negative'].values.reshape(-1, 1))
x_test_negative = negative_normalizer.transform(x_test['negative'].values.reshape(-1, 1))

print('Negative\t\t: ', x_train_negative.shape,',',x_test_negative.shape)

# positive
positive_normalizer = Normalizer()
```

```
positive_normalizer.fit(x_train['positive'].values.reshape(-1, 1))

x_train_positive = positive_normalizer.transform(x_train['positive'].values.reshape(-1, 1))
x_test_positive = positive_normalizer.transform(x_test['positive'].values.reshape(-1, 1))

print('Positive\t\t: ', x_train_positive.shape,',',x_test_positive.shape)

# neutral
neutral_normalizer = Normalizer()
neutral_normalizer.fit(x_train['neutral'].values.reshape(-1, 1))

x_train_neutral = neutral_normalizer.transform(x_train['neutral'].values.reshape(-1, 1))
x_test_neutral = neutral_normalizer.transform(x_test['neutral'].values.reshape(-1, 1))

print('Neutral\t\t\t: ', x_train_neutral.shape,',',x_test_neutral.shape)

# compound
compound_normalizer = Normalizer()
compound_normalizer.fit(x_train['compound'].values.reshape(-1, 1))

x_train_compound = compound_normalizer.transform(x_train['compound'].values.reshape(-1, 1))
x_test_compound = compound_normalizer.transform(x_test['compound'].values.reshape(-1, 1))

print('Compound\t\t: ', x_train_compound.shape,',',x_test_compound.shape)

# title_word_count
title_count_normalizer = Normalizer()
title_count_normalizer.fit(x_train['title_word_count'].values.reshape(-1, 1))

x_train_title_count = title_count_normalizer.transform(x_train['title_word_count'].values.reshape(-1, 1))
x_test_title_count = title_count_normalizer.transform(x_test['title_word_count'].values.reshape(-1, 1))

print('Title Word Count\t: ', x_train_title_count.shape,',',x_test_title_count.shape)
```

```
Shape of matrix after encodig :
(Numerical features)
========================================
Price                    :  (28000, 1) , (12000, 1)
Quantity                 :  (28000, 1) , (12000, 1)
Previous Projects        :  (28000, 1) , (12000, 1)
Negative                 :  (28000, 1) , (12000, 1)
Positive                 :  (28000, 1) , (12000, 1)
Neutral                  :  (28000, 1) , (12000, 1)
Compound                 :  (28000, 1) , (12000, 1)
Title Word Count         :  (28000, 1) , (12000, 1)
```

Response coding on categorical features

In [56]:

```
columns_ = ['school_state', 'project_is_approved']

data.loc[(data.school_state == 'ia')][columns_]

print(len(data.loc[(data.school_state == 'co') & (data.project_is_approved == 1)][columns_]))
print(len(data.loc[(data.school_state == 'co') & (data.project_is_approved == 0)][columns_]))
data.loc[(data.school_state == 'co') & (data.project_is_approved == 1)][columns_]
```

```
352
70
```

Out[56]:

	school_state	project_is_approved
83	co	1
150	co	1
233	co	1
321	co	1
370	co	1
...	...	...
39415	co	1
39499	co	1
39568	co	1
39668	co	1
39687	co	1

352 rows × 2 columns

In [57]:

```
'''
https://www.delftstack.com/howto/python-pandas/pandas-replace-values-in-column/#replace
-column-values-with-collection-in-pandas-dataframe
'''

def responseEncoding(df, column):

    cat_feature = df[column].unique()
    length_of_cat = len(cat_feature)

    positive_class = []
    for cat in tqdm(cat_feature):
        positive_class.append(len(df.loc[(df[column] == cat) & (df.project_is_approved == 1)]))

    negative_class = []
    for cat in cat_feature:
        negative_class.append(len(df.loc[(df[column] == cat) & (df.project_is_approved == 0)]))

    positive_val = []
    for i in range(len(cat_feature)):
        positive_val.append(positive_class[i] / (positive_class[i] + negative_class[i]))

    negative_val = [1-i for i in positive_val]

    positives = dict(zip(cat_feature, positive_val))

    negatives = dict(zip(cat_feature, negative_val))

    return positives, negatives

# responseEncoding(data,'school_state')
```

In [58]:

```
# https://pandas.pydata.org/docs/reference/api/pandas.DataFrame.drop.html
'''
https://www.delftstack.com/howto/python-pandas/pandas-replace-values-in-column/#replace
-column-values-with-collection-in-pandas-dataframe
'''

def render_DataFrame(train, test):

#     cat_list = ['school_state', 'teacher_prefix', 'project_grade_category',
#                 'clean_categories', 'clean_subcategories', 'project_is_approved']

    to_rc_list = ['school_state', 'teacher_prefix', 'project_grade_category',
                  'clean_categories', 'clean_subcategories']

    rc_list = ['school_state_0', 'school_state_1', 'teacher_prefix_0', 'teacher_prefix_1',
               'project_grade_category_0', 'project_grade_category_1',
               'clean_categories_0', 'clean_categories_1',
               'clean_subcategories_0', 'clean_subcategories_1']

    pos_state, neg_state = responseEncoding(train, 'school_state')
    pos_teacher, neg_teacher = responseEncoding(train, 'teacher_prefix')
    pos_proj_g, neg_proj_g = responseEncoding(train, 'project_grade_category')
    pos_clean_cat, neg_clean_cat = responseEncoding(train, 'clean_categories')
    pos_clean_sub, neg_clean_sub = responseEncoding(train, 'clean_subcategories')

#     On Train Data
    train['school_state_0'] = train.school_state.map(neg_state) #negative
    train['school_state_1'] = train.school_state.map(pos_state) #positive

    train['teacher_prefix_0'] = train.teacher_prefix.map(neg_teacher)
    train['teacher_prefix_1'] = train.teacher_prefix.map(pos_teacher)

    train['project_grade_category_0'] = train.project_grade_category.map(neg_proj_g)
    train['project_grade_category_1'] = train.project_grade_category.map(pos_proj_g)

    train['clean_categories_0'] = train.clean_categories.map(neg_clean_cat)
    train['clean_categories_1'] = train.clean_categories.map(pos_clean_cat)

    train['clean_subcategories_0'] = train.clean_subcategories.map(neg_clean_sub)
    train['clean_subcategories_1'] = train.clean_subcategories.map(pos_clean_sub)

    rc_train = pd.DataFrame()
    rc_train = train[rc_list]

#     On Test Data
    test['school_state_0'] = test.school_state.map(neg_state) #negative
    test['school_state_1'] = test.school_state.map(pos_state) #positive

    test['teacher_prefix_0'] = test.teacher_prefix.map(neg_teacher)
    test['teacher_prefix_1'] = test.teacher_prefix.map(pos_teacher)

    test['project_grade_category_0'] = test.project_grade_category.map(neg_proj_g)
    test['project_grade_category_1'] = test.project_grade_category.map(pos_proj_g)
    test['clean_categories_0'] = test.clean_categories.map(neg_clean_cat)
    test['clean_categories_1'] = test.clean_categories.map(pos_clean_cat)

    test['clean_subcategories_0'] = test.clean_subcategories.map(neg_clean_sub)
    test['clean_subcategories_1'] = test.clean_subcategories.map(pos_clean_sub)

    '''
    Applying laplase smoothing value for test set
    ---------------------------------------------

    If test point is present in test but not in train, then applying 0.5 as default
    probability value for that data point
    '''

    rc_test  = pd.DataFrame()
    rc_test = test[rc_list].fillna(0.5)

    return to_rc_list, rc_train, rc_test

rc_cat_list, rc_X_train, rc_X_test = render_DataFrame(x_train, x_test)

print('Response coded categories are :\n', ', '.join(rc_cat_list))

print(f'\nResponse coded x_train shape : {rc_X_train.shape}')
print(f'Response coded x_test shape  : {rc_X_test.shape}')
```

```
100%|██████████████████████████████████████████| 51/51 [00:00<00:00, 457.57it/s]
100%|████████████████████████████████████████████| 5/5 [00:00<00:00, 334.66it/s]
100%|████████████████████████████████████████████| 4/4 [00:00<00:00, 291.80it/s]
100%|██████████████████████████████████████████| 50/50 [00:00<00:00, 530.31it/s]
100%|████████████████████████████████████████| 357/357 [00:00<00:00, 596.51it/s]
```

```
Response coded categories are :
 school_state, teacher_prefix, project_grade_category, clean_categories, clean_subcategories

Response coded x_train shape : (28000, 10)
Response coded x_test shape  : (12000, 10)
```

1.5 Appling Models on different kind of featurization as mentioned in the instructions

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

x_tr_title_tfidf x_te_title_tfidf x_tr_essay_tfidf x_te_essay_tfidf tfidf_w2v_title_x_tr tfidf_w2v_title_x_te tfidf_w2v_essay_x_tr tfidf_w2v_essay_x_te x_tr_rs_sum_tfidf x_te_rs_sum_tfidf x_train_price x_test_price x_train_quantity x_test_quantity x_train_previous_projects x_test_previous_projects x_train_negative x_test_negative x_train_positive x_test_positive x_train_neutral x_test_neutral x_train_compound x_test_compound x_train_title_count x_test_title_count rc_X_train rc_X_test

Set 1

categorical(instead of one hot encoding, try response coding: use probability values, numerical features + project_title(TFIDF+ preprocessed_eassay (TFIDF + sentiment Score of eassay(check the bellow example, include all 4 values as 4 features

In [59]:

```
# https://stackoverflow.com/a/65470570
# https://stackoverflow.com/a/19710648/4084039

tfidf_stack_train = hstack((rc_X_train, x_train_price, x_train_quantity, x_train_previous_projects,
                            x_train_title_count, x_tr_title_tfidf, x_tr_essay_tfidf,
                            x_tr_rs_sum_tfidf, x_train_negative, x_train_positive, x_train_neutral,
                            x_train_compound)).tocsr()

tfidf_stack_test = hstack((rc_X_test, x_test_price, x_test_quantity, x_test_previous_projects,
                           x_test_title_count, x_te_title_tfidf, x_te_essay_tfidf,
                           x_te_rs_sum_tfidf, x_test_negative, x_test_positive, x_test_neutral,
                           x_test_compound)).tocsr()

print('TFIDF stack train shape\t: ', tfidf_stack_train.shape)
print('TFIDF stack test shape\t: ', tfidf_stack_test.shape)
```

```
TFIDF stack train shape :  (28000, 29358)
TFIDF stack test shape  :  (12000, 29358)
```

Hyperparameter Tuning

In [60]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.GradientBoostingClassifier.html
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.RandomizedSearchCV.html

# learning_rate values taken from
# https://machinelearningmastery.com/tune-learning-rate-for-gradient-boosting-with-xgboost-in-python/
# https://stackoverflow.com/a/58782583
# https://www.kaggle.com/willkoehrsen/intro-to-model-tuning-grid-and-random-search

gbdt = GradientBoostingClassifier()

parameters= {'n_estimators' : [5, 10, 50, 75, 100, 200],
             'learning_rate' : [0.0001, 0.001, 0.01, 0.1, 0.2, 0.3]}

clf = RandomizedSearchCV(gbdt, parameters, cv = 5, scoring = 'roc_auc',
                         return_train_score = True, n_jobs =-1)

r_search = clf.fit(tfidf_stack_train, y_train)
best_params_tfidf = r_search.best_params_

print(f'Best parameters fron TF-IDF model : \n{best_params_tfidf}')

tfidf_n_estimators = best_params_tfidf['n_estimators']
tfidf_learning_rate = best_params_tfidf['learning_rate']

data = {'param_n_estimators' : r_search.cv_results_['param_n_estimators'],
        'param_learning_rate' : r_search.cv_results_['param_learning_rate'],
        'mean_train_score' : r_search.cv_results_['mean_train_score'],
        'mean_test_score' : r_search.cv_results_['mean_test_score']
       }

performance_tfidf = pd.DataFrame(data)
# performance_tfidf.head()
```

```
Best parameters fron TF-IDF model :
{'n_estimators': 200, 'learning_rate': 0.1}
```

In [61]:

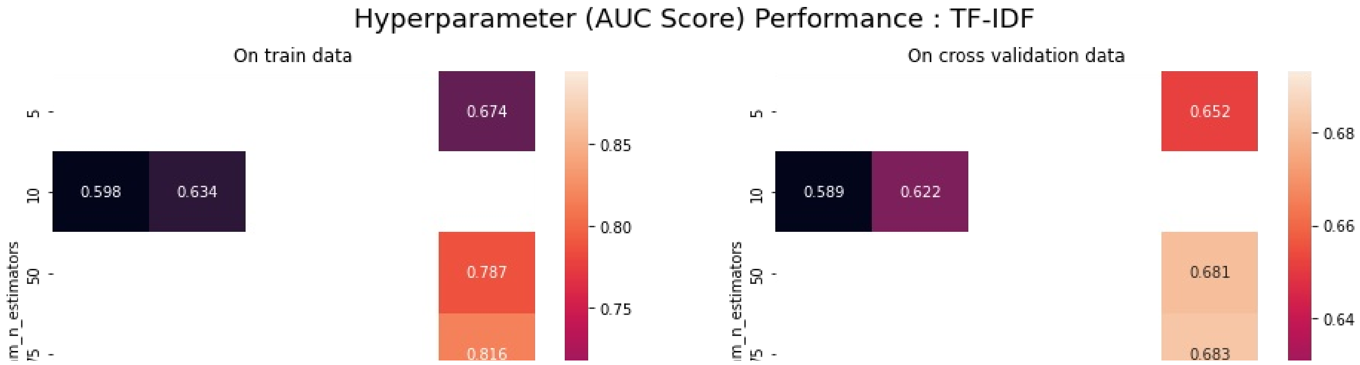
```
group_perf_tfidf = performance_tfidf.groupby(['param_n_estimators', 'param_learning_rate']).max().unstack()
group_perf_tfidf
```

Out[61]:

	mean_train_score					mean_test_score				
param_learning_rate	**0.0001**	**0.0100**	**0.1000**	**0.2000**	**0.3000**	**0.0001**	**0.0100**	**0.1000**	**0.2000**	**0.3000**
param_n_estimators										
5	NaN	NaN	NaN	NaN	0.673952	NaN	NaN	NaN	NaN	0.651965
10	0.598499	0.633748	NaN	NaN	NaN	0.589035	0.622019	NaN	NaN	NaN
50	NaN	NaN	NaN	NaN	0.787376	NaN	NaN	NaN	NaN	0.681015
75	NaN	NaN	NaN	NaN	0.816468	NaN	NaN	NaN	NaN	0.682875
100	NaN	NaN	0.799673	NaN	0.841800	NaN	NaN	0.689446	NaN	0.682534
200	0.611554	NaN	0.849303	0.894586	NaN	0.600954	NaN	0.693226	0.684764	NaN

In [62]:

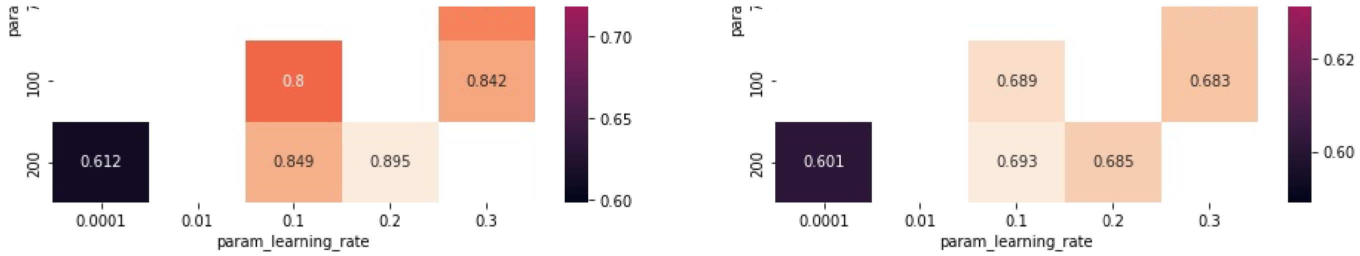
```
fig, axes = plt.subplots(1, 2, figsize = (16,6))
fig.suptitle('Hyperparameter (AUC Score) Performance : TF-IDF', fontsize = 18)

# https://stackoverflow.com/a/39133654

fig_1 = sns.heatmap(group_perf_tfidf.mean_train_score, annot = True, fmt='.3g', ax = axes[0])
fig_1.title.set_text('On train data')

fig_2 = sns.heatmap(group_perf_tfidf.mean_test_score, annot = True, fmt='.3g', ax = axes[1])
fig_2.title.set_text('On cross validation data')

plt.show()
```



Hyperparameter (AUC Score) Performance : TF-IDF

On train data

On cross validation data



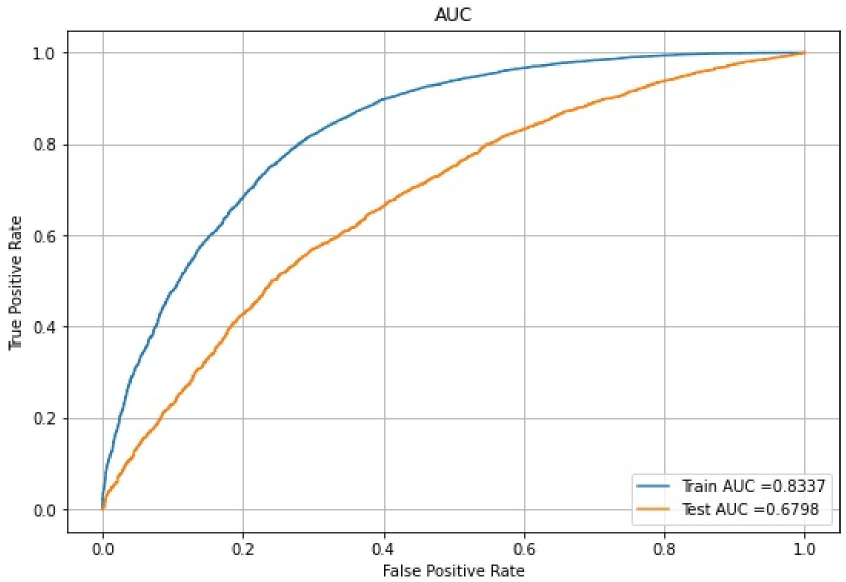
Observation

- While `n_estimators = 200` and `learning_rate = 0.1`, we are getting an **AUC** of **0.849**.
- So we are taking `n_estimators = 200` and `learning_rate = 0.1` as the best parameter.

Training Using Best Hyperparameter

In [63]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
# https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.GradientBoostingClassifier.html

tfidf_gbdt = GradientBoostingClassifier(
                    n_estimators = tfidf_n_estimators,
                    learning_rate = tfidf_learning_rate)

tfidf_gbdt.fit(tfidf_stack_train, y_train)

y_train_pred_tfidf = tfidf_gbdt.predict_proba(tfidf_stack_train)[:,1]
y_test_pred_tfidf = tfidf_gbdt.predict_proba(tfidf_stack_test)[:,1]

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf)

auc_train_set1 = auc(train_fpr, train_tpr)
auc_test_set1 = auc(test_fpr, test_tpr)

#Reference : DonorchooseNB assignment
plt.figure(figsize = (9,6))
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(round(auc_train_set1,4)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(round(auc_test_set1,4)))

plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('AUC')
plt.grid()
plt.legend(loc=4)
plt.show()
```



Train & Test Confusion Matrix

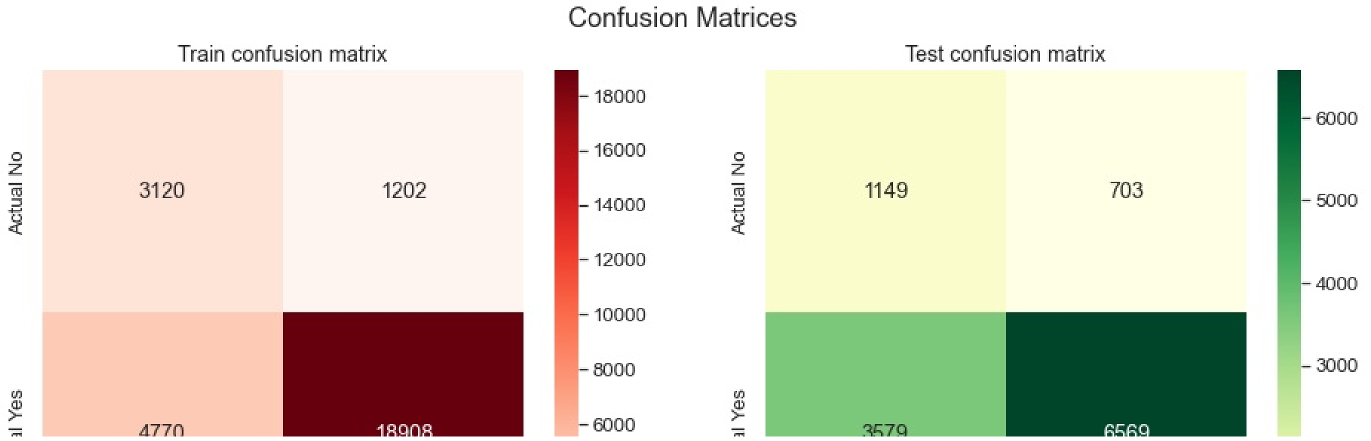
In [64]:

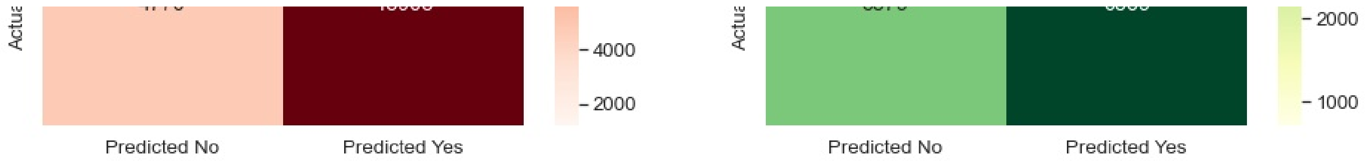
```
# Reference DonorchooseNB

def best_threshold_and_y_pred(threshould, proba, fpr, tpr):
    best_t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if fpr is very low and tpr is very high
    print("The maximum value of tpr*(1-fpr)", round(max(tpr*(1-fpr)),5), "for threshold", np.round(best_t,3))

    predictions = []
    for i in tqdm(proba):
        if i >= best_t:
            predictions.append(1)
        else:
            predictions.append(0)
    return best_t, predictions
```

In [65]:

```
print('Train')
print('=' * 5)
tfidf_tr_thr, tfidf_tr_pred = best_threshold_and_y_pred(tr_thresholds,
                                                            y_train_pred_tfidf, train_fpr, train_tpr)
confusion_mat_tfidf_tr = confusion_matrix(y_train, tfidf_tr_pred)

print('\nTest')
print('=' * 4)
tfidf_te_thr, tfidf_te_pred = best_threshold_and_y_pred(te_thresholds,
                                                                y_test_pred_tfidf, test_fpr, test_tpr)
confusion_mat_tfidf_te = confusion_matrix(y_test, tfidf_te_pred)

print('\nTrain confusion matrix : \n', confusion_mat_tfidf_tr)
print('\nTest confusion matrix : \n', confusion_mat_tfidf_te)


# https://stackoverflow.com/a/61748695
# https://stackoverflow.com/a/39133654

sns.set(font_scale=1.2)
fig, axes = plt.subplots(1, 2, figsize = (16,6))
fig.suptitle('Confusion Matrices', fontsize = 18)

fig_1 = sns.heatmap(confusion_mat_tfidf_tr, annot=True, fmt="d", cmap='Reds', ax = axes[0])
fig_1.title.set_text('Train confusion matrix')
axes[0].set_xticklabels(['Predicted No', 'Predicted Yes'])
axes[0].set_yticklabels(['Actual No', 'Actual Yes'])

fig_2 = sns.heatmap(confusion_mat_tfidf_te, annot=True, fmt="d", cmap='YlGn', ax = axes[1])
fig_2.title.set_text('Test confusion matrix')
axes[1].set_xticklabels(['Predicted No', 'Predicted Yes'])
axes[1].set_yticklabels(['Actual No', 'Actual Yes'])

plt.show()
```

```
Train
=====
The maximum value of tpr*(1-fpr) 0.57646 for threshold 0.832

100%|████████████████████████████████| 28000/28000 [00:00<00:00, 2556889.94it/s]
Test
====
The maximum value of tpr*(1-fpr) 0.4016 for threshold 0.854


100%|████████████████████████████████| 12000/12000 [00:00<00:00, 3439833.79it/s]

Train confusion matrix :
 [[ 3120  1202]
 [ 4770 18908]]

Test confusion matrix :
 [[1149  703]
 [3579 6569]]
```





Observation

- Train AUC (0.8337) is higher than the Test AUC (0.6798) score.
- We can conisder more number of points for training model for more robust model.
- Ratio of `True Positive` to `total data in train data` is 67.52% and while for `test data` the same ratio is only 54.74%.
- The **False Positive** (703) on `test data` is lesser than **False Negative** (3579) value which is not good.

NB : While testing for very samll number of datapoint (5000) the train AUC was 0.78 and Test AUC was 0.55 . On increasing numberof datapoints model is showing a good behaviour. So training model at larger datapoints may can avoid overfitting tendency.

Set 2

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

In [66]:

```
# https://stackoverflow.com/a/65470570
# https://stackoverflow.com/a/19710648/4084039

tfidf_w2v_stack_train = hstack((rc_X_train, x_train_price, x_train_quantity, x_train_previous_projects,
                            x_train_title_count, tfidf_w2v_title_x_tr, tfidf_w2v_essay_x_tr,
                            x_tr_rs_sum_tfidf, x_train_negative, x_train_positive, x_train_neutral,
                            x_train_compound)).tocsr()

tfidf_w2v_stack_test = hstack((rc_X_test, x_test_price, x_test_quantity, x_test_previous_projects,
                           x_test_title_count, tfidf_w2v_title_x_te, tfidf_w2v_essay_x_te,
                           x_te_rs_sum_tfidf, x_test_negative, x_test_positive, x_test_neutral,
                           x_test_compound)).tocsr()

print('TFIDF-W2V stack train shape\t: ', tfidf_w2v_stack_train.shape)
print('TFIDF-W2V stack test shape\t: ', tfidf_w2v_stack_test.shape)
```

```
TFIDF-W2V stack train shape     :  (28000, 7984)
TFIDF-W2V stack test shape      :  (12000, 7984)
```

Hyperparameter Tuning

In [67]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.GradientBoostingClassifier.html
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.RandomizedSearchCV.html

gbdt = GradientBoostingClassifier()

parameters= {'n_estimators' : [5, 10, 50, 75, 100, 200],
             'learning_rate' : [0.0001, 0.001, 0.01, 0.1, 0.2, 0.3]}

clf = RandomizedSearchCV(gbdt, parameters, cv = 5, scoring = 'roc_auc',
                         return_train_score = True, n_jobs =-1)

r_search = clf.fit(tfidf_w2v_stack_train, y_train)
best_params_tfidf_w2v = r_search.best_params_

print(f'Best parameters fron TF-IDF W2V model : \n{best_params_tfidf_w2v}')

tfidf_w2v_n_estimators = best_params_tfidf_w2v['n_estimators']
tfidf_w2v_learning_rate = best_params_tfidf_w2v['learning_rate']

data = {'param_n_estimators' : r_search.cv_results_['param_n_estimators'],
        'param_learning_rate' : r_search.cv_results_['param_learning_rate'],
        'mean_train_score' : r_search.cv_results_['mean_train_score'],
        'mean_test_score' : r_search.cv_results_['mean_test_score']
       }

performance_tfidf_w2v = pd.DataFrame(data)
# performance_tfidf_w2v.head()
```

```
Best parameters fron TF-IDF W2V model :
```

```
{'n_estimators': 100, 'learning_rate': 0.1}
```

In [68]:

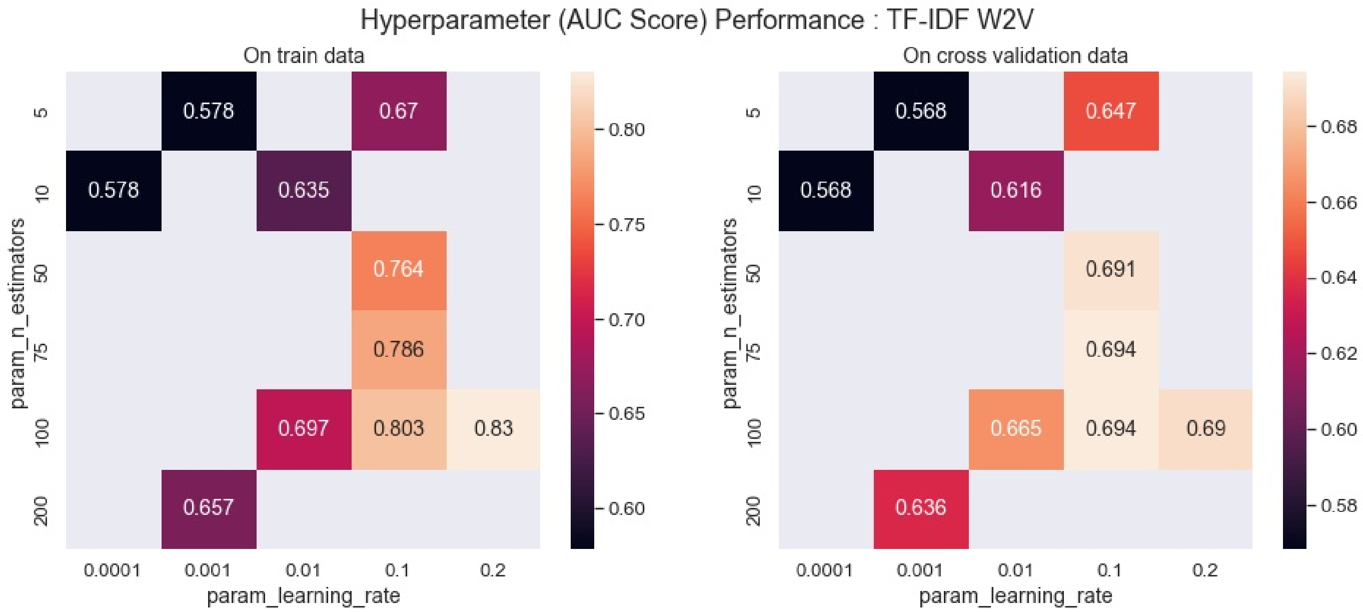
```
group_perf_w2v = performance_tfidf_w2v.groupby(['param_n_estimators', 'param_learning_rate']).max().unstack()
group_perf_w2v
```

Out[68]:

	mean_train_score					mean_test_score				
param_learning_rate	**0.0001**	**0.0010**	**0.0100**	**0.1000**	**0.2000**	**0.0001**	**0.0010**	**0.0100**	**0.1000**	**0.2000**
param_n_estimators										
5	NaN	0.578069	NaN	0.669528	NaN	NaN	0.568341	NaN	0.647179	NaN
10	0.578069	NaN	0.634971	NaN	NaN	0.568341	NaN	0.615764	NaN	NaN
50	NaN	NaN	NaN	0.763606	NaN	NaN	NaN	NaN	0.691127	NaN
75	NaN	NaN	NaN	0.785917	NaN	NaN	NaN	NaN	0.693998	NaN
100	NaN	NaN	0.696748	0.802551	0.830478	NaN	NaN	0.665358	0.694260	0.689633
200	NaN	0.657261	NaN	NaN	NaN	NaN	0.636236	NaN	NaN	NaN

In [69]:

```
fig, axes = plt.subplots(1, 2, figsize = (16,6))
fig.suptitle('Hyperparameter (AUC Score) Performance : TF-IDF W2V', fontsize = 18)

# https://stackoverflow.com/a/39133654

fig_1 = sns.heatmap(group_perf_w2v.mean_train_score, annot = True, fmt='.3g', ax = axes[0])
fig_1.title.set_text('On train data')

fig_2 = sns.heatmap(group_perf_w2v.mean_test_score, annot = True, fmt='.3g', ax = axes[1])
fig_2.title.set_text('On cross validation data')

plt.show()
```



Observation

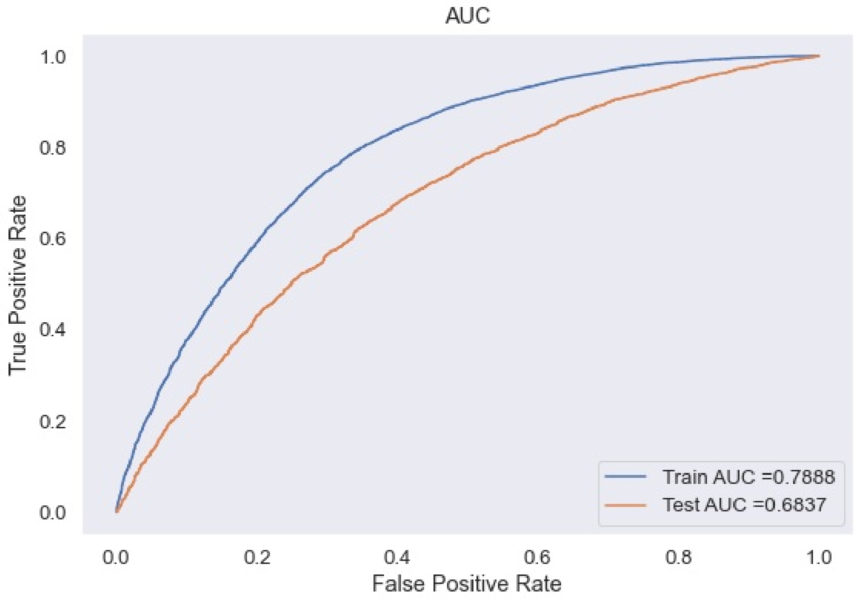
- While `n_estimators = 100` and `learning_rate = 0.1`, we are getting an **AUC** of **0.803**.
- So we are taking `n_estimators = 100` and `learning_rate = 0.1` as the best parameter.

Training Using Best Hyperparameter

In [70]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
# https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.GradientBoostingClassifier.html

tfidf_w2v_gbdt = GradientBoostingClassifier(
                    n_estimators = tfidf_w2v_n_estimators,
                    learning_rate = tfidf_w2v_learning_rate)

tfidf_w2v_gbdt.fit(tfidf_w2v_stack_train, y_train)

y_train_pred_tfidf_w2v = tfidf_w2v_gbdt.predict_proba(tfidf_w2v_stack_train)[:,1]
```

```
y_test_pred_tfidf_w2v = tfidf_w2v_gbdt.predict_proba(tfidf_w2v_stack_test)[:,1]

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_w2v)

auc_train_set2 = auc(train_fpr, train_tpr)
auc_test_set2 = auc(test_fpr, test_tpr)

#Reference : DonorchooseNB assignment
plt.figure(figsize = (9,6))
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(round(auc_train_set2,4)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(round(auc_test_set2,4)))

plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('AUC')
plt.grid()
plt.legend(loc=4)
plt.show()
```

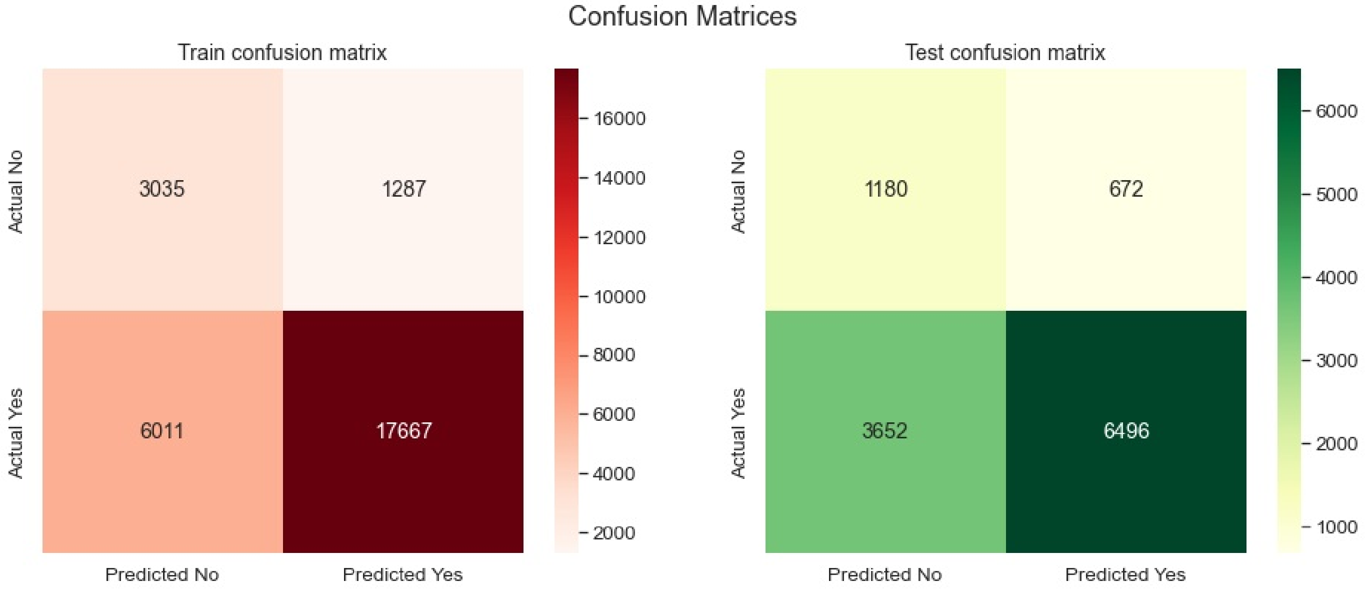


Train & Test Confusion Matrix

In [71]:

```
print('Train')
print('=' * 5)
tfidf_w2v_tr_thr, tfidf_w2v_tr_pred = best_threshold_and_y_pred(tr_thresholds,
                                                    y_train_pred_tfidf_w2v, train_fpr, train_tpr)
confusion_mat_tfidf_w2v_tr = confusion_matrix(y_train, tfidf_w2v_tr_pred)

print('\nTest')
print('=' * 4)
tfidf_w2v_te_thr, tfidf_w2v_te_pred = best_threshold_and_y_pred(te_thresholds,
                                                        y_test_pred_tfidf_w2v, test_fpr, test_tpr)
confusion_mat_tfidf_w2v_te = confusion_matrix(y_test, tfidf_w2v_te_pred)

print('\nTrain confusion matrix : \n', confusion_mat_tfidf_w2v_tr)
print('\nTest confusion matrix : \n', confusion_mat_tfidf_w2v_te)

# https://stackoverflow.com/a/61748695
# https://stackoverflow.com/a/39133654

sns.set(font_scale=1.2)
fig, axes = plt.subplots(1, 2, figsize = (16,6))
fig.suptitle('Confusion Matrices', fontsize = 18)

fig_1 = sns.heatmap(confusion_mat_tfidf_w2v_tr, annot=True, fmt="d", cmap='Reds', ax = axes[0])
fig_1.title.set_text('Train confusion matrix')
axes[0].set_xticklabels(['Predicted No', 'Predicted Yes'])
axes[0].set_yticklabels(['Actual No', 'Actual Yes'])

fig_2 = sns.heatmap(confusion_mat_tfidf_w2v_te, annot=True, fmt="d", cmap='YlGn', ax = axes[1])
fig_2.title.set_text('Test confusion matrix')
axes[1].set_xticklabels(['Predicted No', 'Predicted Yes'])
axes[1].set_yticklabels(['Actual No', 'Actual Yes'])
plt.show()
```

```
Train
=====
The maximum value of tpr*(1-fpr) 0.52395 for threshold 0.838
100%|████████████████████████████████| 28000/28000 [00:00<00:00, 3181635.02it/s]
Test
====
The maximum value of tpr*(1-fpr) 0.40786 for threshold 0.853
100%|████████████████████████████████| 12000/12000 [00:00<00:00, 3384095.21it/s]
Train confusion matrix :
 [[ 3035  1287]
 [ 6011 17667]]

Test confusion matrix :
 [[1180  672]
 [3652 6496]]
```



Observation

- Train AUC (0.7888) is higher than the Test AUC (0.6837) score.
- We can conisder more number of points for training model for more robust model.
- We can conisder more number of points for training model to avoid overfitting.
- Ratio of `True Positive` to `total data in train data` is 63.09% and while for `test data` the same ratio is only 54.13%.
- The **False Positive** (672) on `test data` is lesser than **False Negative** (3652) value which is not good.

NB : While testing for very samll number of datapoint (5000) the train AUC was 0.91 and Test AUC was 0.61 . On increasing numberof datapoints model is showing a good behaviour. So training model at larger datapoints may can avoid overfitting tendency.

3. Summary

As mentioned in the step 4 of instructions

In [72]:

```
time_end = time.time()
```

In [73]:

```
# https://pypi.org/project/prettytable/

x = PrettyTable()

x.field_names = ['Vectorizer', 'Model', 'n_estimators',
                                        'learning_rate','AUC (Train)', 'AUC (Test)']

x.add_row(['TF-IDF', ' GBClassifier ', tfidf_n_estimators,
                           tfidf_learning_rate, round(auc_train_set1, 2), round(auc_test_set1, 2)])

x.add_row(['TF-IDF W2V', ' GBClassifier ', tfidf_w2v_n_estimators,
                           tfidf_w2v_learning_rate, round(auc_train_set2, 2), round(auc_test_set2, 2)])
```

```
print(f'Number of datapoints used : {nrows_}\n')

print(f'Processing Time : {round((time_processing - time_start) / 60, 1)} minutes')
print(f'GBDT Alone      : {round((time_end - time_processing) / 60, 1)} minutes')
print(f'Total Time      : {round((time_end - time_start) / 60, 1)} minutes\n')

print(x)
```

```
Number of datapoints used : 40000

Processing Time : 1.0 minutes
GBDT Alone      : 81.5 minutes
Total Time      : 82.6 minutes

+------------+----------------+--------------+---------------+-------------+------------+
| Vectorizer |     Model      | n_estimators | learning_rate | AUC (Train) | AUC (Test) |
+------------+----------------+--------------+---------------+-------------+------------+
|   TF-IDF   |  GBClassifier  |     200      |      0.1      |     0.83    |    0.68    |
| TF-IDF W2V |  GBClassifier  |     100      |      0.1      |     0.79    |    0.68    |
+------------+----------------+--------------+---------------+-------------+------------+
```

Conclusion

- Train AUC is higher than the Test AUC score both models.
- The train AUC is in range 0.83 to 0.79 and while the test AUC is 0.68 for both models.
- We can conisder more number of points for training model for more robust model.
- We can conisder more number of points for training model to avoid overfitting tendency.
- For both models the ratio of `True Positive` to `total data in train data` is ~80% and while for `test data` the same ratio is only ~56%, the **False Positive** on `test data` is lesser than **False Negative** value which is not good.

NB : While testing for very samll number of datapoint (5000) the train AUC came in range 0.91-0.78 and Test AUC in a range of 0.61-0.55 . On increasing numberof datapoints model is showing a good behaviour. So training model at larger datapoints may can avoid overfitting tendency and can give a robust model.