4_Naive_Bayes

August 30, 2019

1 Install and Import the libraries

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

import pandas as pd
import numpy as np
import nltk
import operator

import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.naive_bayes import MultinomialNB

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

from sklearn.preprocessing import  Normalizer

from sklearn import metrics
from sklearn.metrics import confusion_matrix,roc_curve, auc
from sklearn.metrics import roc_auc_score,accuracy_score
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV
from sklearn.model_selection import GridSearchCV


from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_validate

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/

from nltk.corpus import stopwords
```

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

        from tqdm import tqdm

        from collections import Counter
        from scipy.sparse import hstack

        #Code Reference: https://ptable.readthedocs.io/en/latest/tutorial.html
        from prettytable import PrettyTable
```

```
In [2]: # Read the data into Pandas Dataframe

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

```
In [3]: print('Number of data points in the  Train dataset :',project_data.shape[0])
        print("-"*53)
        print('Number of features in the Train dataset :',project_data.shape[1])
        print("-"*53)
        print("List of Features in the Train dataset:\n",project_data.columns.values.tolist())

Number of data points in the  Train dataset : 109248
-----------------------------------------------------
Number of features in the Train dataset : 17
-----------------------------------------------------
List of Features in the Train dataset:
 ['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state', 'project_submitted_datetim
```

```
In [4]: print('Number of data points in the  Resourse dataset :',resource_data.shape[0])
        print("-"*55)
        print('Number of features in the Resourse dataset :',resource_data.shape[1])
        print("-"*55)
        print("List of Features in the Resourse dataset:",resource_data.columns.values.tolist())

Number of data points in the  Resourse dataset : 1541272
-------------------------------------------------------
Number of features in the Resourse dataset : 4
-------------------------------------------------------
List of Features in the Resourse dataset: ['id', 'description', 'quantity', 'price']
```

```
In [5]: cols=['Date' if each_col=='project_submitted_datetime'
              else each_col for
              each_col in project_data.columns.values.tolist()]
```

```
        project_data['Date']=pd.to_datetime(project_data['project_submitted_datetime'])
        project_data.drop('project_submitted_datetime',axis=1,inplace=True)
        project_data.sort_values(by=['Date'],inplace=True)
```

In [6]:
```
project_data=project_data[cols]

print("Sample records from  Training data ")
project_data.head()
```

```
Sample records from  Training data
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_categories	project_subject_subcategories	project_title	project_essay_1	project_essay_2
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Math & Science	Applied Sciences, Health & Life Science	Engineering STEAM into the Primary Classroom	I have been fortunate enough to use the Fairy ...	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Special Needs	Special Needs	Sensory Tools for Focus	Imagine being 8-9 years old. You're in your th...	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Grades PreK-2	Literacy & Language	Literacy	Mobile Learning with a Mobile Listening Center	Having a class of 24 students comes with diver...	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	Applied Learning	Early Development	Flexible Seating for Flexible Learning	I recently read an article about giving studen...	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	Literacy & Language	Literacy	Going Deep: The Art of Inner Thinking!	My students crave challenge, they eat obstacle...	

```
55660  My students come from a variety of backgrounds...
76127  Most of my students have autism, anxiety, anot...
51140  I have a class of twenty-four kindergarten stu...
473    I teach at a low-income (Title 1) school. Ever...
41558  We are an urban, public k-5 elementary school...

                                          project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...
51140  By having a mobile listening and storage cente...
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...

                                          project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...
51140  A mobile listening center will help keep equip...
473    Benjamin Franklin once said, \"Tell me and I f...
41558  These remarkable gifts will provide students w...

                                 project_resource_summary  \
55660  My students need STEM kits to learn critical s...
76127  My students need Boogie Boards for quiet senso...
51140  My students need a mobile listening center to ...
473    My students need flexible seating in the class...
41558  My students need copies of the New York Times ...

       teacher_number_of_previously_posted_projects  project_is_approved
55660                                            53                   1
76127                                             4                   1
51140                                            10                   1
473                                               2                   1
41558                                             2                   1
```

In [7]:
```
print("Sample records from  Resourse data ")
resource_data.head()
```

```
Sample records from  Resourse data
```

Out[7]:
```
        id                                          description  quantity  \
0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
1  p069063        Bouncy Bands for Desks (Blue support pipes)         3
2  p069063  Cory Stories: A Kid's Book About Living With Adhd         1
3  p069063  Dixon Ticonderoga Wood-Cased #2 HB Pencils, Bo...         2
4  p069063  EDUCATIONAL INSIGHTS FLUORESCENT LIGHT FILTERS...         3

    price
```

```
0  149.00
1   14.95
2    8.45
3   13.59
4   24.95
```

2 Data Preprocessing

2.1 chek for null values

```
In [8]: print("Null values from Train data :\n")
        print(project_data.isnull().sum())
```

```
Null values from Train data :

Unnamed: 0                                      0
id                                              0
teacher_id                                      0
teacher_prefix                                  3
school_state                                    0
Date                                            0
project_grade_category                          0
project_subject_categories                      0
project_subject_subcategories                   0
project_title                                   0
project_essay_1                                 0
project_essay_2                                 0
project_essay_3                            105490
project_essay_4                            105490
project_resource_summary                        0
teacher_number_of_previously_posted_projects    0
project_is_approved                             0
dtype: int64
```

```
In [9]: project_data['teacher_prefix'].fillna(method='ffill',inplace=True)
```

```
In [10]: 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 [11]: project_data.drop(columns=['project_essay_1','project_essay_2',
                                   'project_essay_3','project_essay_4'],axis=1,inplace=True)
```

```
In [12]: project_data.isnull().sum()
```

```
Out[12]: Unnamed: 0                                      0
         id                                              0
```

```
teacher_id                                          0
teacher_prefix                                      0
school_state                                        0
Date                                                0
project_grade_category                              0
project_subject_categories                          0
project_subject_subcategories                       0
project_title                                       0
project_resource_summary                            0
teacher_number_of_previously_posted_projects        0
project_is_approved                                 0
essay                                               0
dtype: int64
```

```
In [13]: print("Null values from Train data :\n")
         print(resource_data.isnull().sum())
```

```
Null values from Train data :

id              0
description    292
quantity         0
price            0
dtype: int64
```

```
In [14]: resource_data['description'].fillna(method='ffill',inplace=True)
```

```
In [15]: resource_data.isnull().sum()
```

```
Out[15]: id             0
         description    0
         quantity       0
         price          0
         dtype: int64
```

2.2 Text Pre-processing

```
In [16]: def processed_list(list_elements):
             processed_list=[]
             for i in list_elements:
                 temp=''
                 for j in i.split(','):
                     if 'The' in j.split():
                         j=j.replace('The','')
                     j=j.replace(' ','')
                     temp+=j.strip()+' '
                     temp=temp.replace('&','_')
                 processed_list.append(temp.strip())
             return processed_list
```

```
In [17]: def get_sorted_dic(col):
             my_Counter=Counter()
             for word in list(project_data[col]):
                 my_Counter.update(word.split())
             count_dict=dict(my_Counter)
             return dict(sorted(count_dict.items(),key=lambda x: x[1]))
```

2.2.1 project_subject_categories

```
In [18]: clean_categories=processed_list(list(project_data['project_subject_categories']))
         project_data['clean_categories']=clean_categories
         project_data.drop(['project_subject_categories'],axis=1,inplace=True)
         sorted_cat_dict=get_sorted_dic('clean_categories')
```

2.2.2 project_subject_subcategories

```
In [19]: clean_sub_categories=processed_list(list(project_data['project_subject_subcategories']))
         project_data['clean_sub_categories']=clean_sub_categories
         project_data.drop(['project_subject_subcategories'],axis=1,inplace=True)
         sorted_subcat_dict=get_sorted_dic('clean_sub_categories')
```

2.2.3 essay

```
In [20]: 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 [21]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're
                     "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him',
                     'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 't
                     'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "th
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'ha
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as'
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through'
```

```
                    'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'ov
                    'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any
                    'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too'
                    's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'no
                    've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't",
                    "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'migh
                    "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'w
                    'won', "won't", 'wouldn', "wouldn't"]
```

```
In [22]: def text_processing(dataset,feature_name):
             processed_text = []
             # tqdm is for printing the status bar
             for sentance in tqdm(dataset[feature_name].values):
                 sent = decontracted(sentance)
                 sent = sent.replace('\\r', ' ')
                 sent = sent.replace('\\"', ' ')
                 sent = sent.replace('\\n', ' ')
                 sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
                 sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
                 processed_text.append(sent.lower().strip())
             return processed_text
```

```
In [23]: project_data['essay']=text_processing(project_data,'essay')
```

```
100%|| 109248/109248 [01:10<00:00, 1551.40it/s]
```

2.2.4 project_title

```
In [24]: project_data['project_title']=text_processing(project_data,'project_title')
```

```
100%|| 109248/109248 [00:03<00:00, 34155.85it/s]
```

2.2.5 project_resource_summary

```
In [25]: project_data['project_resource_summary']=text_processing(project_data,'project_resource
```

```
100%|| 109248/109248 [00:07<00:00, 14418.52it/s]
```

2.2.6 project_grade_category

```
In [26]: processed_grade=[]

         for each_grade in tqdm(project_data['project_grade_category'].values):
             temp=""
             temp=each_grade.lower()
             temp=temp.replace(' ','_')
```

```
            temp=temp.replace('-','_')
            processed_grade.append(temp)

        project_data['project_grade_category']=processed_grade
```

```
100%|| 109248/109248 [00:00<00:00, 946530.75it/s]
```

In [27]:
```
# Merge the projectdata and pricedata by using id feature

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

In [28]:
```
print("Final Feature Names:\n\n", list(project_data.columns))
        print("\nSample Data set")
        project_data.head()
```

```
Final Feature Names:

 ['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state', 'Date', 'project_grade_cat

Sample Data set
```

Out[28]:

	Unnamed: 0	id	teacher_id	teacher_prefix	\
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
2	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
3	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
4	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

	school_state	Date	project_grade_category	\
0	CA	2016-04-27 00:27:36	grades_prek_2	
1	UT	2016-04-27 00:31:25	grades_3_5	
2	CA	2016-04-27 00:46:53	grades_prek_2	
3	GA	2016-04-27 00:53:00	grades_prek_2	
4	WA	2016-04-27 01:05:25	grades_3_5	

	project_title	\
0	engineering steam primary classroom	
1	sensory tools focus	
2	mobile learning mobile listening center	
3	flexible seating flexible learning	
4	going deep art inner thinking	

	project_resource_summary	\
0	students need stem kits learn critical science...	
1	students need boogie boards quiet sensory brea...	
2	students need mobile listening center able enh...	

```
3  students need flexible seating classroom choos...
4  students need copies new york times best selle...

   teacher_number_of_previously_posted_projects  project_is_approved  \
0                                            53                   1
1                                             4                   1
2                                            10                   1
3                                             2                   1
4                                             2                   1

                                               essay   clean_categories  \
0  fortunate enough use fairy tale stem kits clas...       Math_Science
1  imagine 8 9 years old third grade classroom se...       SpecialNeeds
2  class 24 students comes diverse learners stude...  Literacy_Language
3  recently read article giving students choice l...    AppliedLearning
4  students crave challenge eat obstacles breakfa...  Literacy_Language

                clean_sub_categories   price  quantity
0  AppliedSciences Health_LifeScience  725.05         4
1                        SpecialNeeds  213.03         8
2                            Literacy  329.00         1
3                   EarlyDevelopment  481.04         9
4                            Literacy   17.74        14
```

In [29]:
```
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
project_data.head(3)
```

Out[29]:
```
   Unnamed: 0       id                         teacher_id teacher_prefix  \
0        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.
1       37728  p043609  3f60494c61921b3b43ab61bdde2904df            Ms.
2       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           Mrs.

  school_state                Date project_grade_category  \
0           CA 2016-04-27 00:27:36          grades_prek_2
1           UT 2016-04-27 00:31:25             grades_3_5
2           CA 2016-04-27 00:46:53          grades_prek_2

                            project_title  \
0     engineering steam primary classroom
1                     sensory tools focus
2  mobile learning mobile listening center

                           project_resource_summary  \
0  students need stem kits learn critical science...
1  students need boogie boards quiet sensory brea...
2  students need mobile listening center able enh...
```

```
   teacher_number_of_previously_posted_projects  \
0                                            53
1                                             4
2                                            10

                                               essay   clean_categories  \
0  fortunate enough use fairy tale stem kits clas...       Math_Science
1  imagine 8 9 years old third grade classroom se...       SpecialNeeds
2  class 24 students comes diverse learners stude...  Literacy_Language

                clean_sub_categories   price  quantity
0  AppliedSciences Health_LifeScience  725.05         4
1                        SpecialNeeds  213.03         8
2                            Literacy  329.00         1
```

```
In [30]: X_train, X_test, y_train, y_test = train_test_split(project_data, y, test_size=0.30, st
```

```
In [31]: print("Training data set shape:",X_train.shape)
         print("Test data set shape:",X_test.shape)
```

```
Training data set shape: (76473, 15)
Test data set shape: (32775, 15)
```

2.3 Feature Vectorization

```
In [32]: features=tuple()
```

2.3.1 teacher_prefix

```
In [33]: vectorizer=CountVectorizer()
         vectorizer.fit(X_train.teacher_prefix.values)
         X_tr_teacher_onehot=vectorizer.transform(X_train.teacher_prefix.values)
         X_te_teacher_onehot=vectorizer.transform(X_test.teacher_prefix.values)

         features=list(vectorizer.get_feature_names())
```

2.3.2 school_state

```
In [34]: vectorizer=CountVectorizer()
         vectorizer.fit(X_train.school_state.values)
         X_tr_school_onehot=vectorizer.transform(X_train.school_state.values)
         X_te_school_onehot=vectorizer.transform(X_test.school_state.values)

         features=features+(list(vectorizer.get_feature_names()))
```

2.3.3 project_grade_category

```
In [35]: vectorizer=CountVectorizer()
         vectorizer.fit(X_train.project_grade_category.values)
```

```
X_tr_grade_onehot=vectorizer.transform(X_train.project_grade_category.values)
X_te_grade_onehot=vectorizer.transform(X_test.project_grade_category.values)

features=features+(list(vectorizer.get_feature_names()))
```

2.3.4 clean_categories

```
In [36]: vectorizer=CountVectorizer()
         vectorizer.fit(X_train.clean_categories.values)
         X_tr_cat_onehot=vectorizer.transform(X_train.clean_categories.values)
         X_te_cat_onehot=vectorizer.transform(X_test.clean_categories.values)

         features=features+(list(vectorizer.get_feature_names()))
```

2.3.5 clean_sub_categories

```
In [37]: vectorizer=CountVectorizer()
         vectorizer.fit(X_train.clean_sub_categories.values)
         X_tr_sub_cat_onehot=vectorizer.transform(X_train.clean_sub_categories.values)
         X_te_sub_cat_onehot=vectorizer.transform(X_test.clean_sub_categories.values)

         features=features+(list(vectorizer.get_feature_names()))
```

2.4 Normalization

2.4.1 price

```
In [38]: nrml= Normalizer()
         nrml.fit(X_train['price'].values.reshape(1,-1))

         X_tr_price_nrml = nrml.transform(X_train.price.values.reshape(1,-1)).reshape(-1,1)
         X_te_price_nrml = nrml.transform(X_test.price.values.reshape(1,-1)).reshape(-1,1)

         features = list(features)
         features.append('price')
```

2.4.2 teacher_number_of_previously_posted_projects

```
In [39]: nrml = Normalizer()
         nrml.fit(X_train.teacher_number_of_previously_posted_projects.values.reshape(1,-1))
         X_tr_teacher_number_nrml = nrml.transform(X_train.teacher_number_of_previously_posted_p
         X_te_teacher_number_nrml = nrml.transform(X_test.teacher_number_of_previously_posted_pr

         features=list(features)
         features.append('teacher_number_of_previously_posted_projects')
```

```
In [40]: X_tr_vec=hstack((X_tr_teacher_onehot,X_tr_school_onehot,X_tr_grade_onehot,X_tr_cat_oneh
                         X_tr_sub_cat_onehot,X_tr_price_nrml,X_tr_teacher_number_nrml)).tocsr()
```

```
        X_te_vec=hstack((X_te_teacher_onehot,X_te_school_onehot,X_te_grade_onehot,X_te_cat_oneh
                         X_te_price_nrml,X_te_teacher_number_nrml)).tocsr()
```

In [41]:
```
print("After stacking :")
print("Training data set shape :",X_tr_vec.shape)
print("Test data set shape :",X_te_vec.shape)
```

```
After stacking :
Training data set shape : (76473, 101)
Test data set shape : (32775, 101)
```

3 Model Training

3.1 Hypertuning Values

In [42]:
```
alpha_vals=[10**i for i in range(-5,5)]
```

In [43]:
```
def grid_search_plot(model,hyper_param,hyper_values,X_train,y_train):

    hyper_param={str(hyper_param):hyper_values}
    clf = GridSearchCV(model, hyper_param, cv=7, scoring='roc_auc',return_train_score=T
    clf.fit(X_train, y_train)

    train_auc= clf.cv_results_['mean_train_score']
    train_auc_std= clf.cv_results_['std_train_score']
    cv_auc = clf.cv_results_['mean_test_score']
    cv_auc_std= clf.cv_results_['std_test_score']

    hyper_values=np.log10(hyper_values)

    plt.plot(hyper_values, train_auc, label='Train AUC')
    plt.scatter(hyper_values,train_auc)
    # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
    plt.gca().fill_between(hyper_values,train_auc - train_auc_std,train_auc + train_auc

    plt.plot(hyper_values, cv_auc, label='CV AUC')
    plt.scatter(hyper_values,cv_auc)
    # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
    plt.gca().fill_between(hyper_values,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0
    plt.legend()
    plt.xlabel("Hyper parameters with base(log10)")
    plt.ylabel("AUC")
    plt.title("AUC PLOT for Train and CV datasets")
    plt.show()

    del train_auc
    del train_auc_std
```

```
            del cv_auc
            del cv_auc_std
```

In [44]:
```
def build_best_model_plot_roc(model,X_train_data,y_train_data,X_test_data,y_test_data):


    model.fit(X_train_data,y_train_data)

    y_tr_pred_prob=model.predict_proba(X_train_data)
    y_te_pred_prob=model.predict_proba(X_test_data)

    y_te_pred=model.predict(X_test_data)
    y_tr_pred=model.predict(X_train_data)

    plot_roc([y_train_data,y_tr_pred_prob[:,1]],[y_test_data,y_te_pred_prob[:,1]])

    plot_confusion_matrix(y_train_data,y_tr_pred,"Train")
    plot_confusion_matrix(y_test_data,y_te_pred,"Test")
```

In [45]:
```
def plot_roc(y_train,y_test):

    print("ROC Curve for Train and Test Data")

    fpr_tr,tpr_tr,thr_tr=roc_curve(y_train[0],y_train[1])
    fpr_te,tpr_te,thr_te=roc_curve(y_test[0],y_test[1])

    plt.plot(fpr_tr,tpr_tr,label="AUC score for Train data is : {}".format(np.round(auc
    plt.plot(fpr_te,tpr_te,label="AUC score is Test data is  : {}".format(np.round(auc(

    plt.plot([0,1],[0,1],'k--',label="Random Curve AUC score is :{}".format(0.5))

    plt.title("ROC Curve for Train and Test data")
    plt.legend()
    plt.xlabel("False Positive Rate")
    plt.ylabel("True Positive Rate")
    plt.show()
```

In [46]:
```
def plot_confusion_matrix(y_true,y_pred,set_name):

    print("Confusion Matrix for {}".format(set_name))
    sns.heatmap(confusion_matrix(y_true,y_pred), annot=True, fmt="d")
    plt.title("Confusion Matrix")
    plt.xlabel("Predicted labels")
    plt.ylabel("Actual labels")
    plt.show()
```

In [47]:
```
def plot_top_n_features(model,X_train,y_train,top_no_features,feature_set):
```

```
model.fit(X_train,y_train)

feature_imp=dict()
for i,j in zip(feature_set,model.coef_.flatten()):
    feature_imp[i]=j

sorted_feature_imp=sorted(feature_imp.items(),key=lambda x: x[1],reverse=True)[:top

print("Top {} Features :".format(top_no_features))

#print the Feature Important table
count=1
fea_imp_table = PrettyTable()
fea_imp_table.hrules=True
fea_imp_table.field_names = ["Feature Priority","Feature Name","Feature Imp Value"]
for name,value in sorted_feature_imp:
    fea_imp_table.add_row([count,name,np.round(value,4)])
    count=count+1
print(fea_imp_table)

plt.barh([i[0] for i in sorted_feature_imp][::-1] ,[i[1] for i in sorted_feature_im
plt.title("Plot for Top {} Features".format(top_no_features))
plt.show()

del feature_imp
del sorted_feature_imp
```

3.2 Bag of words

3.2.1 project_title

```
In [48]: bog_features=tuple(features)
```

```
In [49]: vectorizer=CountVectorizer(ngram_range=(1,1),min_df=5)
         vectorizer.fit(X_train.project_title.values)
         X_tr_title=vectorizer.transform(X_train.project_title.values)
         X_te_title=vectorizer.transform(X_test.project_title.values)


         bog_features=bog_features+(tuple(vectorizer.get_feature_names()))
```

3.2.2 essay

```
In [50]: vectorizer=CountVectorizer(ngram_range=(1,1),min_df=5)
         vectorizer.fit(X_train.essay.values)
         X_tr_essay=vectorizer.transform(X_train.essay.values)
         X_te_essay=vectorizer.transform(X_test.essay.values)

         bog_features=bog_features+(tuple(vectorizer.get_feature_names()))
```

3.2.3 project_resource_summary

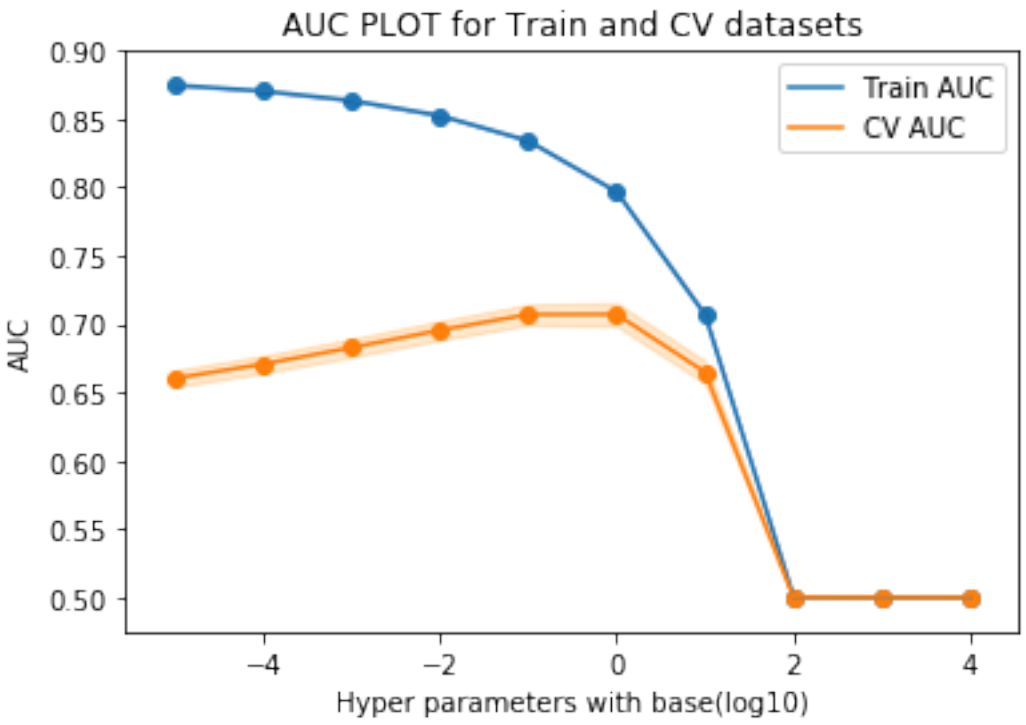
```
In [51]: vectorizer=CountVectorizer(ngram_range=(1,1),min_df=5)
         vectorizer.fit(X_train.project_resource_summary.values)
         X_tr_resource=vectorizer.transform(X_train.project_resource_summary.values)
         X_te_resource=vectorizer.transform(X_test.project_resource_summary.values)

         bog_features=bog_features+(tuple(vectorizer.get_feature_names()))

In [52]: X_train_bow=hstack((X_tr_vec,X_tr_title,X_tr_essay,X_tr_resource)).tocsr()
         X_test_bow=hstack((X_te_vec,X_te_title,X_te_essay,X_te_resource)).tocsr()

In [53]: #code ref:https://stackoverflow.com/questions/10335090/numpy-replace-negative-values-in
         X_train_bow[X_train_bow<0]=0

In [54]: print("Bag of words:")
         print("Training data set shape :",X_train_bow.shape)
         print("Test data set shape :",X_test_bow.shape)
```

```
Bag of words:
Training data set shape : (76473, 30433)
Test data set shape : (32775, 30433)
```

```
In [55]: # Release the memory
         del X_tr_title
         del X_te_title

         del X_tr_resource
         del X_te_resource

         del X_tr_essay
         del X_te_essay

In [56]: print("Hyper Param Values:",alpha_vals)
```

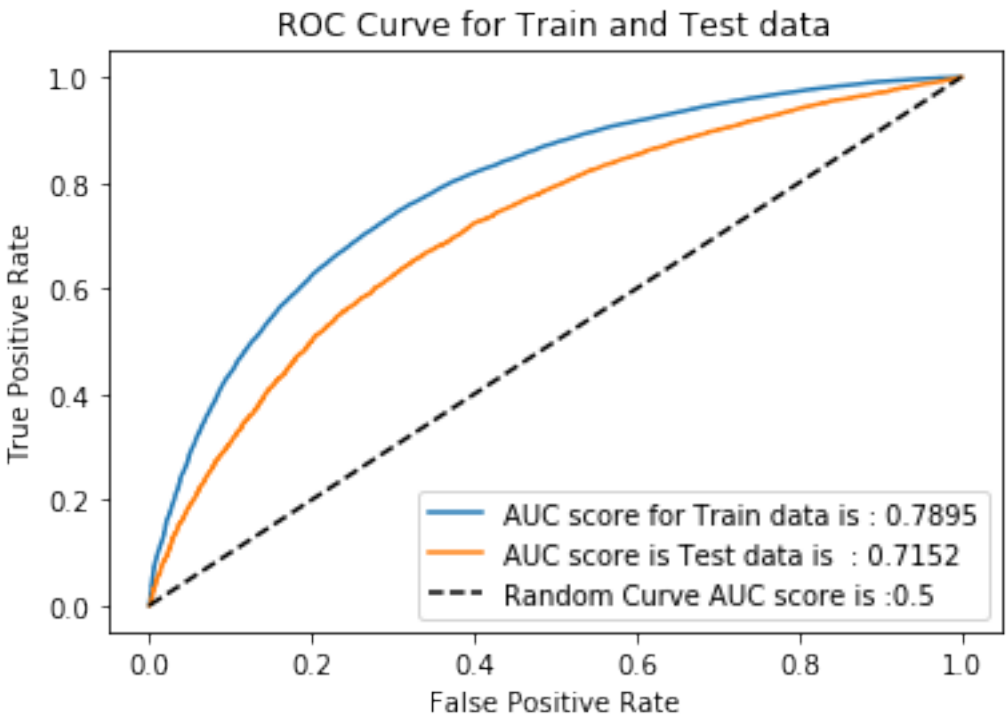
```
Hyper Param Values: [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
```

```
In [57]: grid_search_plot(MultinomialNB(class_prior=[0.5,0.5]),'alpha',alpha_vals,X_train_bow,y_
```

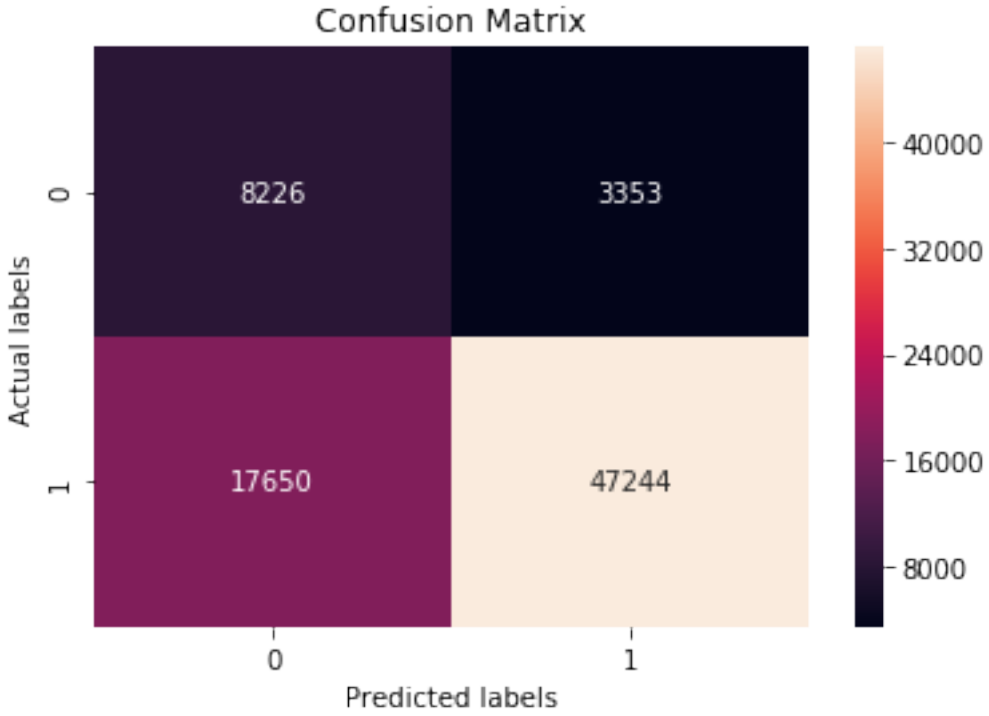



```
In [58]: best_model=MultinomialNB(alpha=10**0,class_prior=[0.5,0.5])

In [59]: build_best_model_plot_roc(best_model,X_train_bow,y_train,X_test_bow,y_test)
```

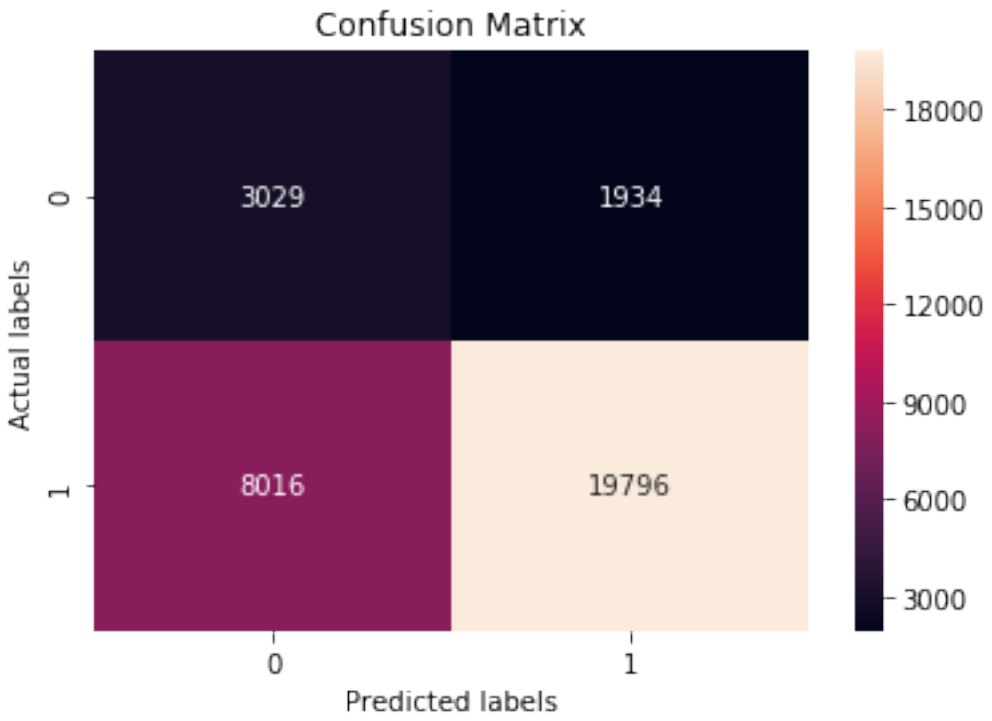
ROC Curve for Train and Test Data



Confusion Matrix for Train



Confusion Matrix for Test

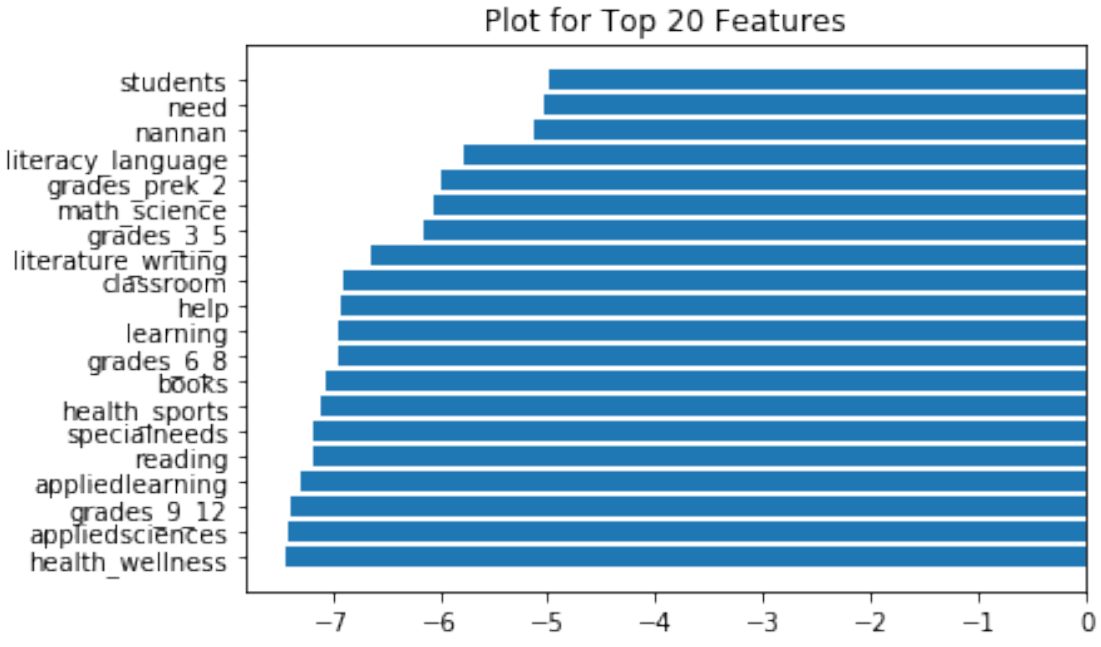


In [60]: plot_top_n_features(best_model,X_train_bow,y_train,20,bog_features)

Top 20 Features :

Feature Priority	Feature Name	Feature Imp Value
1	students	-4.9888
2	need	-5.0259
3	nannan	-5.1211
4	literacy_language	-5.7897
5	grades_prek_2	-5.9809
6	math_science	-6.0569

7	grades_3_5	-6.1472
8	literature_writing	-6.6475
9	classroom	-6.8891
10	help	-6.9239
11	learning	-6.9404
12	grades_6_8	-6.9455
13	books	-7.0682
14	health_sports	-7.1146
15	specialneeds	-7.1736
16	reading	-7.1801
17	appliedlearning	-7.2959
18	grades_9_12	-7.3879
19	appliedsciences	-7.4144
20	health_wellness	-7.4272



3.3 TF-IDF

```
In [61]: tfidf_features=tuple(features)
```

3.3.1 essay

```
In [62]: tf_idf_vectorizer=TfidfVectorizer(ngram_range=(1,1),min_df=5)
         tf_idf_vectorizer.fit(X_train.essay.values)
         X_tr_essay=tf_idf_vectorizer.transform(X_train.essay.values)
         X_te_essay=tf_idf_vectorizer.transform(X_test.essay.values)


         tfidf_features=tfidf_features+(tuple(tf_idf_vectorizer.get_feature_names()))
```

3.3.2 project_title

```
In [63]: tf_idf_vectorizer=TfidfVectorizer(ngram_range=(1,1),min_df=5)
         tf_idf_vectorizer.fit(X_train.project_title.values)
         X_tr_title=tf_idf_vectorizer.transform(X_train.project_title.values)
         X_te_title=tf_idf_vectorizer.transform(X_test.project_title.values)

         tfidf_features=tfidf_features+(tuple(tf_idf_vectorizer.get_feature_names()))
```

3.3.3 project_resource_summary

```
In [64]: tf_idf_vectorizer=TfidfVectorizer(ngram_range=(1,1),min_df=5)
         tf_idf_vectorizer.fit(X_train.project_resource_summary.values)
         X_tr_resource=tf_idf_vectorizer.transform(X_train.project_resource_summary.values)
         X_te_resource=tf_idf_vectorizer.transform(X_test.project_resource_summary.values)

         tfidf_features=tfidf_features+(tuple(tf_idf_vectorizer.get_feature_names()))
```

```
In [65]: X_train_tfidf=hstack((X_tr_vec,X_tr_essay,X_tr_title,X_tr_resource)).tocsr()
         X_test_tfidf=hstack((X_te_vec,X_te_essay,X_te_title,X_te_resource)).tocsr()
```

```
In [66]: print("TF-IDF:")
         print("Training data set shape :",X_train_tfidf.shape)
         print("Test data set shape :",X_test_tfidf.shape)
```

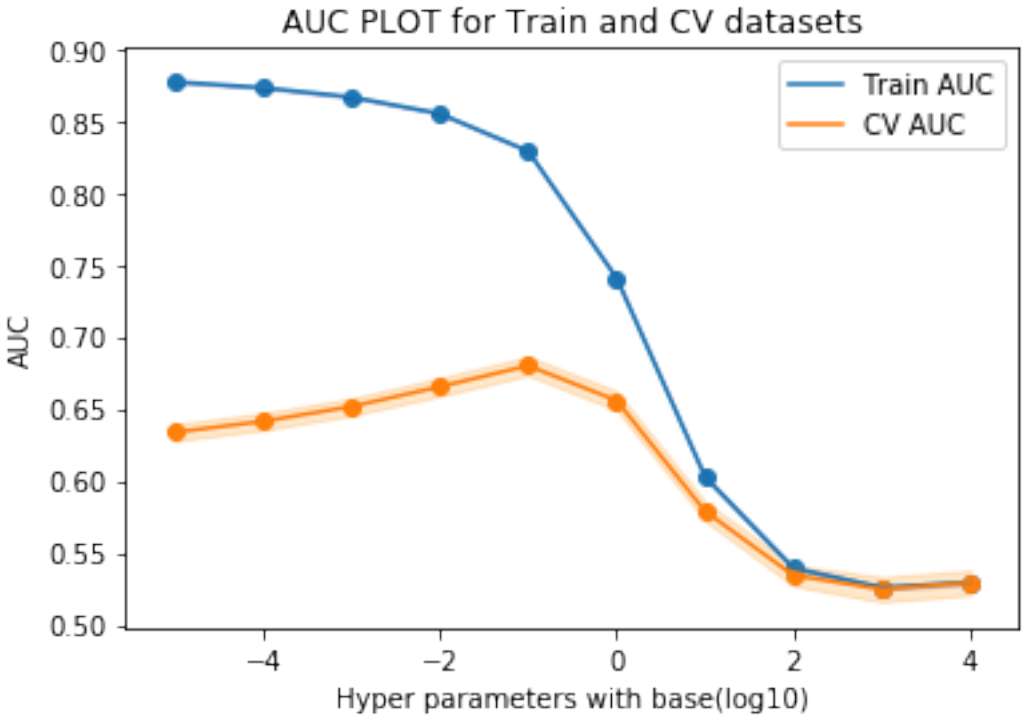
```
TF-IDF:
Training data set shape : (76473, 30433)
Test data set shape : (32775, 30433)
```

```
In [67]: X_train_tfidf[X_train_tfidf<0]=0
```

```
In [68]: print("Hyper Param Values:",alpha_vals)
```

```
Hyper Param Values: [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
```

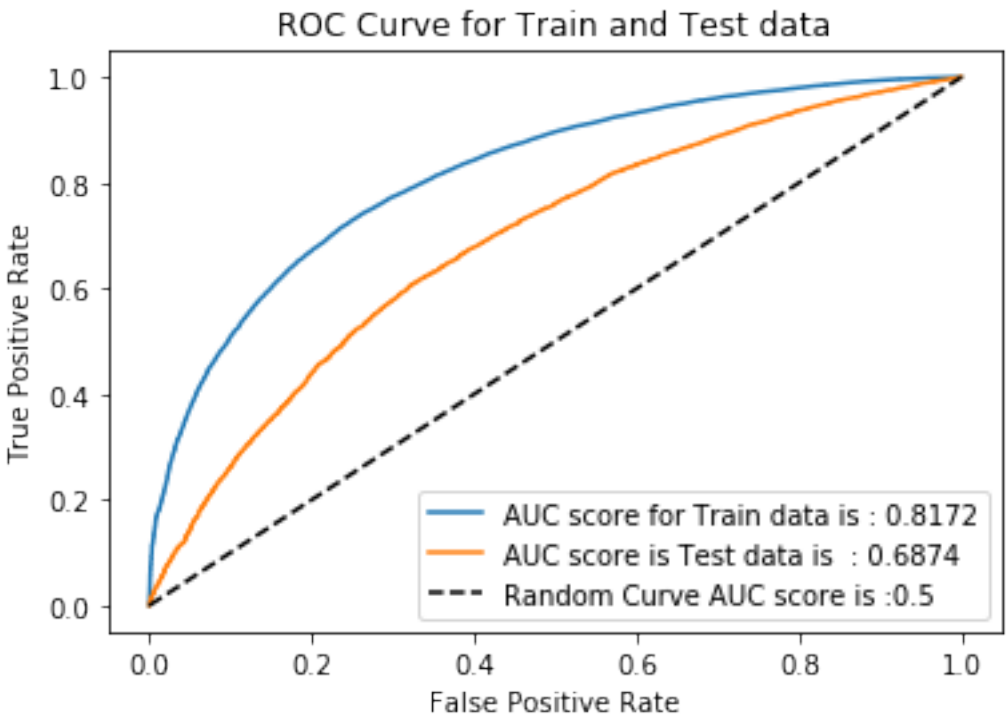
```
In [69]: grid_search_plot(MultinomialNB(class_prior=[0.5,0.5]),'alpha',alpha_vals,X_train_tfidf,
```



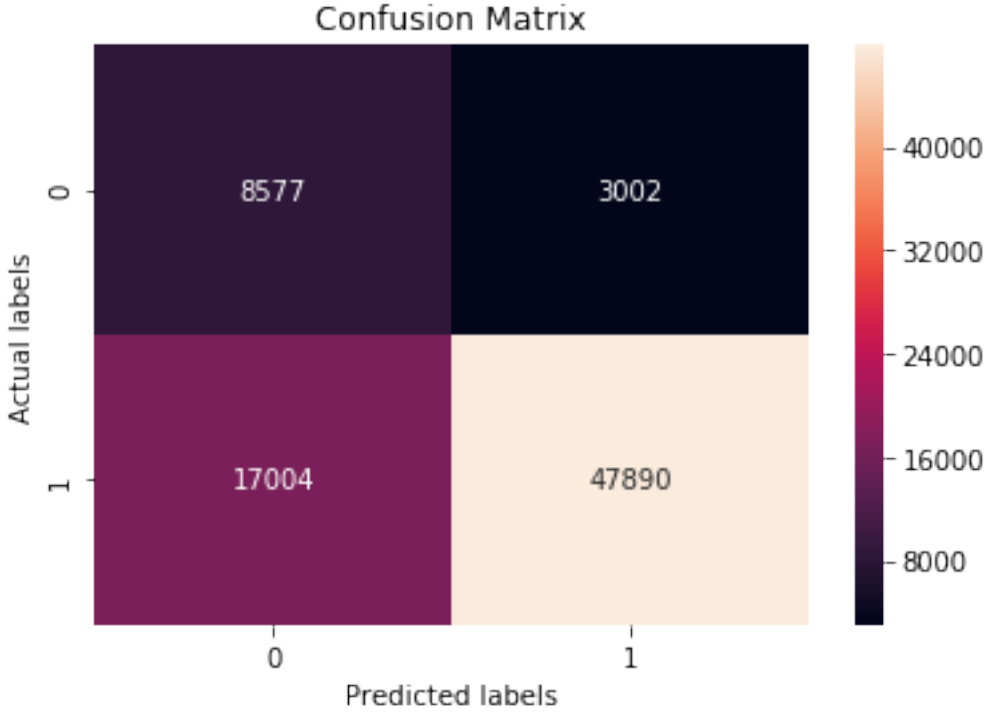

```
In [70]: best_model=MultinomialNB(alpha=10**-1,class_prior=[0.5,0.5])
```

```
In [71]: build_best_model_plot_roc(best_model,X_train_tfidf,y_train,X_test_tfidf,y_test)
```

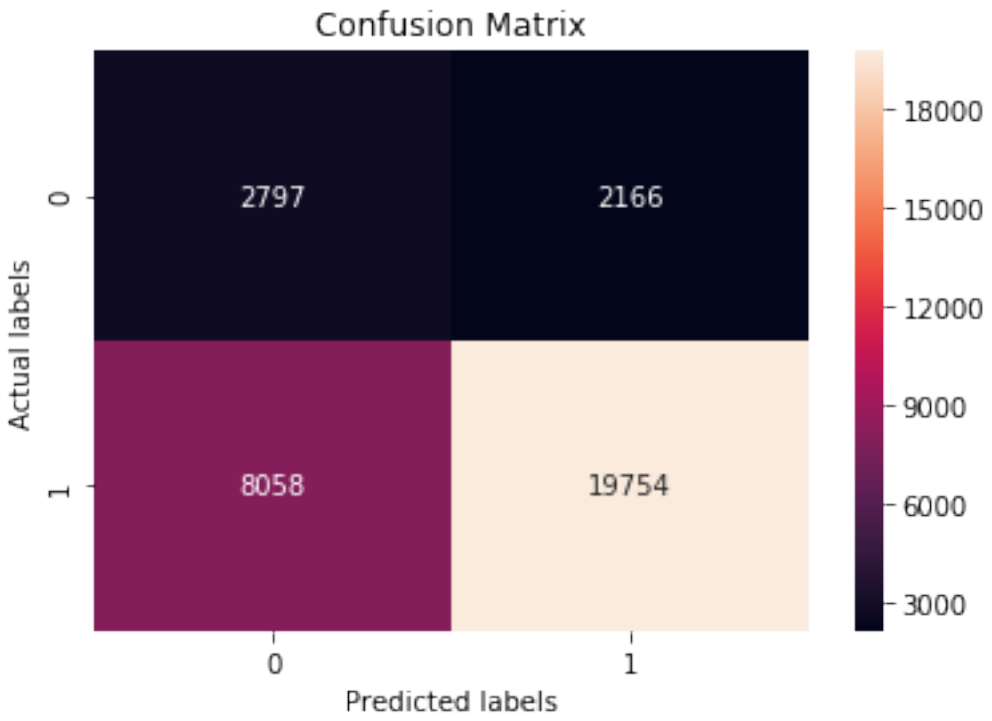
```
ROC Curve for Train and Test Data
```



Confusion Matrix for Train



Confusion Matrix for Test

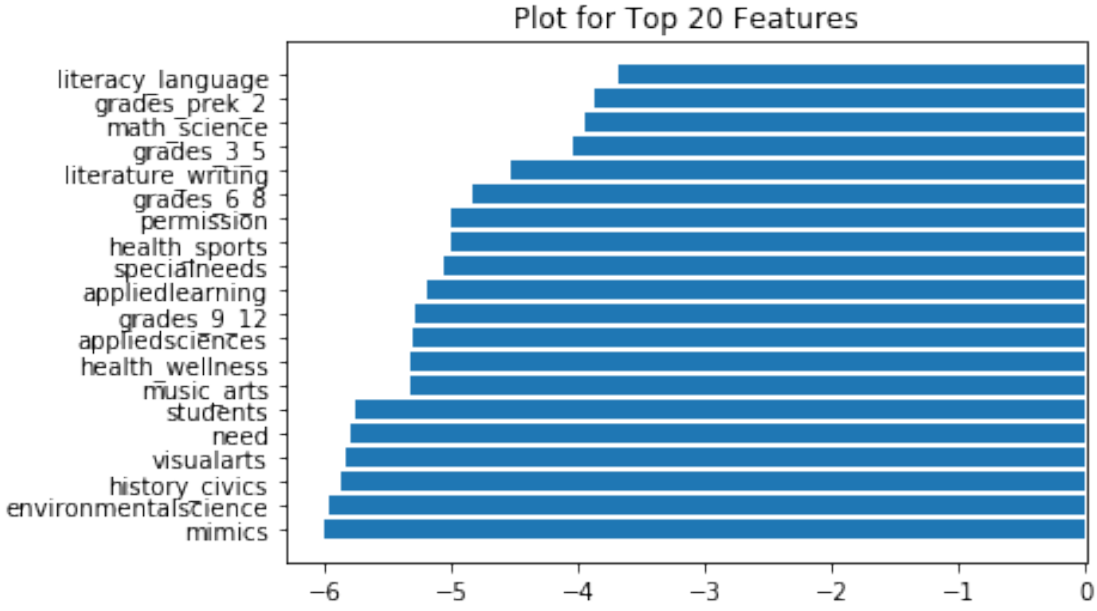


In [72]: plot_top_n_features(best_model,X_train_tfidf,y_train,20,bog_features)

Top 20 Features :

Feature Priority	Feature Name	Feature Imp Value
1	literacy_language	-3.6823
2	grades_prek_2	-3.8735
3	math_science	-3.9495
4	grades_3_5	-4.0399
5	literature_writing	-4.5402
6	grades_6_8	-4.8382

7	permission	-5.004
8	health_sports	-5.0072
9	specialneeds	-5.0663
10	appliedlearning	-5.1886
11	grades_9_12	-5.2806
12	appliedsciences	-5.3071
13	health_wellness	-5.3199
14	music_arts	-5.3263
15	students	-5.769
16	need	-5.7971
17	visualarts	-5.838
18	history_civics	-5.8759
19	environmentalscience	-5.9718
20	mimics	-6.0116



3.4 Summary

```
In [74]: summary_table = PrettyTable()
         summary_table.hrules=True
         summary_table.field_names = ["Vectorizer", "Model","Traindata shape","Testdata shape","
         summary_table.add_row(["BOW", 'GridSearchCv', (76473, 30433),(32775, 30433),1, .7895,.7
         summary_table.add_row(["TF-IDF", 'GridSearchCv', (76473, 30433),(32775, 30433),0.1, .81
         print(summary_table)
```

```
+------------+--------------+-----------------+----------------+------------+-----------+-------
| Vectorizer |    Model     | Traindata shape | Testdata shape | Best Alpha | Train AUC | Test A
+------------+--------------+-----------------+----------------+------------+-----------+-------
|    BOW     | GridSearchCv |  (76473, 30433) | (32775, 30433) |     1      |   0.7895  |  0.715
+------------+--------------+-----------------+----------------+------------+-----------+-------
|   TF-IDF   | GridSearchCv |  (76473, 30433) | (32775, 30433) |    0.1     |   0.8172  |  0.687
+------------+--------------+-----------------+----------------+------------+-----------+-------
```