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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

How to scale current manual processes and resources to screen 500,000 projects so that they ca
<li>How to increase the consistency of project vetting across different volunteers to improve
<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!

`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`

Feature	Description
`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 [1]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")

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

        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer

        import re
        # Tutorial about Python regular expressions: https://pymotw.com/2/re/
        import string
        from nltk.corpus import stopwords
        from nltk.stem import PorterStemmer
        from nltk.stem.wordnet import WordNetLemmatizer

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

        from tqdm import tqdm
        import os

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

1.2 1.1 Reading Data

```
In [2]: project_data = pd.read_csv('train_data.csv')
        resource_data = pd.read_csv('resources.csv')
```

```
In [3]: print("Number of data points in train data", project_data.shape)
        print('-'*50)
        print("The attributes of data :", project_data.columns.values)
```

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

```
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

```
In [4]: print("Number of data points in train data", resource_data.shape)
        print(resource_data.columns.values)
        resource_data.head(2)
```

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

```
Out[4]:         id                                        description  quantity  \
        0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
        1  p069063        Bouncy Bands for Desks (Blue support pipes)         3

            price
        0  149.00
        1   14.95
```

```
In [5]: # join two dataframes in python:
        price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_
        price_data.head(2)
        project_data = pd.merge(project_data, price_data, on='id', how='left')
```

```
In [6]: project_data.columns
```

```
Out[6]: 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',
               'price', 'quantity'],
              dtype='object')
```

1.3 1.2 preprocessing of `project_subject_categories`

```
In [7]: catogories = list(project_data['project_subject_categories'].values)
        # remove special characters from list of strings python: https://stackoverflow.com/a/4

        # https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
        # https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-str
        # https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-pyt
        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", "Warmt
        if 'The' in j.split(): # this will split each of the catogory based on space "
            j=j.replace('The','') # if we have the words "The" we are going to replace
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing sp
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

1.4 1.3 preprocessing of project_subject_subcategories

```
In [8]: sub_catogories = list(project_data['project_subject_subcategories'].values)
        # remove special characters from list of strings python: https://stackoverflow.com/a/4

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

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

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

        # count of all the words in corpus python: https://stackoverflow.com/a/22898595/408403
        my_counter = Counter()
        for word in project_data['clean_subcategories'].values:
            my_counter.update(word.split())

        sub_cat_dict = dict(my_counter)
        sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

1.5 1.3 Text preprocessing

```
In [9]: # 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 [10]: project_data.head(2)
```

```
Out[10]:    Unnamed: 0       id                        teacher_id teacher_prefix  \
         0      160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc           Mrs.
         1      140945  p258326  897464ce9ddc600bced1151f324dd63a            Mr.

           school_state project_submitted_datetime project_grade_category  \
         0           IN        2016-12-05 13:43:57          Grades PreK-2
         1           FL        2016-10-25 09:22:10             Grades 6-8

                                               project_title  \
         0  Educational Support for English Learners at Home
         1             Wanted: Projector for Hungry Learners

                                              project_essay_1  \
         0  My students are English learners that are work...
         1  Our students arrive to our school eager to lea...

                                              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

           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...

            teacher_number_of_previously_posted_projects  project_is_approved  price  \
         0                                             0                    0  154.6
         1                                             7                    1  299.0

            quantity             clean_categories          clean_subcategories  \
         0        23            Literacy_Language                 ESL Literacy
         1         1  History_Civics Health_Sports  Civics_Government TeamSports
```

```
                                                 essay
0  My students are English learners that are work...
1  Our students arrive to our school eager to lea...
```

```
In [11]: #### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

```
In [12]: # printing some random reviews
         print(project_data['essay'].values[0])
         print("="*50)
         print(project_data['essay'].values[150])
         print("="*50)
         print(project_data['essay'].values[1000])
         print("="*50)
         print(project_data['essay'].values[20000])
         print("="*50)
         print(project_data['essay'].values[99999])
         print("="*50)
```

```
My students are English learners that are working on English as their second or third languages
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, a
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cogn
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The g
==================================================
```

```
In [13]: # https://stackoverflow.com/a/47091490/4084039
         import re

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

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

```
In [14]: sent = decontracted(project_data['essay'].values[20000])
         print(sent)
         print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cog
==================================================
```

```
In [15]: # \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-
         sent = sent.replace('\\r', ' ')
         sent = sent.replace('\\"', ' ')
         sent = sent.replace('\\n', ' ')
         print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cog
```

```
In [16]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
         print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cogni
```

```
In [17]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you'
                     "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"]
```

```
In [18]: # Combining all the above stundents
         from tqdm import tqdm
         preprocessed_essays = []
         # tqdm is for printing the status bar
         for sentance in tqdm(project_data['essay'].values):
             sent = decontracted(sentance)
             sent = sent.replace('\\r', ' ')
```

```
            sent = sent.replace('\\"', ' ')
            sent = sent.replace('\\n', ' ')
            sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
            # https://gist.github.com/sebleier/554280
            sent = ' '.join(e for e in sent.split() if e not in stopwords)
            preprocessed_essays.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:44<00:00, 2459.88it/s]
```

```
In [19]: # after preprocesing
         preprocessed_essays[20000]
```

```
Out[19]: 'my kindergarten students varied disabilities ranging speech language delays cognitive
```

```
In [20]: project_data["essay"]=preprocessed_essays
         project_data.essay.values[20000]
```

```
Out[20]: 'my kindergarten students varied disabilities ranging speech language delays cognitive
```

1.4 Preprocessing of project_title

```
In [21]: from tqdm import tqdm
         preprocessed_project_title = []
         # tqdm is for printing the status bar
         for sentance in tqdm(project_data['project_title'].values):
             sent = decontracted(sentance)
             sent = sent.replace('\\r', ' ')
             sent = sent.replace('\\"', ' ')
             sent = sent.replace('\\n', ' ')
             sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
             # https://gist.github.com/sebleier/554280
             sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
             preprocessed_project_title.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:01<00:00, 57298.53it/s]
```

```
In [22]: print(project_data['project_title'].values[20000])
         project_data['project_title']=preprocessed_project_title
         print(project_data['project_title'].values[20000])
```

```
We Need To Move It While We Input It!
need move input
```

```
In [23]: from nltk.sentiment import SentimentIntensityAnalyzer as SID
         #nltk.download('vader_lexicon')
         new_df_as_dictinary=[]
         sid=SID()
         for i in tqdm(project_data.essay.values):
             new_df_as_dictinary.append(sid.polarity_scores(i))
```

```
100%|| 109248/109248 [02:23<00:00, 758.93it/s]
```

```
In [24]: print(project_data.columns)
         print(project_data.shape)
         sentiment_score=pd.DataFrame(new_df_as_dictinary)
         print(sentiment_score.columns)
         print(sentiment_score.shape)
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'essay'],
      dtype='object')
(109248, 20)
Index(['compound', 'neg', 'neu', 'pos'], dtype='object')
(109248, 4)
```

```
In [25]: sentiment_score=pd.DataFrame(new_df_as_dictinary)
         project_data=pd.concat((project_data,sentiment_score),axis=1,ignore_index=True)
         print(project_data.shape)
```

```
(109248, 24)
```

```
In [26]: project_data.columns=['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_sta
                'project_submitted_datetime', 'project_grade_category', 'project_title',
                'project_essay_1', 'project_essay_2', 'project_essay_3',
                'project_essay_4', 'project_resource_summary',
                'teacher_number_of_previously_posted_projects', 'project_is_approved',
                'price', 'quantity', 'clean_categories', 'clean_subcategories',
                'essay','compound', 'neg', 'neu', 'pos']
```

```
In [27]: print(project_data.head(5))
```

```
   Unnamed: 0       id                        teacher_id teacher_prefix  \
0      160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc           Mrs.
1      140945  p258326  897464ce9ddc600bced1151f324dd63a            Mr.
2       21895  p182444  3465aaf82da834c0582ebd0ef8040ca0            Ms.
3          45  p246581  f3cb9bffbba169bef1a77b243e620b60           Mrs.
4      172407  p104768  be1f7507a41f8479dc06f047086a39ec           Mrs.

  school_state project_submitted_datetime project_grade_category  \
0           IN        2016-12-05 13:43:57          Grades PreK-2
1           FL        2016-10-25 09:22:10             Grades 6-8
```

```
2           AZ        2016-08-31 12:03:56            Grades 6-8
3           KY        2016-10-06 21:16:17         Grades PreK-2
4           TX        2016-07-11 01:10:09         Grades PreK-2

                                     project_title  \
0         educational support english learners home
1                  wanted projector hungry learners
2  soccer equipment awesome middle school students
3                            techie kindergarteners
4                            interactive math tools

                                     project_essay_1  \
0  My students are English learners that are work...
1  Our students arrive to our school eager to lea...
2  \r\n\"True champions aren't always the ones th...
3  I work at a unique school filled with both ESL...
4  Our second grade classroom next year will be m...

                                     project_essay_2  ...    \
0  \"The limits of your language are the limits o...  ...
1  The projector we need for our school is very c...  ...
2  The students on the campus come to school know...  ...
3  My students live in high poverty conditions wi...  ...
4  For many students, math is a subject that does...  ...

  project_is_approved   price quantity                clean_categories  \
0                    0  154.60       23               Literacy_Language
1                    1  299.00        1    History_Civics Health_Sports
2                    0  516.85       22                   Health_Sports
3                    1  232.90        4  Literacy_Language Math_Science
4                    1   67.98        4                    Math_Science

            clean_subcategories  \
0                  ESL Literacy
1  Civics_Government TeamSports
2    Health_Wellness TeamSports
3          Literacy Mathematics
4                   Mathematics

                                               essay  compound    neg    neu  \
0  my students english learners working english s...    0.9694  0.012  0.844
1  our students arrive school eager learn they po...    0.9856  0.048  0.669
2  true champions not always ones win guts by mia...    0.9816  0.122  0.659
3  i work unique school filled esl english second...    0.9656  0.106  0.649
4  our second grade classroom next year made arou...    0.8524  0.066  0.791

     pos
0  0.144
```

```
1  0.283
2  0.219
3  0.246
4  0.143

[5 rows x 24 columns]
```

2 Assignment 5: Logistic Regression

```
<li><strong>[Task-1] Logistic Regression(either SGDClassifier with log loss, or LogisticRegress
    <ul>
        <li><font color='red'>Set 1</font>: categorical, numerical features + project_title(BOW
        <li><font color='red'>Set 2</font>: categorical, numerical features + project_title(TFI
        <li><font color='red'>Set 3</font>: categorical, numerical features + project_title(AVG
        <li><font color='red'>Set 4</font>: categorical, numerical features + project_title(TFI
</li>
<br>
<li><strong>Hyper paramter tuning (find best hyper parameters corresponding the algorithm that
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaicou
<li>Find the best hyper paramter using k-fold cross validation or simple cross validation data
<li>Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this ta
    </ul>
</li>
<br>
<li><strong>Representation of results</strong>
    <ul>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='train_cv_auc.JPG' width=300px></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>
</li>
<br>
<li><strong>[Task-2] Apply Logistic Regression on the below feature set <font color='red'> Set
<li> Consider these set of features <font color='red'> Set 5 :</font>
        <ul>
            <li><strong>school_state</strong> : categorical data</li>
            <li><strong>clean_categories</strong> : categorical data</li>
            <li><strong>clean_subcategories</strong> : categorical data</li>
            <li><strong>project_grade_category</strong> :categorical data</li>
            <li><strong>teacher_prefix</strong> : categorical data</li>
            <li><strong>quantity</strong> : numerical data</li>
            <li><strong>teacher_number_of_previously_posted_projects</strong> : numerical data
            <li><strong>price</strong> : numerical data</li>
            <li><strong>sentiment score's of each of the essay</strong> : numerical data</li>
            <li><strong>number of words in the title</strong> : numerical data</li>
            <li><strong>number of words in the combine essays</strong> : numerical data</li>
        </ul>
    And apply the Logistic regression on these features by finding the best hyper paramter as s
</li>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table fo
    <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-leakage, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

2. Logistic Regression

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

```
In [28]: sampling=False
         undersampling=False
         if (not sampling):
             print("Total data ",project_data.shape)

         else:
             if(sampling and undersampling):
                 print("Total data ",project_data.shape)
                 project_data_negative=project_data[project_data.project_is_approved==0]
                 project_data_positive=project_data[project_data.project_is_approved==1]
                 project_data_positive=project_data_positive.sample(n=project_data_negative.sha
                 print("Positive points: ",project_data_positive.shape[0])
                 print("Negaitive points: ",project_data_negative.shape[0])
                 project_data=pd.concat([project_data_positive,project_data_negative])
             else:
                 print("Total data ",project_data.shape)
                 project_data_negative=project_data[project_data.project_is_approved==0]
                 project_data_positive=project_data[project_data.project_is_approved==1]
                 project_data_negative=project_data_negative.sample(n=project_data_positive.sha
                 print("Positive points: ",project_data_positive.shape[0])
                 print("Negaitive points: ",project_data_negative.shape[0])
```

```
                project_data=pd.concat([project_data_positive,project_data_negative])

        #data_point_size=50000
        #project_data=project_data.sample(n=data_point_size,random_state=42,replace=True)
        print("positive and negative counts")
        print(project_data.project_is_approved.value_counts())
        project_data_Y=project_data.project_is_approved
        project_data_X=project_data.drop(columns=['project_is_approved'])
        print("After sampling: ",project_data_X.shape)
```

```
Total data  (109248, 24)
positive and negative counts
1    92706
0    16542
Name: project_is_approved, dtype: int64
After sampling:  (109248, 23)
```

```
In [29]: from sklearn.model_selection import train_test_split
         project_data_X_train,project_data_X_test,project_data_Y_train,project_data_Y_test=tra
```

```
In [30]: print(project_data_X_train.shape)
         print(project_data_X_test.shape)
         print(project_data_Y_train.shape)
         print(project_data_Y_test.shape)
```

```
(87398, 23)
(21850, 23)
(87398,)
(21850,)
```

2.2 Make Data Model Ready: encoding numerical, categorical features
2.2.1 Categorical features

```
In [31]: from sklearn.feature_extraction.text import CountVectorizer
         vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False
         vectorizer.fit(project_data_X_train['clean_categories'].values)
         print(vectorizer.get_feature_names())

         #for train data
         categories_one_hot_train = vectorizer.transform(project_data_X_train['clean_categorie
         print("Shape of matrix after one hot encodig ",categories_one_hot_train.shape)


         #for test
         categories_one_hot_test = vectorizer.transform(project_data_X_test['clean_categories']
         print("Shape of matrix after one hot encodig ",categories_one_hot_test.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', '
Shape of matrix after one hot encodig  (87398, 9)
Shape of matrix after one hot encodig  (21850, 9)
```

```
In [32]: vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=Fa
         vectorizer.fit(project_data_X_train['clean_subcategories'].values)
         print(vectorizer.get_feature_names())

         #for train data
         sub_categories_one_hot_train = vectorizer.transform(project_data_X_train['clean_subcat
         print("Shape of matrix after one hot encodig ",sub_categories_one_hot_train.shape)

         #for test
         sub_categories_one_hot_test = vectorizer.transform(project_data_X_test['clean_subcateg
         print("Shape of matrix after one hot encodig ",sub_categories_one_hot_test.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
Shape of matrix after one hot encodig  (87398, 30)
Shape of matrix after one hot encodig  (21850, 30)
```

```
In [33]: project_data_X_train.teacher_prefix = project_data_X_train.teacher_prefix.replace(np.
         print(project_data_X_train.teacher_prefix.value_counts())
         project_data_X_test.teacher_prefix = project_data_X_test.teacher_prefix.replace(np.na
         print(project_data_X_test.teacher_prefix.value_counts())
```

```
Mrs.       45800
Ms.        31168
Mr.         8519
Teacher     1898
Dr.           11
               2
Name: teacher_prefix, dtype: int64
Mrs.       11469
Ms.         7787
Mr.         2129
Teacher      462
Dr.            2
               1
Name: teacher_prefix, dtype: int64
```

```
In [34]: # we use count vectorizer to convert the values into one hot encoded features
         vectorizer = CountVectorizer(vocabulary=['Mrs.','Ms.','Mr.','Teacher','Dr.'], lowercas
         vectorizer.fit(project_data_X_train['teacher_prefix'].values)
         print(vectorizer.get_feature_names())

         teacher_prefix_one_hot_train = vectorizer.transform(project_data_X_train['teacher_pre
         print("Shape of matrix after one hot encodig ",teacher_prefix_one_hot_train.shape)

         teacher_prefix_one_hot_test = vectorizer.transform(project_data_X_test['teacher_prefi
         print("Shape of matrix after one hot encodig ",teacher_prefix_one_hot_test.shape)
```

```
['Mrs.', 'Ms.', 'Mr.', 'Teacher', 'Dr.']
Shape of matrix after one hot encodig  (87398, 5)
Shape of matrix after one hot encodig  (21850, 5)
```

```
In [35]: # we use count vectorizer to convert the values into one hot encoded features
         vectorizer = CountVectorizer(vocabulary=list(project_data_X_train['project_grade_categ
         vectorizer.fit(project_data_X_train['project_grade_category'].values)
         print(vectorizer.get_feature_names())

         project_grade_category_one_hot_train = vectorizer.transform(project_data_X_train['proj
         print("Shape of matrix after one hot encodig ",project_grade_category_one_hot_train.sh

         project_grade_category_one_hot_test = vectorizer.transform(project_data_X_test['projec
         print("Shape of matrix after one hot encodig ",project_grade_category_one_hot_test.sha
```

```
['Grades PreK-2', 'Grades 3-5', 'Grades 6-8', 'Grades 9-12']
Shape of matrix after one hot encodig  (87398, 4)
Shape of matrix after one hot encodig  (21850, 4)
```

```
In [36]: # we use count vectorizer to convert the values into one hot encoded features
         vectorizer = CountVectorizer(vocabulary=list(project_data_X_train['school_state'].uniq
         vectorizer.fit(project_data_X_train['school_state'].values)
         print(vectorizer.get_feature_names())


         school_state_one_hot_train = vectorizer.transform(project_data_X_train['school_state']
         print("Shape of matrix after one hot encodig ",school_state_one_hot_train.shape)

         school_state_one_hot_test = vectorizer.transform(project_data_X_test['school_state'].v
         print("Shape of matrix after one hot encodig ",school_state_one_hot_test.shape)
```

```
['NY', 'MD', 'OK', 'MA', 'CA', 'AR', 'FL', 'PA', 'SC', 'NC', 'AZ', 'MI', 'AL', 'WI', 'NV', 'UT
Shape of matrix after one hot encodig  (87398, 51)
Shape of matrix after one hot encodig  (21850, 51)
```

2.2.2 Numerical features

```
In [37]: # check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
         # standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.
         from sklearn.preprocessing import StandardScaler
```

```
# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ..
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data_X_train['price'].values.reshape(-1,1)) # finding the me
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.va

# Now standardize the data with above maen and variance.
price_standardized_train = price_scalar.transform(project_data_X_train['price'].values
# Now standardize the data with above maen and variance.
price_standardized_test = price_scalar.transform(project_data_X_test['price'].values.
```

```
Mean : 298.64356770177807, Standard deviation : 368.42853396795914
```

In [38]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.
from sklearn.preprocessing import StandardScaler,normalize

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ..
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data_X_train['teacher_number_of_previously_posted_projects']
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.va

# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_train = price_scalar.transfo

# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_test = price_scalar.transfo
```

```
Mean : 11.102897091466623, Standard deviation : 27.572082372998246
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [39]:
```
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2),max_features=5000)
vectorizer.fit(project_data_X_train.essay.values)

text_bow_train=vectorizer.fit_transform(project_data_X_train.essay.values)
print(text_bow_train.shape)

text_bow_test=vectorizer.transform(project_data_X_test.essay.values)
print(text_bow_test.shape)
```

```
(87398, 5000)
(21850, 5000)
```

```
In [40]: # Similarly you can vectorize for title also
         vectorizer = CountVectorizer(min_df=10)
         vectorizer.fit(project_data_X_train.project_title.values)

         title_text_bow_train=vectorizer.fit_transform(project_data_X_train.project_title.valu
         print(title_text_bow_train.shape)

         title_text_bow_test=vectorizer.transform(project_data_X_test.project_title.values)
         print(title_text_bow_test.shape)
```

```
(87398, 2803)
(21850, 2803)
```

```
In [41]: from sklearn.feature_extraction.text import TfidfVectorizer
         vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2),max_features=5000)
         vectorizer.fit(project_data_X_train.essay.values)

         text_tfidf_train=vectorizer.fit_transform(project_data_X_train.essay.values)
         print(text_tfidf_train.shape)

         text_tfidf_test=vectorizer.transform(project_data_X_test.essay.values)
         print(text_tfidf_test.shape)
```

```
(87398, 5000)
(21850, 5000)
```

```
In [42]: # Similarly you can vectorize for title also
         from sklearn.feature_extraction.text import TfidfVectorizer
         vectorizer = TfidfVectorizer(min_df=10)
         vectorizer.fit(project_data_X_train.project_title.values)

         title_text_tfidf_train=vectorizer.fit_transform(project_data_X_train.project_title.val
         print(title_text_tfidf_train.shape)

         title_text_tfidf_test=vectorizer.transform(project_data_X_test.project_title.values)
         print(title_text_tfidf_test.shape)
```

```
(87398, 2803)
(21850, 2803)
```

```
In [43]: # Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
         def loadGloveModel(gloveFile):
```

```
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
# borrowed from https://therenegadecoder.com/code/how-to-check-if-a-file-exists-in-py
import os
exists = os.path.isfile('./glove_vectors')
if(not exists):
    model = loadGloveModel('glove.42B.300d.txt')

    '''# ============================
    Output:

    Loading Glove Model
    1917495it [06:32, 4879.69it/s]
    Done. 1917495  words loaded!

    # ============================'''

    words = []
    for i in preproced_texts:
        words.extend(i.split(' '))

    for i in preproced_titles:
        words.extend(i.split(' '))
    print("all the words in the coupus", len(words))
    words = set(words)
    print("the unique words in the coupus", len(words))

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

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


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

```
             import pickle
             with open('glove_vectors', 'wb') as f:
                 pickle.dump(words_courpus, f)
         else:
             print("glove already exists. No need to compute")
```

```
glove already exists. No need to compute
```

```
In [44]: with open('glove_vectors', 'rb') as f:
             model = pickle.load(f)
             glove_words =  set(model.keys())
```

```
In [45]: # average Word2Vec
         # compute average word2vec for each review.
         avg_w2v_vectors_essay_train = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_train.essay.values): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_essay_train.append(vector)

         print(len(avg_w2v_vectors_essay_train))
         print(len(avg_w2v_vectors_essay_train[0]))
```

```
100%|| 87398/87398 [00:19<00:00, 4560.29it/s]


87398
300
```

```
In [46]: # average Word2Vec
         # compute average word2vec for each review.
         avg_w2v_vectors_essay_test = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_test.essay.values): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_essay_test.append(vector)

         print(len(avg_w2v_vectors_essay_test))
         print(len(avg_w2v_vectors_essay_test[0]))
```

```
100%|| 21850/21850 [00:04<00:00, 4514.38it/s]


21850
300
```

```
In [47]: # average Word2Vec
         # compute average word2vec for each title.
         title_avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_train.project_title.values): # for each review/se
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             title_avg_w2v_vectors_train.append(vector)

         print(len(title_avg_w2v_vectors_train))
         print(len(title_avg_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [00:00<00:00, 88824.17it/s]


87398
300
```

```
In [48]: # average Word2Vec
         # compute average word2vec for each title.
         title_avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_test.project_title.values): # for each review/sen
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
```

```
            title_avg_w2v_vectors_test.append(vector)

        print(len(title_avg_w2v_vectors_test))
        print(len(title_avg_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:00<00:00, 88577.91it/s]


21850
300
```

```
In [49]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         tfidf_model = TfidfVectorizer()
         tfidf_model.fit(project_data_X_train.essay.values)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
         essay_tfidf_words = set(tfidf_model.get_feature_names())
```

```
In [50]: # average Word2Vec
         # compute average word2vec for each review.
         essay_tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored
         for sentence in tqdm(project_data_X_train.essay.values): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in essay_tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     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
             essay_tfidf_w2v_vectors_train.append(vector)

         print(len(essay_tfidf_w2v_vectors_train))
         print(len(essay_tfidf_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [02:17<00:00, 637.26it/s]


87398
300
```

```
In [51]: # average Word2Vec
         # compute average word2vec for each review.
         essay_tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored i
         for sentence in tqdm(project_data_X_test.essay.values): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in essay_tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     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
             essay_tfidf_w2v_vectors_test.append(vector)

         print(len(essay_tfidf_w2v_vectors_test))
         print(len(essay_tfidf_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:35<00:00, 617.76it/s]


21850
300
```

```
In [52]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         tfidf_model = TfidfVectorizer()
         tfidf_model.fit(project_data_X_train.project_title.values)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
         essay_tfidf_words = set(tfidf_model.get_feature_names())
```

```
In [53]: # average Word2Vec
         # compute average word2vec for each review.
         title_tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored
         for sentence in tqdm(project_data_X_train.project_title.values): # for each review/se
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in essay_tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     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
             title_tfidf_w2v_vectors_train.append(vector)
```

```
        print(len(title_tfidf_w2v_vectors_train))
        print(len(title_tfidf_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [00:01<00:00, 44042.37it/s]


87398
300
```

```
In [54]: # average Word2Vec
         # compute average word2vec for each review.
         title_tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored i
         for sentence in tqdm(project_data_X_test.project_title.values): # for each review/sen
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in essay_tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     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
             title_tfidf_w2v_vectors_test.append(vector)

         print(len(title_tfidf_w2v_vectors_test))
         print(len(title_tfidf_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:00<00:00, 46247.65it/s]


21850
300
```

2.4 Appling Logistic Regression on different kind of featurization as mentioned in the instructions

Apply Logistic Regression 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

2.0.1 2.4.1 Applying LR on BOW, SET 1

```
In [55]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         BOW = hstack((categories_one_hot_train, sub_categories_one_hot_train,school_state_one_
         print(BOW.shape)
         BOW_test= hstack((categories_one_hot_test, sub_categories_one_hot_test,school_state_or
         print(BOW_test.shape)
```

```
(87398, 7900)
(21850, 7900)
```

```
In [56]: from sklearn.linear_model import LogisticRegression
         from sklearn.model_selection import GridSearchCV
         model=LogisticRegression(class_weight='balanced')
         a=[10**-4,10**-3,10**-2,10**-1,10**0,10**1,10**2,10**3,10**4]
         print(a)
         parameters = {'C': a }
         clf = GridSearchCV(model, parameters, cv=4,scoring='roc_auc',n_jobs=4,verbose=10)
         clf.fit(BOW,project_data_Y_train)
```

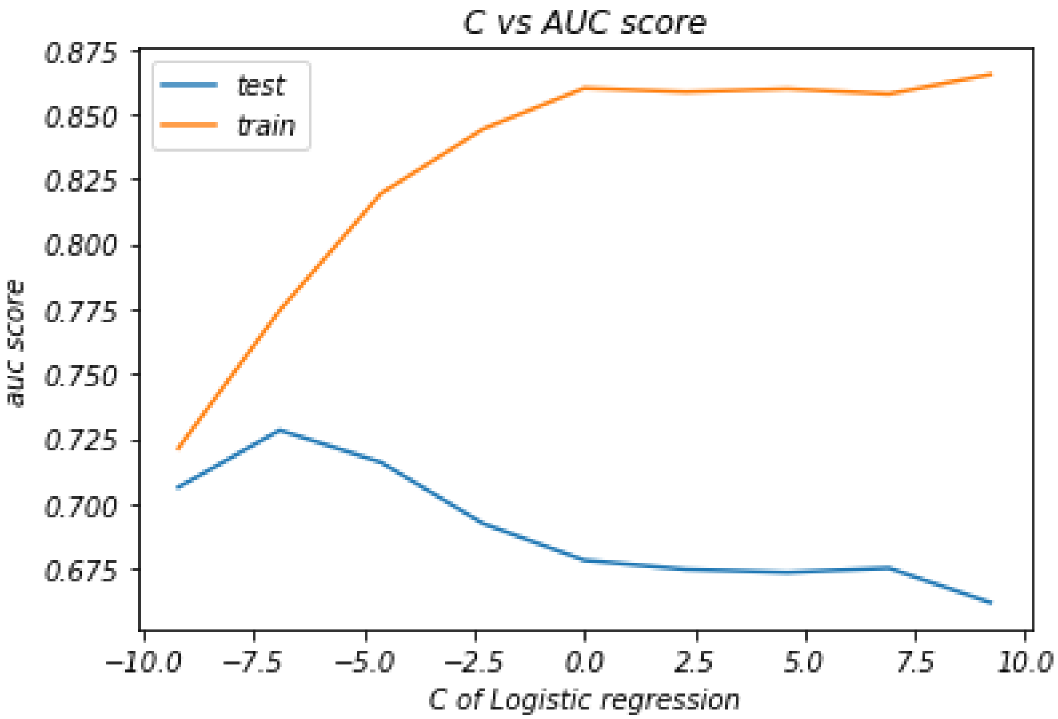
```
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
Fitting 4 folds for each of 9 candidates, totalling 36 fits
```

```
[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   18.7s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   40.3s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  2.9min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  7.2min
[Parallel(n_jobs=4)]: Done  33 out of  36 | elapsed: 16.0min remaining:  1.4min
[Parallel(n_jobs=4)]: Done  36 out of  36 | elapsed: 18.8min finished
```

```
Out[56]: GridSearchCV(cv=4, error_score='raise-deprecating',
                estimator=LogisticRegression(C=1.0, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

```
In [57]: k=a
         auc_cv=clf.cv_results_['mean_test_score']
         auc_train=clf.cv_results_['mean_train_score']
         plt.plot(np.log(k),auc_cv)
         plt.plot(np.log(k),auc_train)
         plt.title('C vs AUC score')
         plt.xlabel('C of Logistic regression')
         plt.ylabel('auc score')
         plt.legend({"test":"","train":""})
```

```
Out[57]: <matplotlib.legend.Legend at 0x2681315d080>
```



```
In [61]: print(clf.cv_results_['mean_test_score'])
         print(np.log(k))

[0.70631602 0.72820106 0.71590037 0.69237698 0.6781808  0.67466286
 0.67347534 0.67518525 0.66187874]
[-9.21034037 -6.90775528 -4.60517019 -2.30258509  0.          2.30258509
  4.60517019  6.90775528  9.21034037]
```

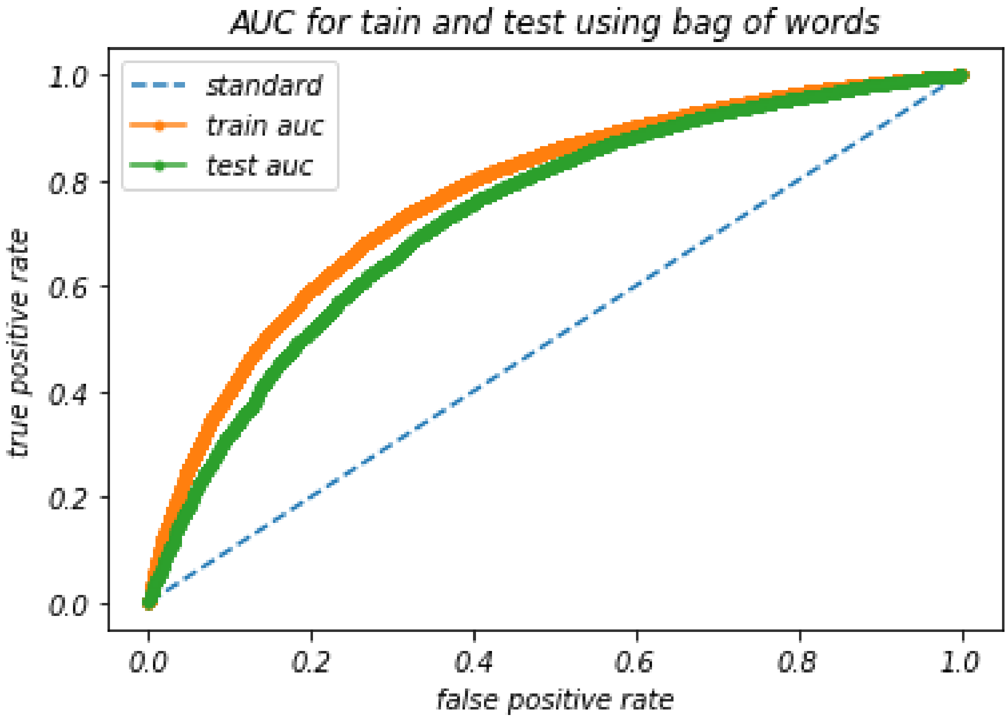
```
In [62]: print(np.exp(-6.90775528))

0.0009999999989821371
```

10**-3 is the optimal value

```
In [63]: model=LogisticRegression(class_weight='balanced',C=10**-3,n_jobs=4)
         model.fit(BOW,project_data_Y_train)

Out[63]: LogisticRegression(C=0.001, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=4, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

```
In [64]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(BOW_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(BOW)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()
```

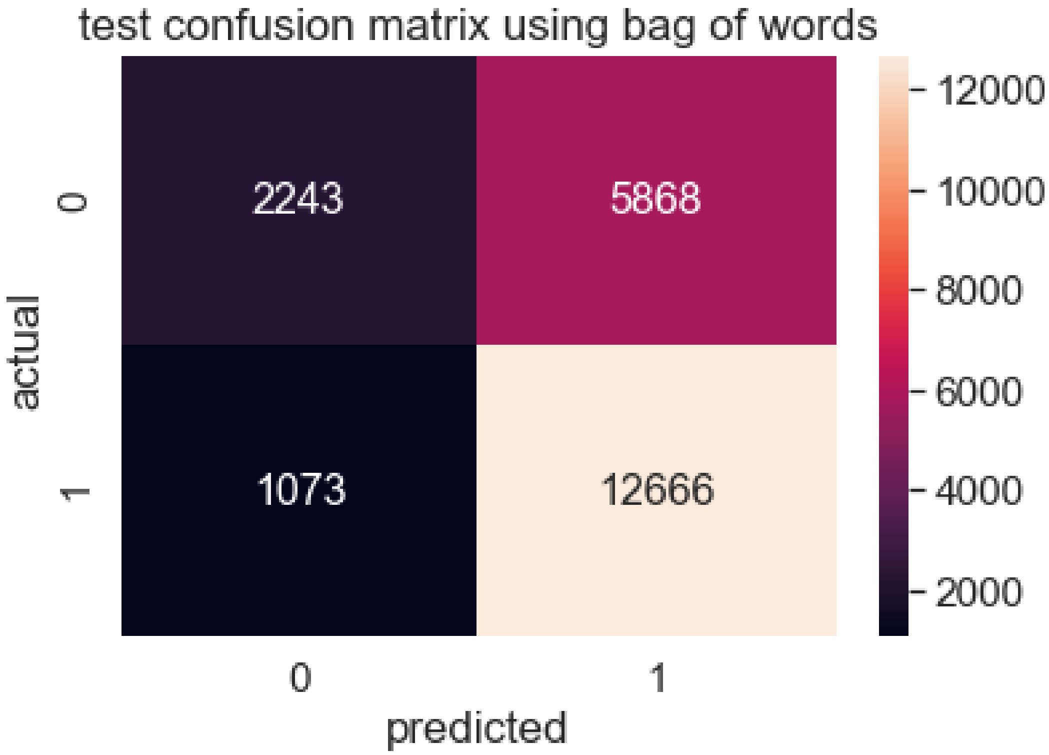
```
AUC: 0.736
AUC: 0.772
```



```
In [65]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(BOW_test)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_test,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("test confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

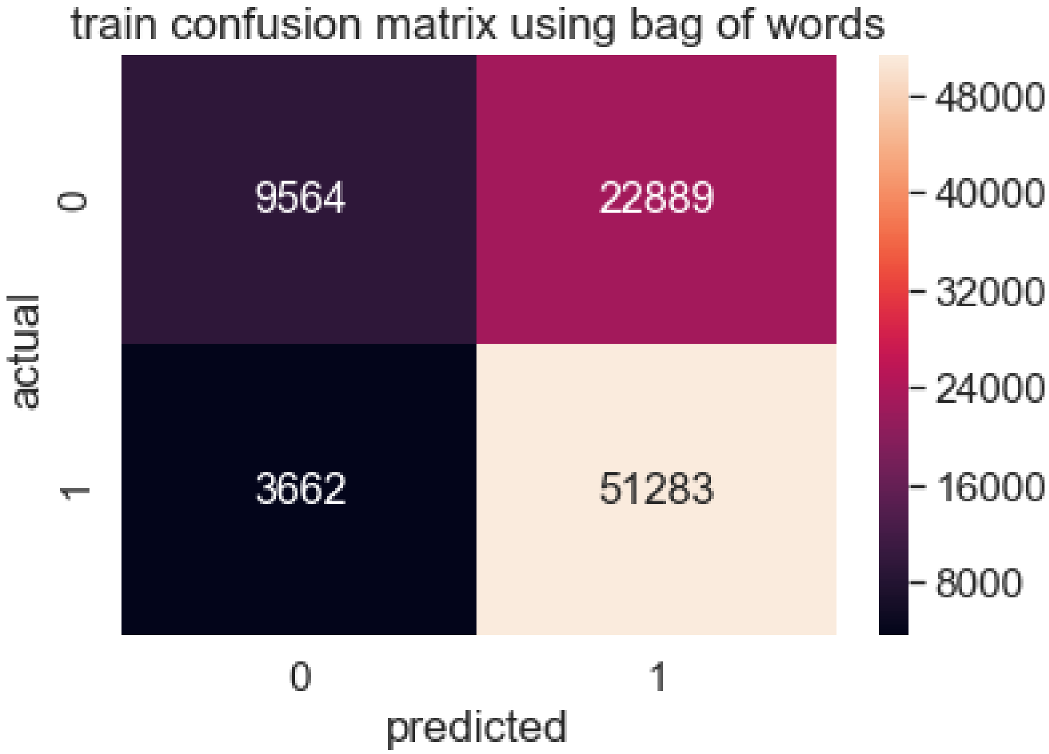
```
2243 1073 5868 12666
true positive rate 0.683392683716413
true negaitive rate 0.6764173703256936
```

```
[[2243, 5868], [1073, 12666]]
```



```
In [66]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(BOW)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_train,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("train confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

```
9564 3662 22889 51283
true positive rate 0.6914064606590088
true negaitive rate 0.7231211250567064
[[9564, 22889], [3662, 51283]]
```



2.0.2 2.4.1 Applying LR on TFIDF, SET 2

```
In [67]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         TFIDF = hstack((categories_one_hot_train, sub_categories_one_hot_train,school_state_o
         print(TFIDF.shape)
         TFIDF_test = hstack((categories_one_hot_test, sub_categories_one_hot_test,school_stat
         print(TFIDF_test.shape)
```

```
(87398, 7900)
(21850, 7900)
```

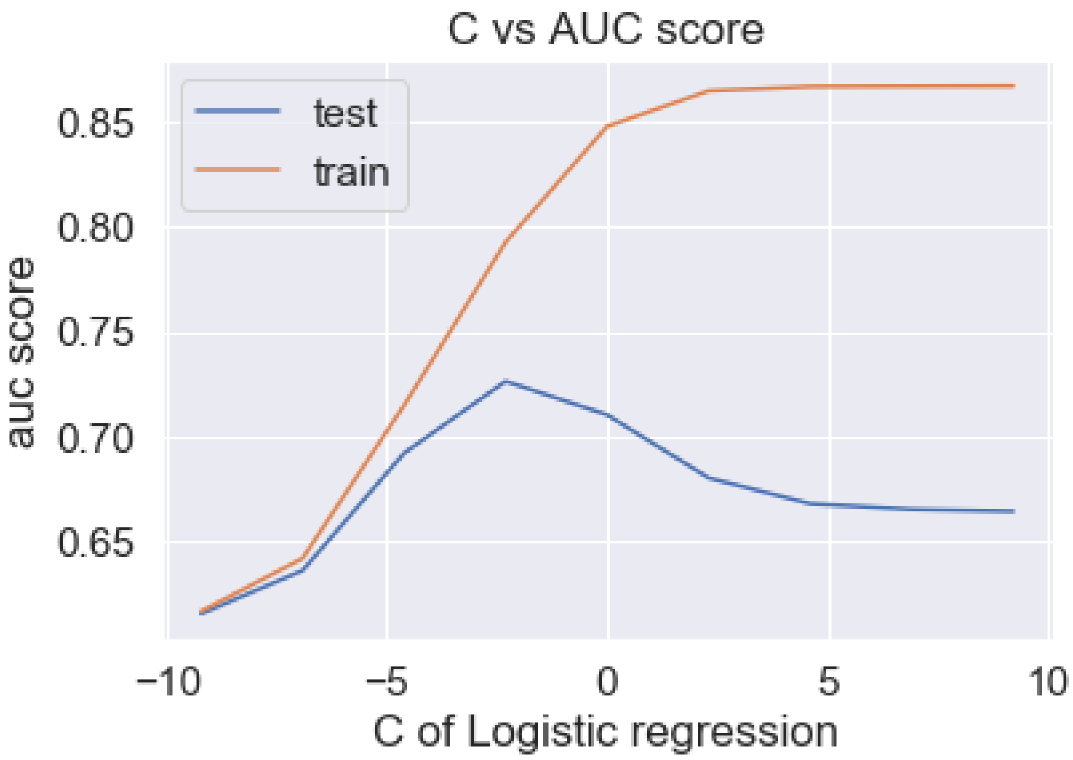
```
In [68]: from sklearn.linear_model import LogisticRegression
         from sklearn.model_selection import GridSearchCV
         model=LogisticRegression(class_weight='balanced')
         a=[10**-4,10**-3,10**-2,10**-1,10**0,10**1,10**2,10**3,10**4]
         print(a)
         parameters = {'C': a }
         clf = GridSearchCV(model, parameters, cv=4,scoring='roc_auc',n_jobs=4,verbose=10)
         clf.fit(TFIDF,project_data_Y_train)
```

```
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
Fitting 4 folds for each of 9 candidates, totalling 36 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:    9.5s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   22.3s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  1.1min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  2.1min
[Parallel(n_jobs=4)]: Done  33 out of  36 | elapsed:  5.8min remaining:   31.8s
[Parallel(n_jobs=4)]: Done  36 out of  36 | elapsed:  6.6min finished
```

```
Out[68]: GridSearchCV(cv=4, error_score='raise-deprecating',
                estimator=LogisticRegression(C=1.0, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

```
In [69]: k=a
         auc_cv=clf.cv_results_['mean_test_score']
         auc_train=clf.cv_results_['mean_train_score']
         plt.plot(np.log(k),auc_cv)
         plt.plot(np.log(k),auc_train)
         plt.title('C vs AUC score')
         plt.xlabel('C of Logistic regression')
         plt.ylabel('auc score')
         plt.legend({"test":"","train":""})
```

```
Out[69]: <matplotlib.legend.Legend at 0x2681eecc978>
```



```
In [70]: print(clf.cv_results_['mean_test_score'])
         print(np.log(k))

[0.61549793 0.63605198 0.69201184 0.72625863 0.71027254 0.68017441
 0.6679054  0.66519146 0.66432133]
[-9.21034037 -6.90775528 -4.60517019 -2.30258509  0.          2.30258509
  4.60517019  6.90775528  9.21034037]
```

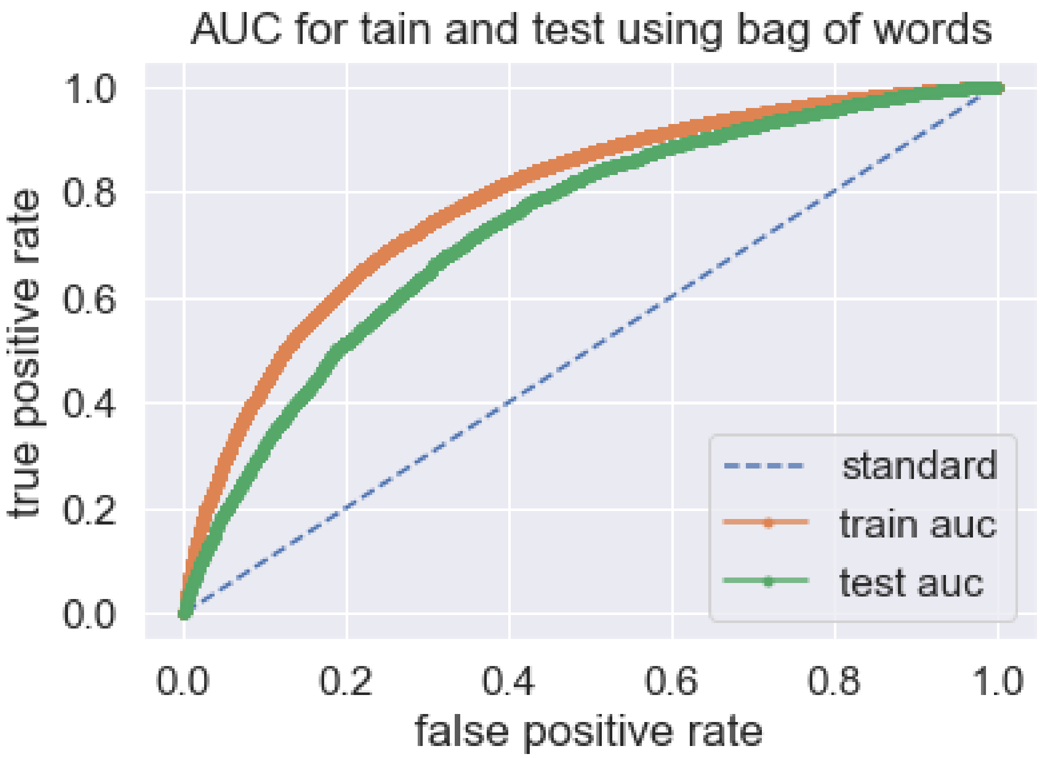
```
In [71]: print(np.exp(-2.30258509))

0.10000000029940456
```

10**-1 is the optimal value

```
In [72]: model=LogisticRegression(class_weight='balanced',C=10**-1,n_jobs=4)
         model.fit(TFIDF,project_data_Y_train)

Out[72]: LogisticRegression(C=0.1, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=4, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

```
In [73]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(TFIDF)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()
```

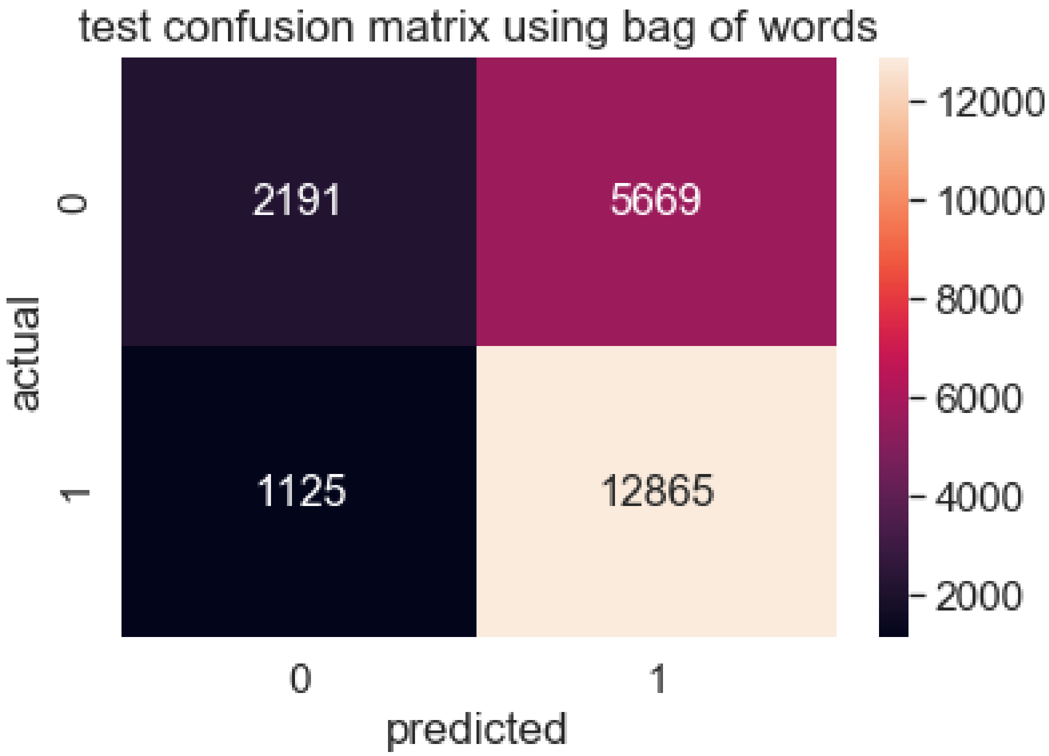
```
AUC: 0.735
AUC: 0.789
```



```
In [74]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(TFIDF_test)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_test,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("test confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

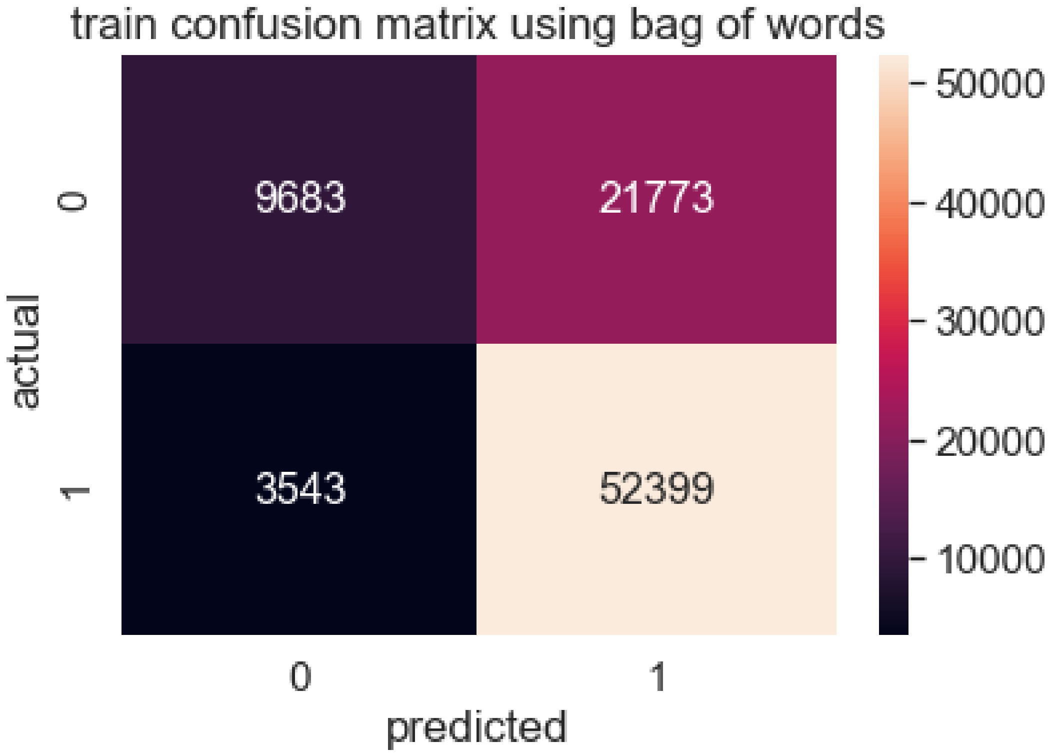
```
2191 1125 5669 12865
true positive rate 0.6941297075644761
true negaitive rate 0.6607358262967431
```

```
[[2191, 5669], [1125, 12865]]
```



```
In [75]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(TFIDF)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_train,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("train confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

```
9683 3543 21773 52399
true positive rate 0.7064525697028529
true negaitive rate 0.7321185543626191
[[9683, 21773], [3543, 52399]]
```



2.0.3 2.4.1 Applying LR on average word to vector, SET 3

```
In [76]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         AVG_W2V = hstack((categories_one_hot_train, sub_categories_one_hot_train,school_state_
         print(AVG_W2V.shape)
         AVG_W2V_test = hstack((categories_one_hot_test, sub_categories_one_hot_test,school_sta
         print(AVG_W2V_test.shape)
```

```
(87398, 697)
(21850, 697)
```

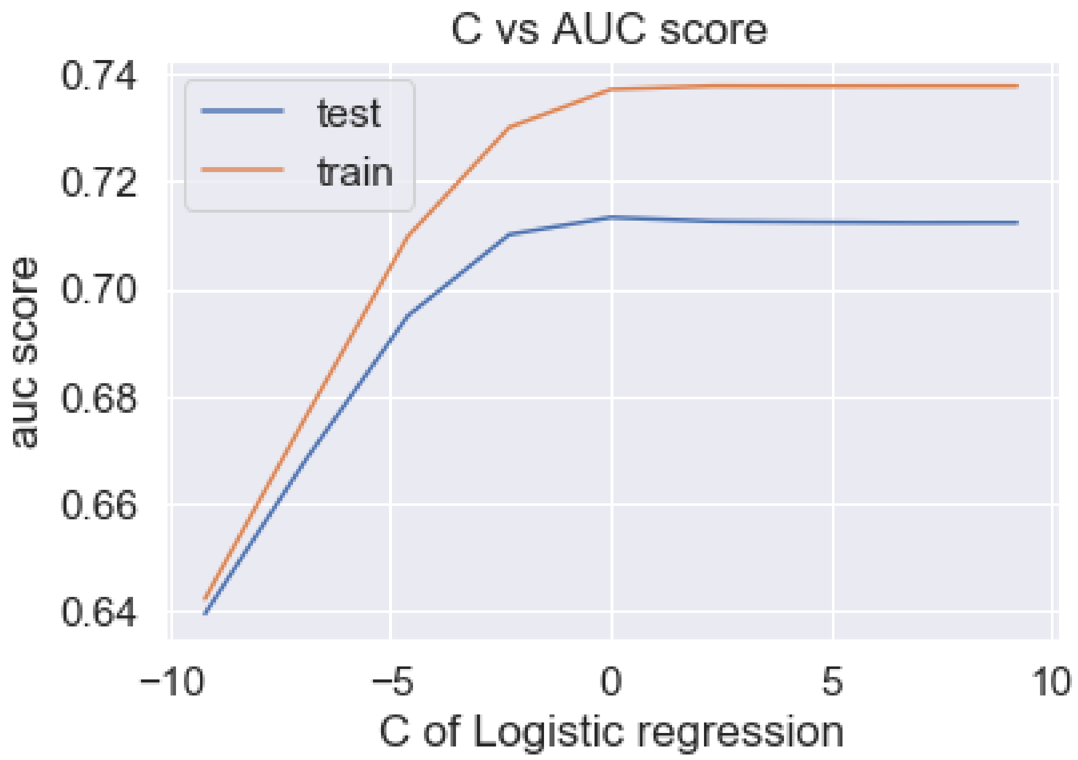
```
In [77]: from sklearn.linear_model import LogisticRegression
         from sklearn.model_selection import GridSearchCV
         model=LogisticRegression(class_weight='balanced')
         a=[10**-4,10**-3,10**-2,10**-1,10**0,10**1,10**2,10**3,10**4]
         print(a)
         parameters = {'C': a }
         clf = GridSearchCV(model, parameters, cv=4,scoring='roc_auc',n_jobs=4,verbose=10)
         clf.fit(AVG_W2V,project_data_Y_train)
```

```
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
Fitting 4 folds for each of 9 candidates, totalling 36 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   46.3s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:  1.6min
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  5.0min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  9.1min
[Parallel(n_jobs=4)]: Done  33 out of  36 | elapsed: 17.1min remaining:  1.6min
[Parallel(n_jobs=4)]: Done  36 out of  36 | elapsed: 18.0min finished
```

```
Out[77]: GridSearchCV(cv=4, error_score='raise-deprecating',
                estimator=LogisticRegression(C=1.0, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

```
In [78]: k=a
         auc_cv=clf.cv_results_['mean_test_score']
         auc_train=clf.cv_results_['mean_train_score']
         plt.plot(np.log(k),auc_cv)
         plt.plot(np.log(k),auc_train)
         plt.title('C vs AUC score')
         plt.xlabel('C of Logistic regression')
         plt.ylabel('auc score')
         plt.legend({"test":"","train":""})
```

```
Out[78]: <matplotlib.legend.Legend at 0x2680e01ed30>
```



```
In [79]: print(clf.cv_results_['mean_test_score'])
         print(np.log(k))
```

```
[0.63930371 0.66821107 0.6949272  0.71011909 0.71332398 0.71259163
 0.71243786 0.71233063 0.71234299]
[-9.21034037 -6.90775528 -4.60517019 -2.30258509  0.          2.30258509
  4.60517019  6.90775528  9.21034037]
```

```
In [80]: print(np.exp(0))
```

```
1.0
```

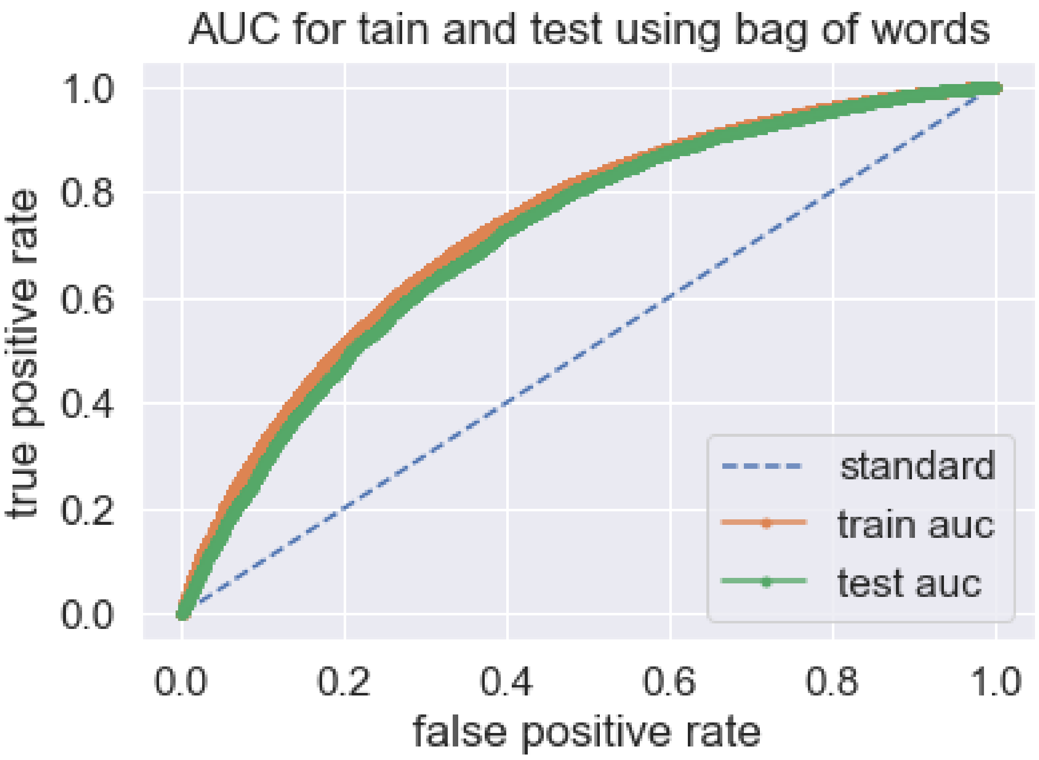
10**0 is the optimal value

```
In [81]: model=LogisticRegression(class_weight='balanced',C=1,n_jobs=4)
         model.fit(AVG_W2V,project_data_Y_train)
```

```
Out[81]: LogisticRegression(C=1, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=4, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

```
In [82]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(AVG_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(AVG_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()
```

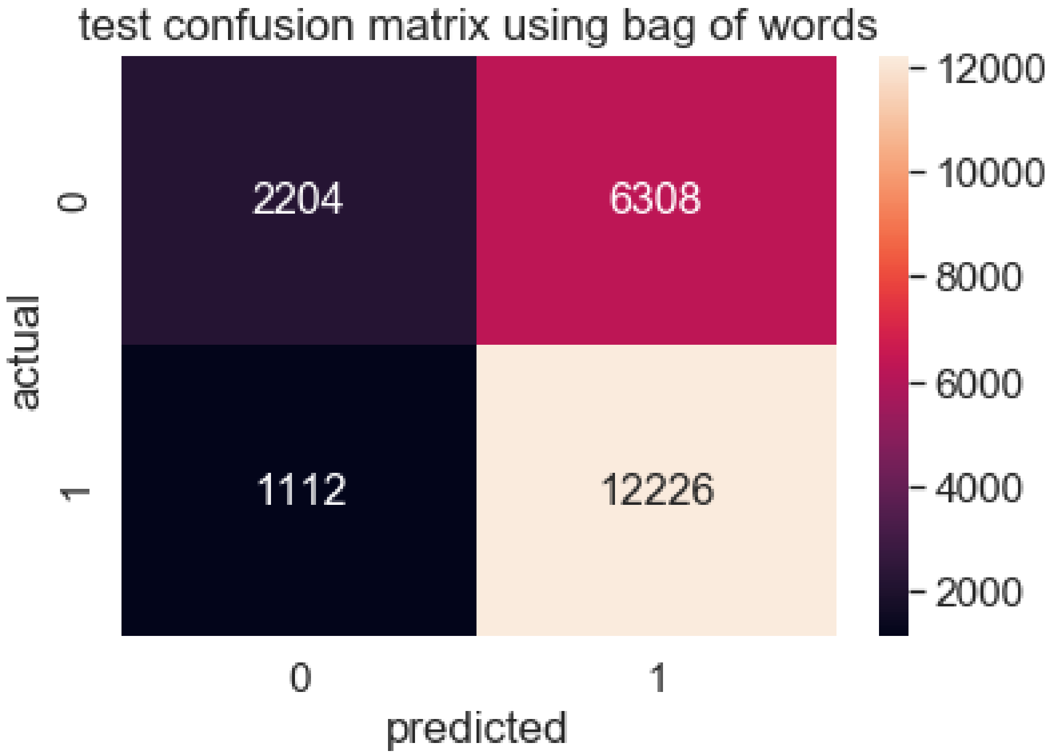
```
AUC: 0.718
AUC: 0.734
```



```
In [83]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(AVG_W2V_test)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_test,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("test confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

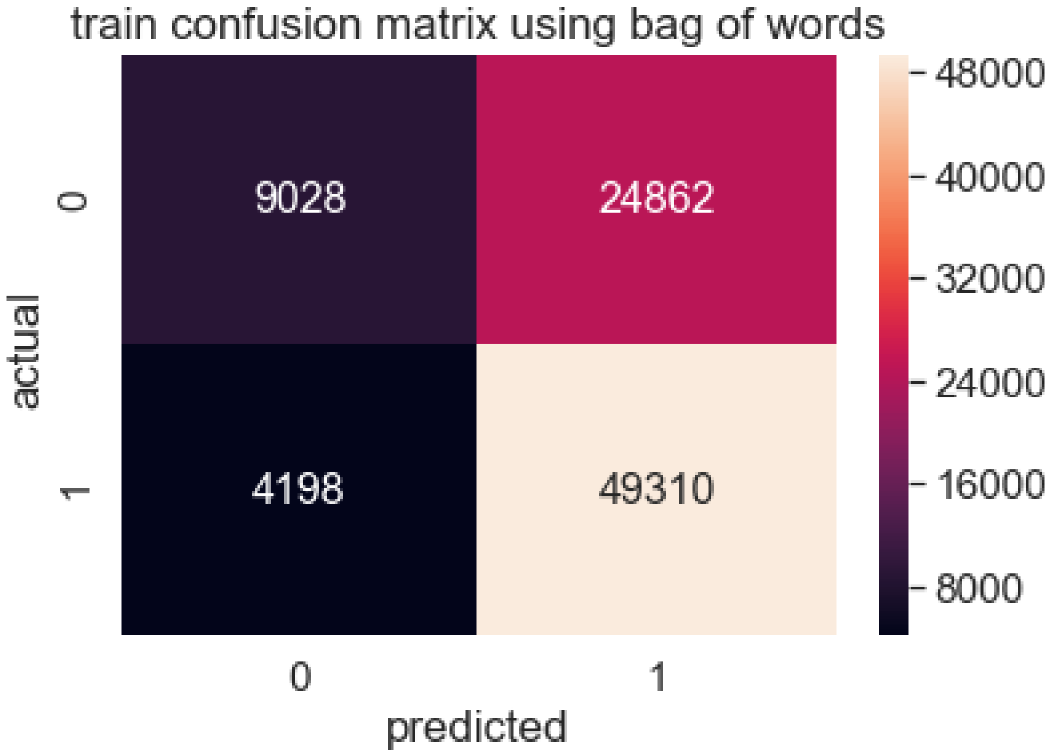
```
2204 1112 6308 12226
true positive rate 0.659652530484515
true negaitive rate 0.6646562123039808
```

```
[[2204, 6308], [1112, 12226]]
```



```
In [84]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(AVG_W2V)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_train,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("train confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

```
9028 4198 24862 49310
true positive rate 0.6648061263010301
true negaitive rate 0.6825948888552851
[[9028, 24862], [4198, 49310]]
```



2.0.4 2.4.1 Applying LR on tfidf word to vector, SET 4

```
In [85]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense matri
         TFIDF_W2V = hstack((categories_one_hot_train, sub_categories_one_hot_train,school_sta
         print(TFIDF_W2V.shape)
         TFIDF_W2V_test = hstack((categories_one_hot_test, sub_categories_one_hot_test,school_s
         print(TFIDF_W2V_test.shape)
```

```
(87398, 697)
(21850, 697)
```

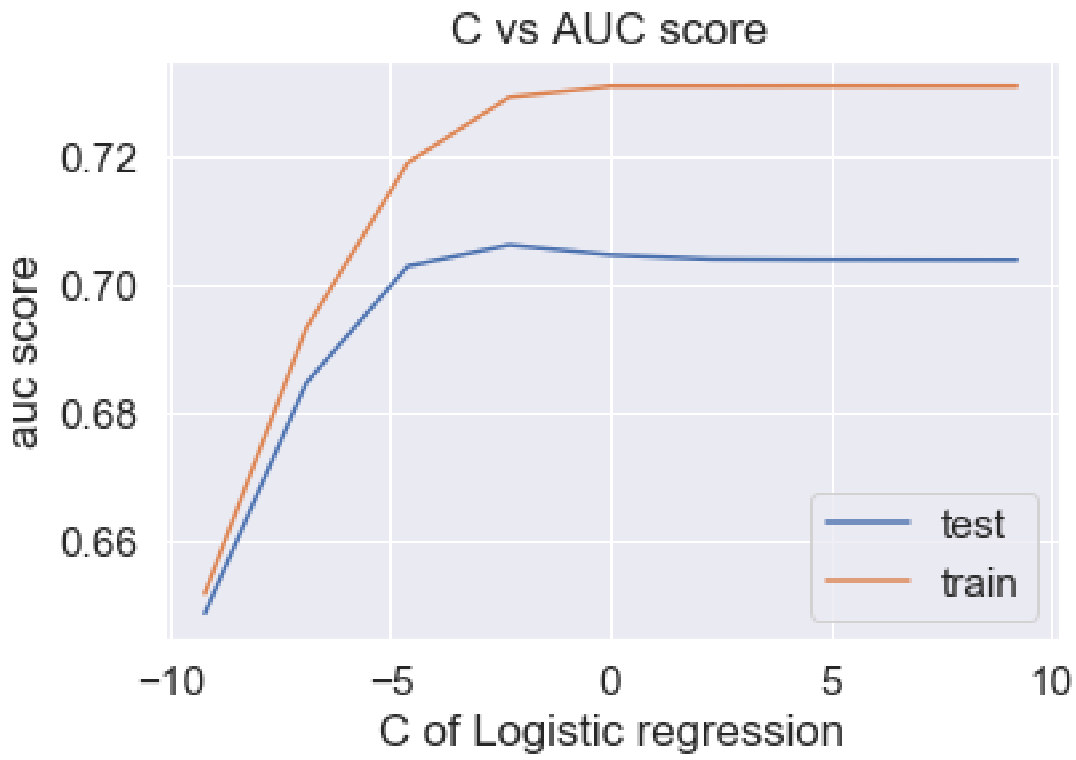
```
In [86]: from sklearn.linear_model import LogisticRegression
         from sklearn.model_selection import GridSearchCV
         model=LogisticRegression(class_weight='balanced')
         a=[10**-4,10**-3,10**-2,10**-1,10**0,10**1,10**2,10**3,10**4]
         print(a)
         parameters = {'C': a }
         clf = GridSearchCV(model, parameters, cv=4,scoring='roc_auc',n_jobs=4,verbose=10)
         clf.fit(TFIDF_W2V,project_data_Y_train)
```

```
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
Fitting 4 folds for each of 9 candidates, totalling 36 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   44.8s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:  1.5min
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  4.2min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  6.1min
[Parallel(n_jobs=4)]: Done  33 out of  36 | elapsed: 11.4min remaining:  1.0min
[Parallel(n_jobs=4)]: Done  36 out of  36 | elapsed: 11.9min finished
```

```
Out[86]: GridSearchCV(cv=4, error_score='raise-deprecating',
                estimator=LogisticRegression(C=1.0, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

```
In [87]: k=a
         auc_cv=clf.cv_results_['mean_test_score']
         auc_train=clf.cv_results_['mean_train_score']
         plt.plot(np.log(k),auc_cv)
         plt.plot(np.log(k),auc_train)
         plt.title('C vs AUC score')
         plt.xlabel('C of Logistic regression')
         plt.ylabel('auc score')
         plt.legend({"test":"","train":""})
```

```
Out[87]: <matplotlib.legend.Legend at 0x2682f66e9e8>
```



```
In [88]: print(clf.cv_results_['mean_test_score'])
         print(np.log(k))

[0.64873826 0.68464745 0.70284485 0.70616459 0.7046037  0.70394507
 0.70385525 0.70383068 0.70380748]
[-9.21034037 -6.90775528 -4.60517019 -2.30258509  0.          2.30258509
  4.60517019  6.90775528  9.21034037]
```

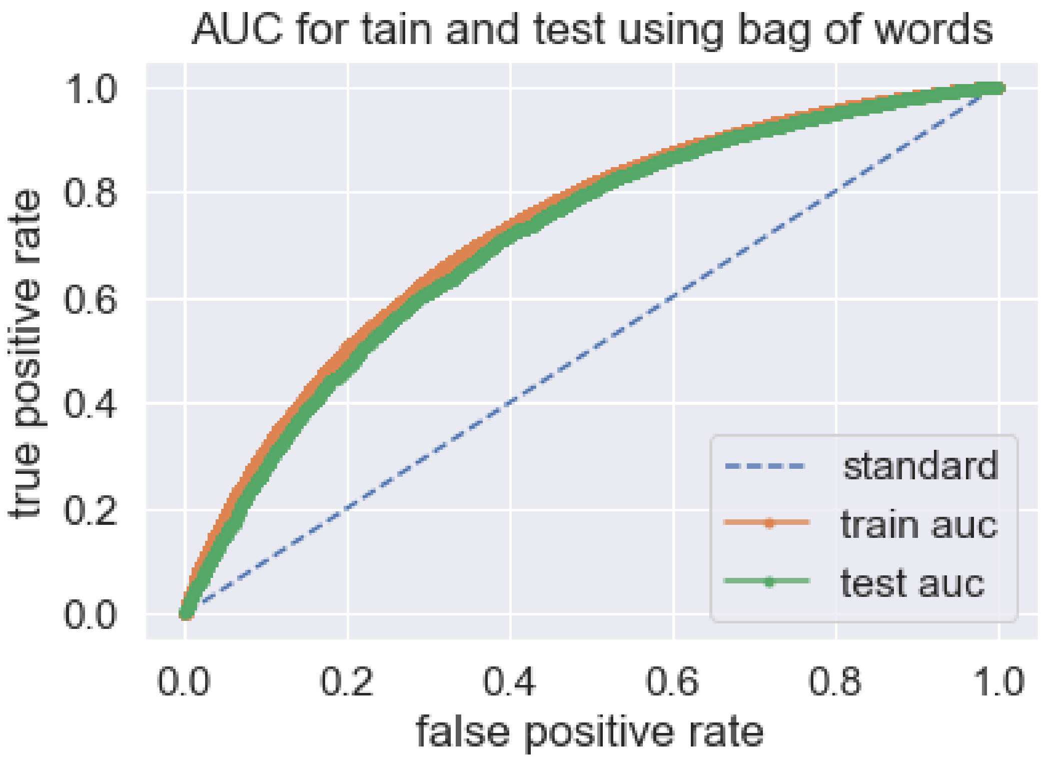
```
In [89]: print(np.exp(-2.30258509))

0.10000000029940456
```

10**-1 is the optimal value

```
In [90]: model=LogisticRegression(class_weight='balanced',C=10**-1,n_jobs=4)
         model.fit(TFIDF_W2V,project_data_Y_train)

Out[90]: LogisticRegression(C=0.1, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=4, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

```
In [91]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(TFIDF_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()
```

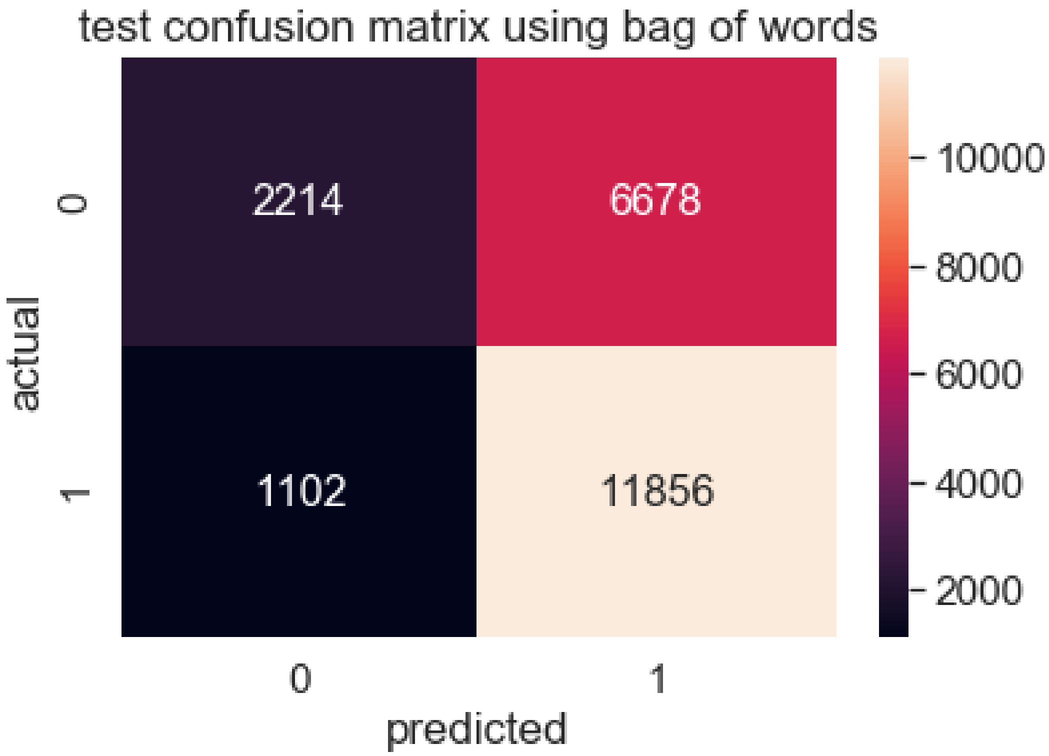
```
AUC: 0.711
AUC: 0.727
```



```
In [92]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(TFIDF_W2V_test)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_test,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("test confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

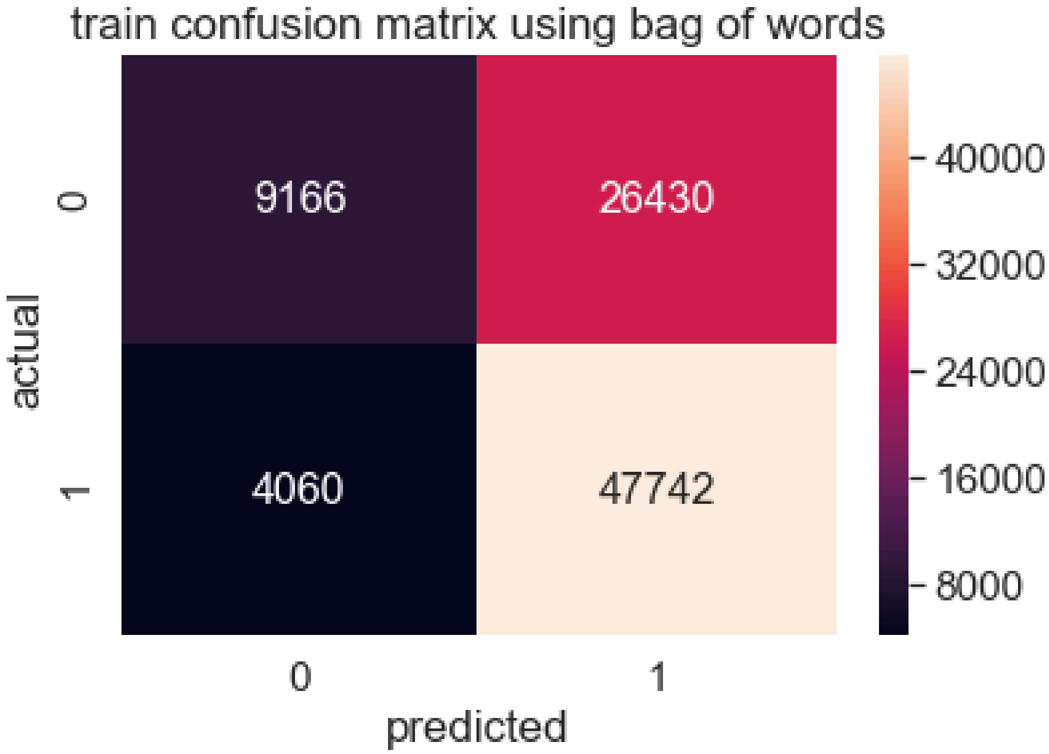
```
2214 1102 6678 11856
true positive rate 0.6396892198122369
true negaitive rate 0.6676718938480096
```

```
[[2214, 6678], [1102, 11856]]
```



```
In [93]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
         #compute confudion matrix values and plot
         from sklearn.metrics import confusion_matrix
         predicted_bow_test=model.predict(TFIDF_W2V)
         tn, fp, fn, tp = confusion_matrix(project_data_Y_train,predicted_bow_test).ravel()
         print(tn, fp, fn, tp)
         print("true positive rate",(tp/(tp+fn)))
         print("true negaitive rate",(tn/(tn+fp)))
         matrix=[[tn,fn],[fp,tp]]
         print(matrix)
         df_cm = pd.DataFrame(matrix, range(2),
                           range(2))
         #plt.figure(figsize = (10,7))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
         plt.title("train confusion matrix using bag of words")
         plt.xlabel("predicted")
         plt.ylabel("actual")
         plt.show()
```

```
9166 4060 26430 47742
true positive rate 0.6436660734508979
true negaitive rate 0.6930288825041585
[[9166, 26430], [4060, 47742]]
```



2.5 Logistic Regression with added Features Set 5

```
In [94]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         WITHOUT_WORDS = hstack((categories_one_hot_train, sub_categories_one_hot_train,school_
         print(WITHOUT_WORDS.shape)
         WITHOUT_WORDS_test= hstack((categories_one_hot_test, sub_categories_one_hot_test,schoo
         print(WITHOUT_WORDS_test.shape)
```

```
(87398, 101)
(21850, 101)
```

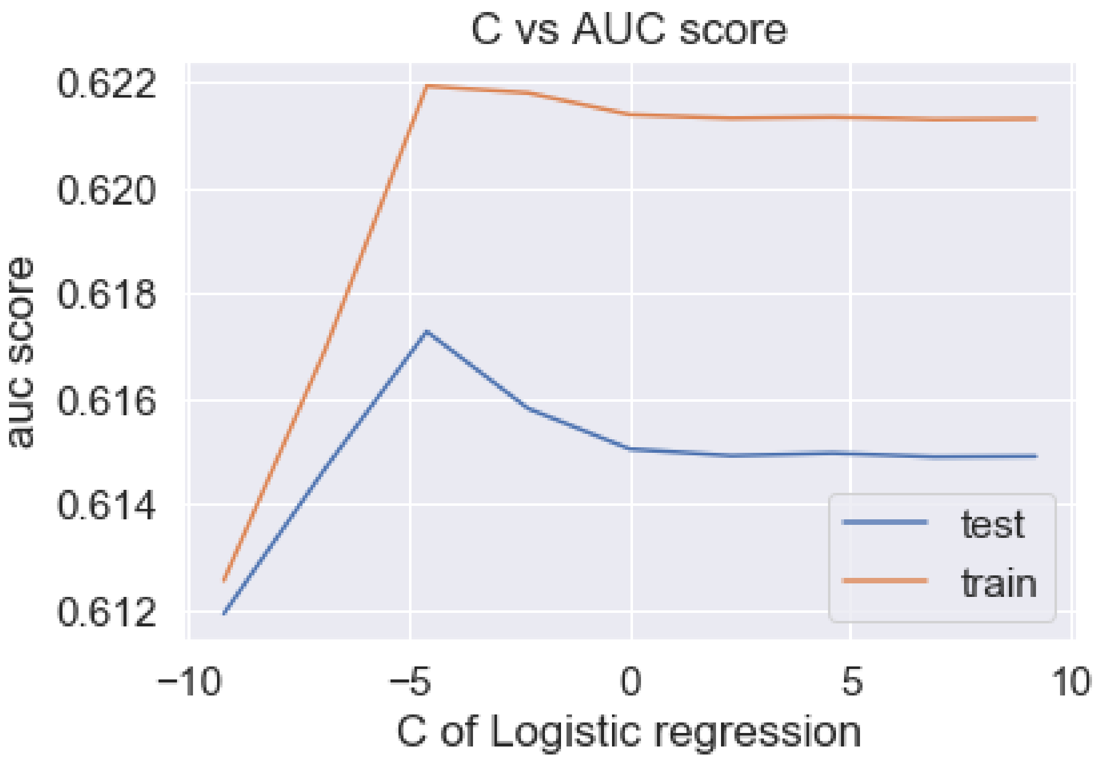
```
In [95]: from sklearn.linear_model import LogisticRegression
         from sklearn.model_selection import GridSearchCV
         model=LogisticRegression(class_weight='balanced')
         a=[10**-4,10**-3,10**-2,10**-1,10**0,10**1,10**2,10**3,10**4]
         print(a)
         parameters = {'C': a }
         clf = GridSearchCV(model, parameters, cv=4,scoring='roc_auc',n_jobs=4,verbose=10)
         clf.fit(WITHOUT_WORDS,project_data_Y_train)
```

```
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
Fitting 4 folds for each of 9 candidates, totalling 36 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:    1.5s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:    2.6s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:    5.6s
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:    7.7s
[Parallel(n_jobs=4)]: Done  33 out of  36 | elapsed:   11.8s remaining:    1.0s
[Parallel(n_jobs=4)]: Done  36 out of  36 | elapsed:   12.4s finished
```

```
Out[95]: GridSearchCV(cv=4, error_score='raise-deprecating',
                estimator=LogisticRegression(C=1.0, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

```
In [96]: k=a
         auc_cv=clf.cv_results_['mean_test_score']
         auc_train=clf.cv_results_['mean_train_score']
         plt.plot(np.log(k),auc_cv)
         plt.plot(np.log(k),auc_train)
         plt.title('C vs AUC score')
         plt.xlabel('C of Logistic regression')
         plt.ylabel('auc score')
         plt.legend({"test":"","train":""})
```

```
Out[96]: <matplotlib.legend.Legend at 0x268331089e8>
```



```
In [97]: print(clf.cv_results_['mean_test_score'])
         print(np.log(k))
```

```
[0.61191807 0.61467438 0.61727165 0.61580968 0.61504122 0.61491431
 0.61496344 0.61489287 0.61490382]
[-9.21034037 -6.90775528 -4.60517019 -2.30258509  0.          2.30258509
  4.60517019  6.90775528  9.21034037]
```

```
In [98]: print(np.exp(-4.60517019))
```

```
0.009999999959880915
```

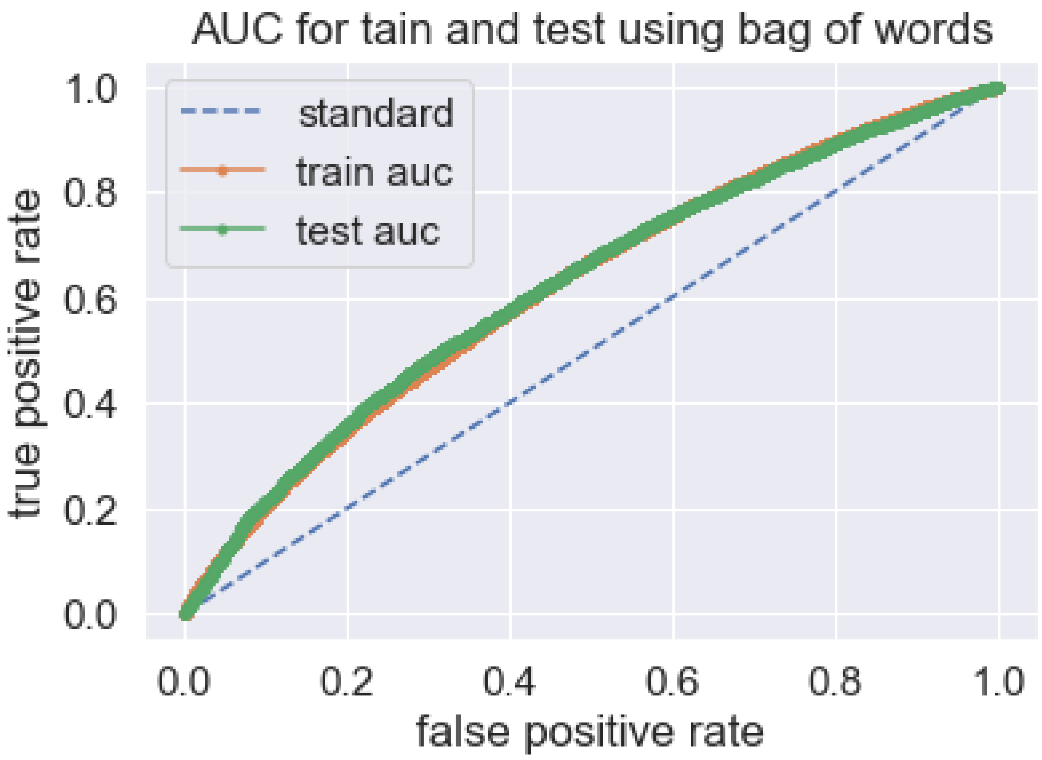
10**-1 is the optimal value

```
In [99]: model=LogisticRegression(class_weight='balanced',C=10**-2,n_jobs=4)
         model.fit(WITHOUT_WORDS,project_data_Y_train)
```

```
Out[99]: LogisticRegression(C=0.01, class_weight='balanced', dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='warn', n_jobs=4, penalty='l2', random_state=None,
                   solver='warn', tol=0.0001, verbose=0, warm_start=False)
```

```
In [100]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-class
          from sklearn.metrics import roc_curve
          from sklearn.metrics import roc_auc_score
          from tqdm import tqdm

          probs_test = model.predict_proba(WITHOUT_WORDS_test)
          # keep probabilities for the positive outcome only
          probs_test = probs_test[:, 1]
          auc_test = roc_auc_score(project_data_Y_test, probs_test)
          print('AUC: %.3f' % auc_test)
          fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

          probs_train = model.predict_proba(WITHOUT_WORDS)
          # keep probabilities for the positive outcome only
          probs_train = probs_train[:, 1]
          auc_train = roc_auc_score(project_data_Y_train, probs_train)
          print('AUC: %.3f' % auc_train)
          fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


          plt.plot([0, 1], [0, 1], linestyle='--')
          plt.plot(fpr1, tpr1, marker='.')
          plt.plot(fpr, tpr, marker='.')

          plt.legend({"standard":"","train auc":"","test auc":""})
          plt.title("AUC for tain and test using bag of words")
          plt.xlabel("false positive rate")
          plt.ylabel("true positive rate")
          plt.show()
```

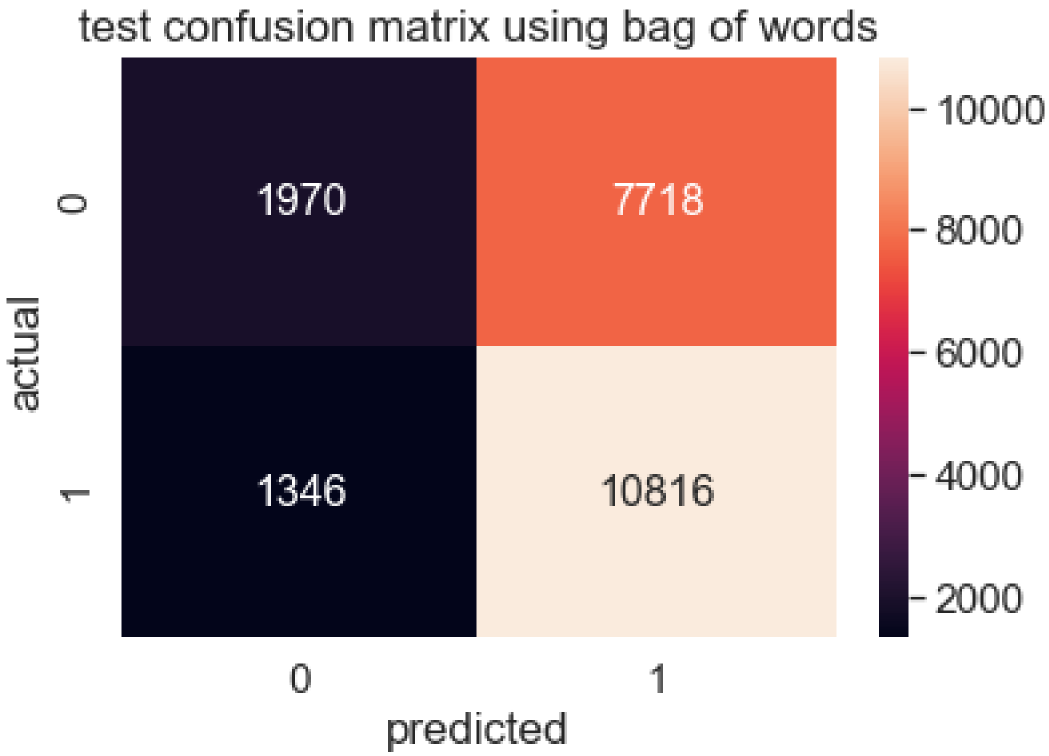
```
AUC: 0.624
AUC: 0.622
```



```
In [101]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
          #compute confudion matrix values and plot
          from sklearn.metrics import confusion_matrix
          predicted_bow_test=model.predict(WITHOUT_WORDS_test)
          tn, fp, fn, tp = confusion_matrix(project_data_Y_test,predicted_bow_test).ravel()
          print(tn, fp, fn, tp)
          print("true positive rate",(tp/(tp+fn)))
          print("true negaitive rate",(tn/(tn+fp)))
          matrix=[[tn,fn],[fp,tp]]
          print(matrix)
          df_cm = pd.DataFrame(matrix, range(2),
                            range(2))
          #plt.figure(figsize = (10,7))
          sns.set(font_scale=1.4)#for label size
          sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
          plt.title("test confusion matrix using bag of words")
          plt.xlabel("predicted")
          plt.ylabel("actual")
          plt.show()
```

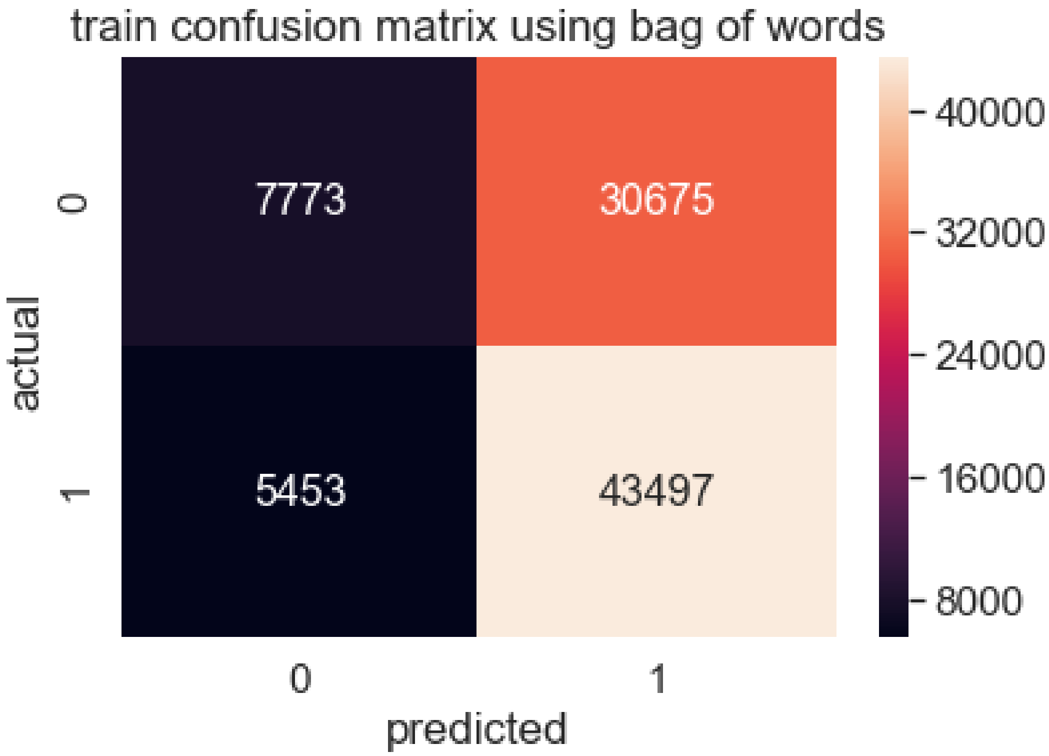
```
1970 1346 7718 10816
true positive rate 0.5835761303550232
true negaitive rate 0.5940892641737032
```

```
[[1970, 7718], [1346, 10816]]
```



```
In [102]: #https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
          #compute confudion matrix values and plot
          from sklearn.metrics import confusion_matrix
          predicted_bow_test=model.predict(WITHOUT_WORDS)
          tn, fp, fn, tp = confusion_matrix(project_data_Y_train,predicted_bow_test).ravel()
          print(tn, fp, fn, tp)
          print("true positive rate",(tp/(tp+fn)))
          print("true negaitive rate",(tn/(tn+fp)))
          matrix=[[tn,fn],[fp,tp]]
          print(matrix)
          df_cm = pd.DataFrame(matrix, range(2),
                            range(2))
          #plt.figure(figsize = (10,7))
          sns.set(font_scale=1.4)#for label size
          sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
          plt.title("train confusion matrix using bag of words")
          plt.xlabel("predicted")
          plt.ylabel("actual")
          plt.show()
```

```
7773 5453 30675 43497
true positive rate 0.5864342339427278
true negaitive rate 0.5877060335702404
[[7773, 30675], [5453, 43497]]
```



Wothout words the model is not performing well. The auc is 0.62 and the tpr and fpr are also not so good. Hence I reject this model

3. Conclusion

```
In [103]: from prettytable import PrettyTable
          x = PrettyTable()
          x.field_names = ["Vectorizer", "Model","alpha", "AUC"]
          x.add_row(["BAG of words", "Logistic regression",  10**-3,0.736])
          x.add_row(["TFIDF", "Logistic regression" , 10**-1,0.735])
          x.add_row(["Average W2V", "Logistic regression",  1,0.718])
          x.add_row(["TFIDF W2V", "Logistic regression" ,  10**-1,0.711])
          x.add_row(["Logistic Regression with added Features", "Logistic regression" , 10**-1
          x.border=True
          print(x)
```

```
+------------------------------------------+----------------------+-------+-------+
|                Vectorizer                |        Model         | alpha |  AUC  |
+-----------------------------------------+---------------------+-------+-------+
|               BAG of words              | Logistic regression | 0.001 | 0.736 |
|                  TFIDF                  | Logistic regression |  0.1  | 0.735 |
|               Average W2V               | Logistic regression |   1   | 0.718 |
|                TFIDF W2V                | Logistic regression |  0.1  | 0.711 |
| Logistic Regression with added Features | Logistic regression |  0.1  | 0.624 |
+-----------------------------------------+---------------------+-------+-------+
```