DonorsChoose

In [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")
warnings.filterwarnings(action='ignore', category=UserWarning, module='gensim')

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
import math as ma

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
```

```
E:\Programs\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: dete
cted Windows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

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)
project_data.head(2)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'scho
ol_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

Out[3]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sul
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	20

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

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

Out[4]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

2. Removing Duplicates

First combine projects and resources

In [5]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
project_data = pd.merge(project_data, price_data, on='id', how='left')
print(project_data.shape)
```

```
(109248, 19)
```

In [6]:
```
#Are their any duplicates same essays, project titles, cost, quantity and teacher
sorted_data=project_data.sort_values('project_title', axis=0, ascending=True, inp
bool_series = sorted_data[["project_title","teacher_id","school_state","project_
sorted_data[bool_series]
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	proj
105890	135375	p031163	a1ac9e40c0fd222153380491f2354c8e	Mrs.	NY	
69781	99030	p085192	a1ac9e40c0fd222153380491f2354c8e	Mrs.	NY	
95014	171243	p103848	e0840936cd050c5995b8a9622952b9b9	Mr.	TX	
34032	171640	p217863	e0840936cd050c5995b8a9622952b9b9	Mr.	TX	
71552	31570	p251176	bd33c4e96d29173282f35b26df9de481	Ms.	ID	
77471	9086	p015266	bd33c4e96d29173282f35b26df9de481	Ms.	ID	
68304	139161	p093540	bd33c4e96d29173282f35b26df9de481	Ms.	ID	
20971	102904	p018814	119707593fc6f78bbba6e5c50173f236	Mrs.	TX	
20743	13433	p183181	119707593fc6f78bbba6e5c50173f236	Mrs.	TX	
5283	100090	p046627	299aa8570c30fc482b75bf32183fa6c5	Ms.	NV	
16255	167072	p148564	299aa8570c30fc482b75bf32183fa6c5	Ms.	NV	
38798	131740	p201524	9ee677c6530a33dea52491fc6d9d9fad	Ms.	AZ	

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	proj
47312	124740	p175263	9ee677c6530a33dea52491fc6d9d9fad	Ms.	AZ	
97851	123637	p168484	3cf6707010632c8fdb1f85a07869e471	Mrs.	PA	
48265	98988	p210208	3cf6707010632c8fdb1f85a07869e471	Mrs.	PA	

We see that although the project id and time are different. These projects are essentially the same as the essays, cost, quantity, project title etc are excatly same. Therefore we remove the dupilcates from them.

In [7]:
```
project_data=project_data.drop_duplicates(subset={"project_title","teacher_id","
print(project_data.shape)
```

```
(109240, 19)
```

In [8]:
```
#Are their any duplicates of same projects in the data?
sorted_data=project_data.sort_values('id', axis=0, ascending=True, inplace=False
bool_series = sorted_data[["id"]].duplicated(keep=False)
sorted_data[bool_series]
```

Out[8]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade

In [9]:
```
#Are their any duplicates same teacher posting at same time?
sorted_data=project_data.sort_values('project_submitted_datetime', axis=0, ascen
bool_series = sorted_data[["project_submitted_datetime","teacher_id"]].duplicate
sorted_data[bool_series]
```

Out[9]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade

In [10]:
```
#have different teachers posted same project?
sorted_data=project_data.sort_values('project_title', axis=0, ascending=True, inp
bool_series = sorted_data[["project_title","school_state","project_essay_1","proj
sorted_data[bool_series]
```

Out[10]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
35481	164898	p019084	6f3f0e6dcadc61f516b10efa8613ed6d	Mrs.	MA	
78408	166527	p243927	9fc77e9bbfbc40a689b3474a0fede264	Ms.	MA	

We remove this duplication because it is essentially same project

In [11]:
```
project_data=project_data.drop_duplicates(subset={"project_title","school_state"
print(project_data.shape)
```

```
(109239, 19)
```

In [12]:
```
#Duplicates with essentially the same content but a slightly different project t
sorted_data=project_data.sort_values('teacher_id', axis=0, ascending=True, inpla
bool_series = sorted_data[["school_state","project_grade_category","project_essa
sorted_data[bool_series]
```

Out[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	p
106368	165106	p077552	0b970008579b1930b28b49957348a2fa	Mrs.	TX	
104334	134224	p105628	0b970008579b1930b28b49957348a2fa	Mrs.	TX	
47357	103101	p037737	0cb366a6c4d01fa08715a213d182ce77	Mr.	SC	
32348	175070	p004681	0cb366a6c4d01fa08715a213d182ce77	Mr.	SC	

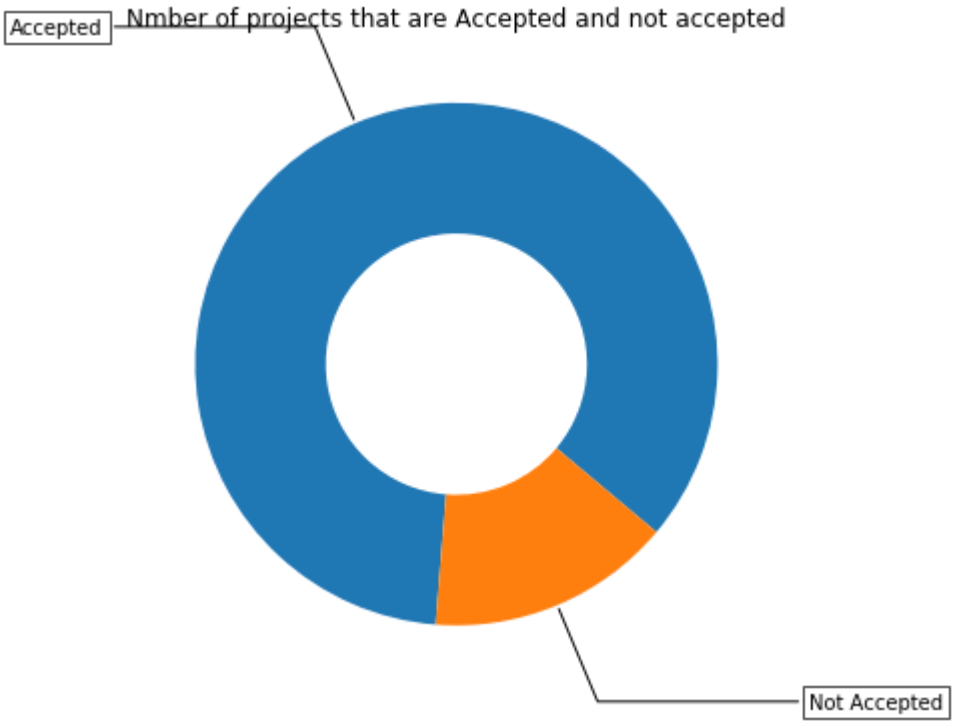
In [13]:
```
project_data=project_data.drop_duplicates(subset={"school_state","project_grade_
project_data.shape
```

Out[13]: (109141, 19)

3. Data Analysis

In [14]:
```
# PROVIDE CITATIONS TO YOUR CODE IF YOU TAKE IT FROM ANOTHER WEBSITE.
# https://matplotlib.org/gallery/pie_and_polar_charts/pie_and_donut_labels.html#s


y_value_counts = project_data['project_is_approved'].value_counts()

print("Number of projects thar are approved for funding ", y_value_counts[1], ",
print("Number of projects thar are not approved for funding ", y_value_counts[0],

fig, ax = plt.subplots(figsize=(6, 6), subplot_kw=dict(aspect="equal"))
recipe = ["Accepted", "Not Accepted"]

data = [y_value_counts[1], y_value_counts[0]]

wedges, texts = ax.pie(data, wedgeprops=dict(width=0.5), startangle=-40)

bbox_props = dict(boxstyle="square,pad=0.3", fc="w", ec="k", lw=0.72)
kw = dict(xycoords='data', textcoords='data', arrowprops=dict(arrowstyle="-"),
          bbox=bbox_props, zorder=0, va="center")

for i, p in enumerate(wedges):
    ang = (p.theta2 - p.theta1)/2. + p.theta1
    y = np.sin(np.deg2rad(ang))
    x = np.cos(np.deg2rad(ang))
    horizontalalignment = {-1: "right", 1: "left"}[int(np.sign(x))]
    connectionstyle = "angle,angleA=0,angleB={}".format(ang)
    kw["arrowprops"].update({"connectionstyle": connectionstyle})
    ax.annotate(recipe[i], xy=(x, y), xytext=(1.35*np.sign(x), 1.4*y),
                horizontalalignment=horizontalalignment, **kw)

ax.set_title("Nmber of projects that are Accepted and not accepted")

plt.show()
```

```
Number of projects thar are approved for funding  92601 , ( 84.84529187014962
%)
Number of projects thar are not approved for funding  16540 , ( 15.154708129850
377 %)
```



4. Data Preprocessing

4.1 Categorical data

1. School State

In [15]:
```
from collections import Counter #counter is used to calculate how many time each
my_counter = Counter()
for word in project_data['school_state'].values:
    my_counter.update(word.split())
```

In [16]:
```
state_dict = dict(my_counter)
sorted_state_dict = dict(sorted(state_dict.items(), key=lambda kv: kv[1])) # sor
```

2. Teacher Prefix

In [17]:
```
project_data['teacher_prefix'].fillna("", inplace = True)
teacher_prefix = list(project_data['teacher_prefix'].values)

teacher_prefix_list = []
for i in teacher_prefix:
    temp = ""
    for j in i.split(','): # it will split it in three parts ["Math & Science",
         # if we have the words "The" we are going to replace it with ''(i.e rem
        j = j.replace('.','') # we are placeing all the ' '(space) with ''(empty
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
        temp = temp.replace('&','_')
    teacher_prefix_list.append(temp.strip())
```

In [18]:
```
project_data['clean_teacher_prefix'] = teacher_prefix_list
project_data.drop(['teacher_prefix'], axis=1, inplace=True)
project_data.head(2)
```

Out[18]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [19]:
```
#project_data['teacher_prefix'].fillna(" ", inplace = True)
from collections import Counter
my_counter = Counter()
for word in project_data['clean_teacher_prefix'].values:
        my_counter.update(word.split())
```

In [20]:
```
teacher_prefix_dict = dict(my_counter)
sorted_teacher_prefix_dict = dict(sorted(teacher_prefix_dict.items(), key=lambda
```

3. project_grade_category

In [21]:
```
grades_cat = list(project_data['project_grade_category'].values)
# remove special characters from list of strings python: https://stackoverflow.co

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-
grades_cat_list = []
for i in grades_cat:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",
         # if we have the words "The" we are going to replace it with ''(i.e remo
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
        temp = temp.replace('&','_') # we are replacing the & value into
    grades_cat_list.append(temp.strip())
```

In [22]:
```
project_data['clean_grades_categories'] = grades_cat_list
project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data.head(2)
```

Out[22]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [23]:
```
from collections import Counter
my_counter = Counter()
for word in project_data['clean_grades_categories'].values:
        my_counter.update(word.split())
```

In [24]:
```
project_grade_category_dict = dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.iter
```

4. project_subject_categories

In [25]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.co

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())
```

In [26]:
```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

Out[26]:

Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [27]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4
# replacing na values in college with No college
from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())
```

In [28]:
```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

5. project_subject_subcategories

In [29]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.co

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

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",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trail
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())
```

In [30]:
```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(2)
```

Out[30]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [31]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4
from collections import Counter
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())
```

In [32]:
```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

6. presence_of_numerical_digits

In [33]:
```
#https://stackoverflow.com/questions/19859282/check-if-a-string-contains-a-numbe
def hasNumbers(inputString):

    if (any(char.isdigit() for char in inputString)):

        return 'yes'

    else:
        return 'No'


presence_of_numerical_digits=project_data['project_resource_summary'].map(hasNuml
```

In [34]:
```
#Add a new column to projects table
project_data['presence_of_numerical_digits'] = presence_of_numerical_digits
```

In [35]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4
from collections import Counter
my_counter = Counter()
for word in project_data['presence_of_numerical_digits'].values:
    my_counter.update(word.split())
```

In [36]:
```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
presence_of_numerical_digits_dict = dict(my_counter)
sorted_presence_of_numerical_digits_dict = dict(sorted(presence_of_numerical_digi
```

4.2 Text data

In [37]:
```
# 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 [38]:
```
project_data.drop(['project_essay_1','project_essay_2','project_essay_3','projec
project_data.head(2)
```

Out[38]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [39]:
```
# 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 [40]:
```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itse
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'tha
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'ha
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 't
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'of
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than'
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should'v
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "d
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma'
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn
            'won', "won't", 'wouldn', "wouldn't"]
```

1. Essay

In [41]:
```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in 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())
```

In [42]:
```
project_data['clean_essay'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
project_data.head(2)
```

Out[42]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

2. Project title

In [43]:
```
from tqdm import tqdm
preprocessed_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 not in stopwords)
    preprocessed_title.append(sent.lower().strip())
```

```
100%|████████████████████████████████| 109141/109141 [00:02<00:00, 39570.25it/s]
```

In [44]:
```
project_data['clean_project_title'] = preprocessed_title
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(2)
```

Out[44]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

3. Project_resource_summary

In [45]:
```
from tqdm import tqdm
preprocessed_project_resource_summary = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_resource_summary'].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_project_resource_summary.append(sent.lower().strip())
```

```
100%|████████████████████████████████| 109141/109141 [00:06<00:00, 17033.68it/s]
```

In [46]:
```
project_data['clean_project_resource_summary'] = preprocessed_project_resource_su
project_data.drop(['project_resource_summary'], axis=1, inplace=True)
project_data.head(2)
```

Out[46]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_datetime
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:43:57
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:22:10

In [47]:
```
project_data.shape
```

Out[47]:
```
(109141, 17)
```

5. Splitting the Data

In [48]:
```
y = project_data['project_is_approved']
project_data.drop(['project_is_approved'], axis=1, inplace=True)
X=project_data
print(X.shape)
print(y.shape)
```

```
(109141, 16)
(109141,)
```

In [49]:
```
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from collections import Counter
from sklearn.metrics import accuracy_score
from sklearn import model_selection
```

I am splitting only in Train and test because GridSearch CV will take care of 3-fold cross validation from the training dataset itself and we will end up using more data as training data

In [50]:
```
#Split the data into train and test

X_tr, X_test, y_tr, y_test = model_selection.train_test_split(X, y, test_size=0.
```

In [51]:
```
print(X_tr.shape)
print(y_tr.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(76398, 16)
(76398,)
(32743, 16)
(32743,)
```

6. Vectorising text, categorical and numerical features

Fitting of the vectorizer will only be done on the training data and using the parameters of the fit we will transform both training data and test data. This will avoid data leakage.

6.1 Text features Vectorisation

BOW

In [52]:
```
feature_name_bow=list()
```

1.Essay

In [53]:
```
vectorizer_essay_bow = CountVectorizer(min_df=10,max_features=5000)
vectorizer_essay_bow.fit(X_tr['clean_essay'].values) # fit has to happen only on
X_tr_essay_bow = vectorizer_essay_bow.transform(X_tr['clean_essay'].values)
X_test_essay_bow = vectorizer_essay_bow.transform(X_test['clean_essay'].values)
print("The shape of matrix after vectorisation")
print(X_tr_essay_bow.shape, y_tr.shape)
print(X_test_essay_bow.shape, y_test.shape)
for a in vectorizer_essay_bow.get_feature_names() :
    feature_name_bow.append(a)
```

```
The shape of matrix after vectorisation
(76398, 5000) (76398,)
(32743, 5000) (32743,)
```

2.Project Title

In [54]:
```
vectorizer_project_title_bow = CountVectorizer(min_df=10,max_features=5000)
vectorizer_project_title_bow.fit(X_tr['clean_project_title'].values) # fit has to
X_tr_project_title_bow = vectorizer_project_title_bow.transform(X_tr['clean_proj
X_test_project_title_bow = vectorizer_project_title_bow.transform(X_test['clean_
print("The shape of matrix after vectorisation")
print(X_tr_project_title_bow.shape, y_tr.shape)
print(X_test_project_title_bow.shape, y_test.shape)
for a in vectorizer_project_title_bow.get_feature_names() :
    feature_name_bow.append(a)
```

```
The shape of matrix after vectorisation
(76398, 2689) (76398,)
(32743, 2689) (32743,)
```

2.Project Resource Summary

In [55]:
```
vectorizer = CountVectorizer(min_df=10,max_features=5000)
vectorizer.fit(X_tr['clean_project_resource_summary'].values) # fit has to happe
X_tr_clean_project_resource_summary_bow = vectorizer.transform(X_tr['clean_proje
X_test_clean_project_resource_summary_bow = vectorizer.transform(X_test['clean_p
print("The shape of matrix after vectorisation")
print(X_tr_clean_project_resource_summary_bow.shape, y_tr.shape)
print(X_test_clean_project_resource_summary_bow.shape, y_test.shape)
```

```
The shape of matrix after vectorisation
(76398, 4942) (76398,)
(32743, 4942) (32743,)
```

TFIDF

In [56]:
```
feature_name_tfidf=list()
```

1.Essay

In [57]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
```

In [58]:
```
vectorizer_essay_tfidf = TfidfVectorizer(min_df=10,max_features=5000)
vectorizer_essay_tfidf.fit(X_tr['clean_essay'].values) # fit has to happen only
X_tr_essay_tfidf = vectorizer_essay_tfidf.transform(X_tr['clean_essay'].values)
X_test_essay_tfidf = vectorizer_essay_tfidf.transform(X_test['clean_essay'].valu
print("The shape of matrix after vectorisation")
print(X_tr_essay_tfidf.shape, y_tr.shape)
print(X_test_essay_tfidf.shape, y_test.shape)

for a in vectorizer_essay_tfidf.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
The shape of matrix after vectorisation
(76398, 5000) (76398,)
(32743, 5000) (32743,)
```

2. Project Title

In [59]:
```
vectorizer_project_title_tfidf = CountVectorizer(min_df=10,max_features=5000)
vectorizer_project_title_tfidf.fit(X_tr['clean_project_title'].values) # fit has
X_tr_project_title_tfidf = vectorizer_project_title_tfidf.transform(X_tr['clean_
X_test_project_title_tfidf = vectorizer_project_title_tfidf.transform(X_test['cl
print("The shape of matrix after vectorisation")
print(X_tr_project_title_tfidf.shape, y_tr.shape)
print(X_test_project_title_tfidf.shape, y_test.shape)

for a in vectorizer_project_title_tfidf.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
The shape of matrix after vectorisation
(76398, 2689) (76398,)
(32743, 2689) (32743,)
```

3. Project Resource Summary

In [60]:
```
vectorizer = CountVectorizer(min_df=10,max_features=5000)
vectorizer.fit(X_tr['clean_project_resource_summary'].values) # fit has to happe
X_tr_clean_project_resource_summary_tfidf = vectorizer.transform(X_tr['clean_pro
X_test_clean_project_resource_summary_tfidf = vectorizer.transform(X_test['clean
print("The shape of matrix after vectorisation")
print(X_tr_clean_project_resource_summary_tfidf.shape, y_tr.shape)
print(X_test_clean_project_resource_summary_tfidf.shape, y_test.shape)
```

```
The shape of matrix after vectorisation
(76398, 4942) (76398,)
(32743, 4942) (32743,)
```

avg word2vec

In [61]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-t
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

1.Text

In [62]:
```
# average Word2Vec
# compute average word2vec for each review.
Tr_avg_w2v_vectors_essay = []; # the avg-w2v for each sentence/review is stored 
for sentence in tqdm(X_tr['clean_essay'].values): # for each review/sentence
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Tr_avg_w2v_vectors_essay.append(vector)
print("Training data")
print(len(Tr_avg_w2v_vectors_essay))
print(len(Tr_avg_w2v_vectors_essay[0]))


Test_avg_w2v_vectors_essay = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(X_test['clean_essay'].values): # for each review/sentence
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Test_avg_w2v_vectors_essay.append(vector)

print("Test data")
print(len(Test_avg_w2v_vectors_essay))
print(len(Test_avg_w2v_vectors_essay[0]))
```

```
100%|████████████████████████████████████| 76398/76398 [00:20<00:00, 3706.81it/s]

Training data
76398
50

100%|████████████████████████████████████| 32743/32743 [00:08<00:00, 3712.57it/s]

Test data
32743
50
```

2.Project Title

In [63]:
```
# average Word2Vec
# compute average word2vec for each review.
Tr_avg_w2v_vectors_project_title = []; # the avg-w2v for each sentence/review is
for sentence in tqdm(X_tr['clean_project_title'].values): # for each review/sente
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Tr_avg_w2v_vectors_project_title.append(vector)
print("Training data")
print(len(Tr_avg_w2v_vectors_project_title))
print(len(Tr_avg_w2v_vectors_project_title[0]))



Test_avg_w2v_vectors_project_title = []; # the avg-w2v for each sentence/review
for sentence in tqdm(X_test['clean_project_title'].values): # for each review/se
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Test_avg_w2v_vectors_project_title.append(vector)

print("Test data")
print(len(Test_avg_w2v_vectors_project_title))
print(len(Test_avg_w2v_vectors_project_title[0]))
```

```
100%|████████████████████████████████| 76398/76398 [00:00<00:00, 83036.54it/s]

Training data
76398
50

100%|████████████████████████████████| 32743/32743 [00:00<00:00, 81445.62it/s]

Test data
32743
50
```

3.Project Resource Summary

In [64]:
```
# average Word2Vec
# compute average word2vec for each review.
Tr_avg_w2v_vectors_project_resource_summary = []; # the avg-w2v for each sentence
for sentence in tqdm(X_tr['clean_project_resource_summary'].values): # for each r
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Tr_avg_w2v_vectors_project_resource_summary.append(vector)
print("Training data")
print(len(Tr_avg_w2v_vectors_project_resource_summary))
print(len(Tr_avg_w2v_vectors_project_resource_summary[0]))



Test_avg_w2v_vectors_project_resource_summary = []; # the avg-w2v for each senter
for sentence in tqdm(X_test['clean_project_resource_summary'].values): # for eacl
    vector = np.zeros(50) # 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][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Test_avg_w2v_vectors_project_resource_summary.append(vector)

print("Test data")
print(len(Test_avg_w2v_vectors_project_resource_summary))
print(len(Test_avg_w2v_vectors_project_resource_summary[0]))
```

```
100%|████████████████████████████████| 76398/76398 [00:02<00:00, 35269.45it/s]

Training data
76398
50

100%|████████████████████████████████| 32743/32743 [00:00<00:00, 34979.84it/s]

Test data
32743
50
```

tfidf word2vec

In [65]:
```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_tr['clean_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_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

1.Text

In [66]:
```
tr_tfidf_w2v_vectors_essay = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(X_tr['clean_essay'].values): # for each review/sentence
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    tr_tfidf_w2v_vectors_essay.append(vector)

print("Training data")
print(len(tr_tfidf_w2v_vectors_essay))
print(len(tr_tfidf_w2v_vectors_essay[0]))



Test_tfidf_w2v_vectors_essay = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(X_test['clean_essay'].values): # for each review/sentence
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    Test_tfidf_w2v_vectors_essay.append(vector)

print("Test data")
print(len(Test_tfidf_w2v_vectors_essay))
print(len(Test_tfidf_w2v_vectors_essay[0]))
```

```
100%|████████████████████████████████████| 76398/76398 [02:32<00:00, 499.95it/s]

Training data
76398
50

100%|████████████████████████████████████| 32743/32743 [01:05<00:00, 500.76it/s]

Test data
32743
50
```

2.Project Title

In [67]:
```
tr_tfidf_w2v_vectors_project_title = []; # the avg-w2v for each sentence/review
for sentence in tqdm(X_tr['clean_project_title'].values): # for each review/sente
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    tr_tfidf_w2v_vectors_project_title.append(vector)

print("Training data")
print(len(tr_tfidf_w2v_vectors_project_title))
print(len(tr_tfidf_w2v_vectors_project_title[0]))


Test_tfidf_w2v_vectors_project_title = []; # the avg-w2v for each sentence/revie
for sentence in tqdm(X_test['clean_project_title'].values): # for each review/se
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    Test_tfidf_w2v_vectors_project_title.append(vector)

print("Test data")
print(len(Test_tfidf_w2v_vectors_project_title))
print(len(Test_tfidf_w2v_vectors_project_title[0]))
```

```
100%|████████████████████████████████| 76398/76398 [00:02<00:00, 36976.59it/s]

Training data
76398
50

100%|████████████████████████████████| 32743/32743 [00:00<00:00, 37121.46it/s]

Test data
32743
50
```

3. Project Resource Summary

In [68]:
```
tr_tfidf_w2v_vectors_project_resource_summary = []; # the avg-w2v for each sentence
for sentence in tqdm(X_tr['clean_project_resource_summary'].values): # for each r
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    tr_tfidf_w2v_vectors_project_resource_summary.append(vector)

print("Training data")
print(len(tr_tfidf_w2v_vectors_project_resource_summary))
print(len(tr_tfidf_w2v_vectors_project_resource_summary[0]))


Test_tfidf_w2v_vectors_project_resource_summary = []; # the avg-w2v for each sent
for sentence in tqdm(X_test['clean_project_resource_summary'].values): # for each
    vector = np.zeros(50) # 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 tfidf_words):
            vec = model[word][:50] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            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
    Test_tfidf_w2v_vectors_project_resource_summary.append(vector)

print("Test data")
print(len(Test_tfidf_w2v_vectors_project_resource_summary))
print(len(Test_tfidf_w2v_vectors_project_resource_summary[0]))
```

```
100%|████████████████████████████████| 76398/76398 [00:06<00:00, 12363.43it/s]

Training data
76398
50

100%|████████████████████████████████| 32743/32743 [00:02<00:00, 12458.57it/s]

Test data
32743
50
```

6.2 Categorical features Vectorisation

1. School State

In [69]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_school_state = CountVectorizer(vocabulary=list(sorted_state_dict.keys
vectorizer_school_state.fit(X_tr['school_state'].values)
print(vectorizer_school_state.get_feature_names())


Tr_state_one_hot = vectorizer_school_state.transform(X_tr['school_state'].values
Test_state_one_hot = vectorizer_school_state.transform(X_test['school_state'].va

print("Shape of matrix after one hot encoding")
print(Tr_state_one_hot.shape)
print(Test_state_one_hot.shape)

for a in vectorizer_school_state.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_school_state.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI',
'DC', 'NM', 'KS', 'IA', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'NV', 'MD',
'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ', 'NJ', 'OK', 'WA', 'MA', 'LA', 'OH',
'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX', 'CA']
Shape of matrix after one hot encoding
(76398, 51)
(32743, 51)
```

2. Teacher Prefix

In [70]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_teacher_prefix = CountVectorizer(vocabulary=list(sorted_teacher_prefi
vectorizer_teacher_prefix.fit(X_tr['clean_teacher_prefix'].values)
print(vectorizer_teacher_prefix.get_feature_names())


Tr_clean_teacher_prefix_one_hot = vectorizer_teacher_prefix.transform(X_tr['clea
Test_clean_teacher_prefix_one_hot = vectorizer_teacher_prefix.transform(X_test['

print("Shape of matrix after one hot encoding")
print(Tr_clean_teacher_prefix_one_hot.shape)
print(Test_clean_teacher_prefix_one_hot.shape)

for a in vectorizer_teacher_prefix.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_teacher_prefix.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
['Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
Shape of matrix after one hot encoding
(76398, 5)
(32743, 5)
```

3. Grades Cateogory

In [71]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_grades_caterories = CountVectorizer(vocabulary=list(sorted_project_gra
vectorizer_grades_caterories.fit(X_tr['clean_teacher_prefix'].values)
print(vectorizer_grades_caterories.get_feature_names())


Tr_clean_grades_categories_one_hot = vectorizer_grades_caterories.transform(X_tr
Test_clean_grades_categories_one_hot = vectorizer_grades_caterories.transform(X_

print("Shape of matrix after one hot encoding")
print(Tr_clean_grades_categories_one_hot.shape)
print(Test_clean_grades_categories_one_hot.shape)


for a in vectorizer_grades_caterories.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_grades_caterories.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
['Grades9-12', 'Grades6-8', 'Grades3-5', 'GradesPreK-2']
Shape of matrix after one hot encoding
(76398, 4)
(32743, 4)
```

4. Subject Categories

In [72]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_caterories = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()),
vectorizer_caterories.fit(X_tr['clean_categories'].values)
print(vectorizer_caterories.get_feature_names())


Tr_clean_categories_one_hot = vectorizer_caterories.transform(X_tr['clean_categor
Test_clean_categories_one_hot = vectorizer_caterories.transform(X_test['clean_ca

print("Shape of matrix after one hot encoding")
print(Tr_clean_categories_one_hot.shape)
print(Test_clean_categories_one_hot.shape)

for a in vectorizer_caterories.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_caterories.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'S
pecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encoding
(76398, 9)
(32743, 9)
```

5. Subject SubCategories

In [73]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_subcaterories = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.k
vectorizer_subcaterories.fit(X_tr['clean_subcategories'].values)
print(vectorizer_subcaterories.get_feature_names())


Tr_clean_subcategories_one_hot = vectorizer_subcaterories.transform(X_tr['clean_
Test_clean_subcategories_one_hot = vectorizer_subcaterories.transform(X_test['cl

print("Shape of matrix after one hot encoding")
print(Tr_clean_subcategories_one_hot.shape)
print(Test_clean_subcategories_one_hot.shape)


for a in vectorizer_subcaterories.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_subcaterories.get_feature_names() :
    feature_name_tfidf.append(a)

print(len(feature_name_tfidf))
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Ex
tracurricular', 'Civics_Government', 'ForeignLanguages', 'NutritionEducation',
'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts', 'CharacterEducatio
n', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_Geography',
'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness', 'EnvironmentalS
cience', 'VisualArts', 'Health_Wellness', 'AppliedSciences', 'SpecialNeeds', 'L
iterature_Writing', 'Mathematics', 'Literacy']
Shape of matrix after one hot encoding
(76398, 30)
(32743, 30)
7788
```

6. Presence of Numerical digit in resource summary

In [74]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_presence_of_numerical_digits = CountVectorizer(vocabulary=list(sorted_
vectorizer_presence_of_numerical_digits.fit(X_tr['presence_of_numerical_digits']
print(vectorizer_presence_of_numerical_digits.get_feature_names())


Tr_presence_of_numerical_digits_one_hot = vectorizer_presence_of_numerical_digits
Test_presence_of_numerical_digits_one_hot = vectorizer_presence_of_numerical_digi

print("Shape of matrix after one hot encoding")
print(Tr_presence_of_numerical_digits_one_hot.shape)
print(Test_presence_of_numerical_digits_one_hot.shape)

for a in vectorizer_presence_of_numerical_digits.get_feature_names() :
    feature_name_bow.append(a)

for a in vectorizer_presence_of_numerical_digits.get_feature_names() :
    feature_name_tfidf.append(a)
```

```
['yes', 'No']
Shape of matrix after one hot encoding
(76398, 2)
(32743, 2)
```

6.3 Numerical features Vectorisation

1.Price

In [75]:
```
from sklearn.preprocessing import StandardScaler
b= list()
price_scalar = StandardScaler()
price_scalar.fit(X_tr['price'].values.reshape(-1,1)) # finding the mean and stand
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scala

# Now standardize the data with above maen and variance.
Tr_price_standardized = price_scalar.transform(X_tr['price'].values.reshape(-1, 1
Test_price_standardized = price_scalar.transform(X_test['price'].values.reshape(

print("Shape of matrix after standarsation")
print(Tr_price_standardized.shape)
print(Test_price_standardized.shape)

feature_name_bow.append("price")
feature_name_tfidf.append("price")
```

```
Mean : 298.4207332652687, Standard deviation : 370.0163510413358
Shape of matrix after standarsation
(76398, 1)
(32743, 1)
```

2. Teacher number of previously posted scalars

In [76]:
```
teacher_number_of_previously_posted_projects_scalar = StandardScaler()
teacher_number_of_previously_posted_projects_scalar.fit(X_tr['teacher_number_of_
print(f"Mean : {teacher_number_of_previously_posted_projects_scalar.mean_[0]}, S

# Now standardize the data with above maen and variance.
Tr_teacher_number_of_previously_posted_projects_standardized = teacher_number_of_
Test_teacher_number_of_previously_posted_projects_standardized = teacher_number_

print("Shape of matrix after standarsation")
print(Tr_teacher_number_of_previously_posted_projects_standardized.shape)
print(Test_teacher_number_of_previously_posted_projects_standardized.shape)

feature_name_bow.append("teacher_number_of_previously_posted_projects")
feature_name_tfidf.append("teacher_number_of_previously_posted_projects")
```

```
E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.


Mean : 11.031558417759626, Standard deviation : 27.35184440105008

E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.


Shape of matrix after standarsation
(76398, 1)
(32743, 1)
```

3. Quantity

In [77]:
```
quantity_scalar = StandardScaler()
quantity_scalar.fit(X_tr['quantity'].values.reshape(-1,1)) # finding the mean and
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity

# Now standardize the data with above maen and variance.
Tr_quantity_standardized = quantity_scalar.transform(X_tr['quantity'].values.resh
Test_quantity_standardized = quantity_scalar.transform(X_test['quantity'].values

print("Shape of matrix after standarsation")
print(Tr_quantity_standardized.shape)
print(Test_quantity_standardized.shape)

feature_name_bow.append("Quantity")
feature_name_tfidf.append("Quantity")
```

```
E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.


Mean : 17.03942511584073, Standard deviation : 25.904357242036095

E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

E:\Programs\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataCo
nversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.


Shape of matrix after standarsation
(76398, 1)
(32743, 1)
```

7. Apply Decision Tree

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

In [78]:
```
from scipy.sparse import hstack
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score
import pylab
##https://stackoverflow.com/questions/3899980/how-to-change-the-font-size-on-a-ma
font = {'family' : 'normal',
        'weight' : 'bold',
        'size'   : 12}

plt.rc('font', **font)
```

In [79]:
```
# First combine all features to create total matrix
X_tr_LR_BOW = hstack((X_tr_essay_bow,X_tr_project_title_bow,Tr_state_one_hot,Tr_
                      Tr_clean_grades_categories_one_hot,Tr_clean_categories_one_
                      Tr_presence_of_numerical_digits_one_hot,
                      Tr_price_standardized, Tr_teacher_number_of_previously_post
                      Tr_quantity_standardized
                     ))

X_test_LR_BOW = hstack((X_test_essay_bow,X_test_project_title_bow,Test_state_one_
                      Test_clean_grades_categories_one_hot,Test_clean_categories_
                      Test_presence_of_numerical_digits_one_hot,
                      Test_price_standardized, Test_teacher_number_of_previously_
                      Test_quantity_standardized
                     ))
print(X_tr_LR_BOW.shape)
print(X_test_LR_BOW.shape)
```

```
(76398, 7793)
(32743, 7793)
```

In [80]:
```
from sklearn.model_selection import GridSearchCV
from sklearn import linear_model
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV

param_grid = {'max_depth':[ 1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500]}

#Hyper parameter Tuning for lamda with 3 fold cross validation
clf = DecisionTreeClassifier()

clf_cv= GridSearchCV(clf,param_grid,cv=2,scoring='roc_auc')

clf_cv.fit(X_tr_LR_BOW.toarray(),y_tr)

print(clf_cv.best_params_)

print(clf_cv.best_score_)

#https://www.kaggle.com/jinilcs/grid-search-to-find-best-tuning-parameters
results_df = pd.DataFrame(clf_cv.cv_results_)

scores = np.array(results_df.mean_test_score).reshape(7, 4)

sns.heatmap(scores, annot=True,
            yticklabels=param_grid['max_depth'], xticklabels=param_grid['min_sam
plt.ylabel('max_depth')
plt.xlabel('min_samples_split')
```

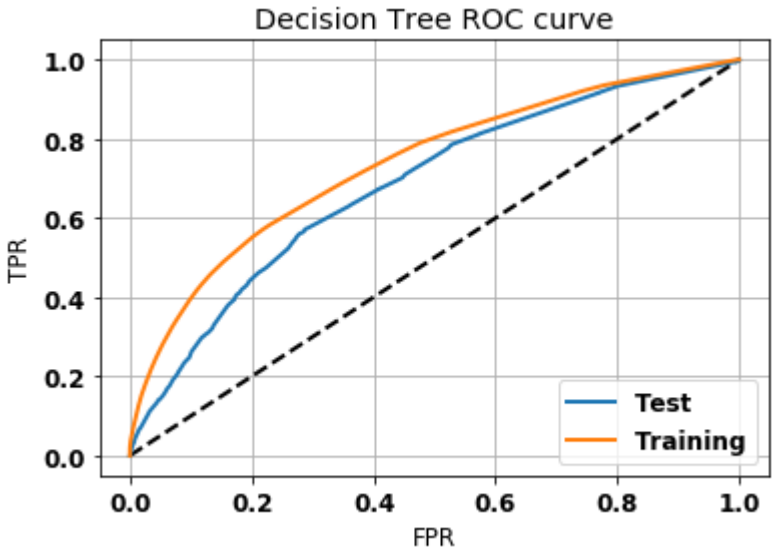
```
{'max_depth': 10, 'min_samples_split': 500}
0.6730367627338749

E:\Programs\Anaconda3\lib\site-packages\matplotlib\font_manager.py:1241: UserWa
rning:

findfont: Font family ['normal'] not found. Falling back to DejaVu Sans.
```

Out[80]:
```
Text(0.5, 12.0, 'min_samples_split')

E:\Programs\Anaconda3\lib\site-packages\matplotlib\font_manager.py:1241: UserWa
rning:

findfont: Font family ['normal'] not found. Falling back to DejaVu Sans.
```


max_depth
1
5
10
50
100
500
1000
0.57 0.57 0.57 0.57
0.67 0.66 0.66 0.66
0.67 0.67 0.67 0.67
0.52 0.53 0.58 0.64
0.49 0.51 0.55 0.62
0.54 0.54 0.57 0.61
0.54 0.54 0.57 0.61
5
10
100
500
min_samples_split
0.66
0.63
0.60
0.57
0.54
0.51

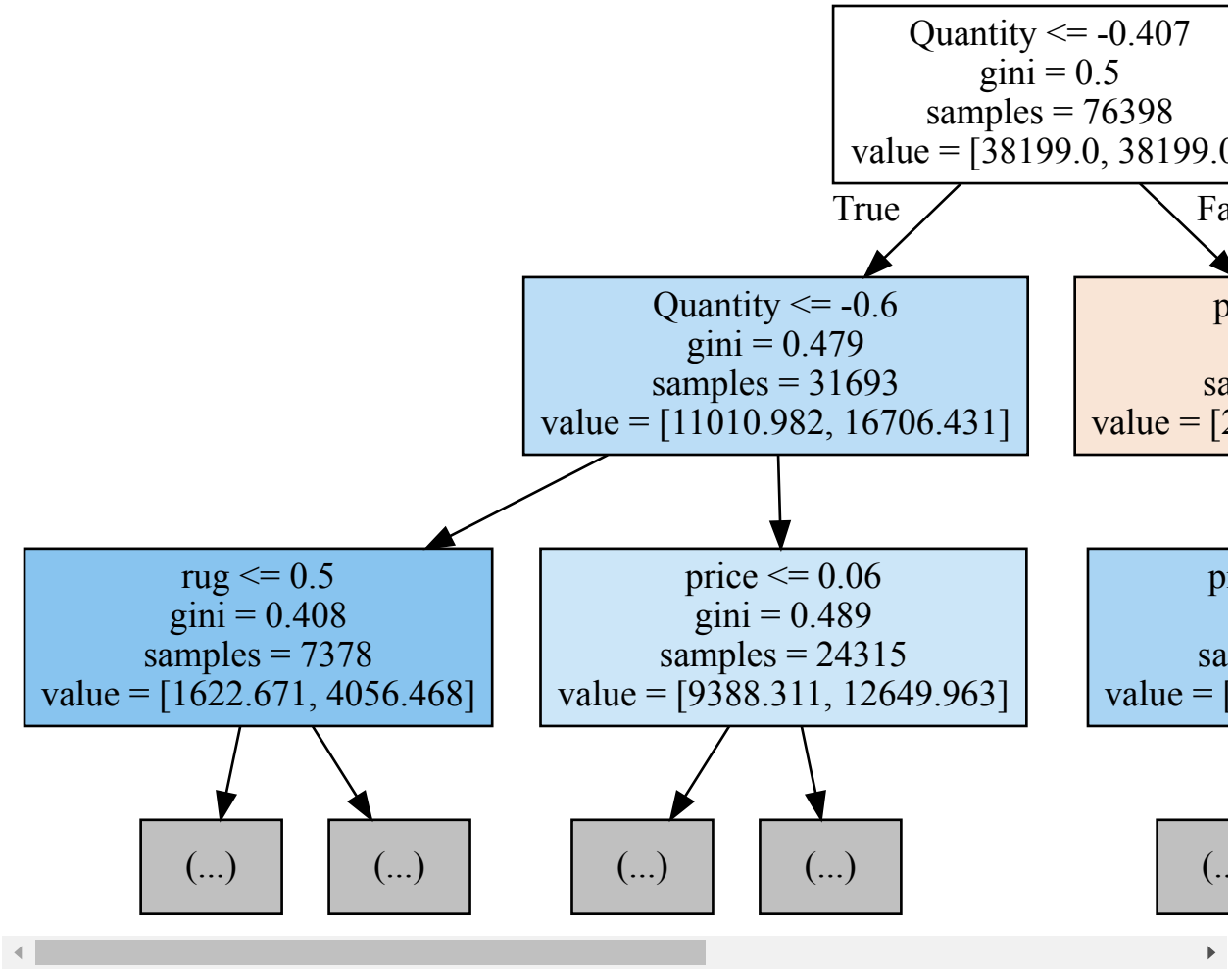
In [81]:
```
#Instantiate Classifier
clf = DecisionTreeClassifier(class_weight='balanced',max_depth=clf_cv.best_params
clf.fit(X_tr_LR_BOW.toarray(),y_tr)
y_pred_proba_test = clf.predict_proba(X_test_LR_BOW.toarray())[:,1]
y_pred_proba_tr = clf.predict_proba(X_tr_LR_BOW.toarray())[:,1]
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, y_pred_proba_test)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(y_tr, y_pred_proba_tr)
plt.plot([0,1],[0,1],'k--',linewidth=2.0)
plt.plot(fpr_test,tpr_test, label='Test',linewidth=2.0)
plt.plot(fpr_tr,tpr_tr, label='Training',linewidth=2.0)
plt.xlabel('FPR')
plt.ylabel('TPR')
pylab.legend(loc='lower right')
plt.title('Decision Tree ROC curve')
plt.grid()
plt.show()
#Area under ROC curve
print('The Training AUC (area under curve) for hypertuned parameter maximum depth
print('The Test AUC (area under curve) for hypertuned parameter maximum depth={}

test_AUC_BOW = roc_auc_score(y_test,y_pred_proba_test)
training_AUC_BOW = roc_auc_score(y_tr,y_pred_proba_tr)
depth_BOW = clf_cv.best_params_.get('max_depth')
split_BOW = clf_cv.best_params_.get('min_samples_split')
```

```
E:\Programs\Anaconda3\lib\site-packages\matplotlib\font_manager.py:1241: UserWa
rning:

findfont: Font family ['normal'] not found. Falling back to DejaVu Sans.
```




```
The Training AUC (area under curve) for hypertuned parameter maximum depth=10 a
nd min_samples_split =500 = 0.7362523843308941
The Test AUC (area under curve) for hypertuned parameter maximum depth=10 and m
in_samples_split =500 = 0.6825737208929942
```

In [82]:
```
from graphviz import Digraph
import os
os.environ["PATH"] += os.pathsep + 'J:/Program Files (x86)/Graphviz2.38/bin/'

from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn import tree
from IPython.display import SVG
from graphviz import Source
from IPython.display import display

graph = Source(tree.export_graphviz(clf, out_file=None, max_depth=2, filled = Tru
display(SVG(graph.pipe(format='svg')))
```



Finding optimum threshold value

Finding optimum threshold using training data for high tpr and low fpr. For this we use maximum value of parameter tr=tpr*(1-fpr)

In [83]:
```
#https://stackoverflow.com/questions/28719067/roc-curve-and-cut-off-point-python
i = np.arange(0,len(tpr_tr))
roc = pd.DataFrame({'fpr' : pd.Series(fpr_tr, index=i),'tpr' : pd.Series(tpr_tr,
roc.ix[(roc.tf-0).abs().argsort()[:1]]

index=roc['tf'].idxmax()

optimim_threshold=roc['thresholds'].iloc[index]
print(roc.iloc[index])
print(optimim_threshold)
```

```
fpr           0.292674
tpr           0.639471
1-fpr         0.707326
tf            0.452314
thresholds    0.473488
Name: 88, dtype: float64
0.47348802787445843
```

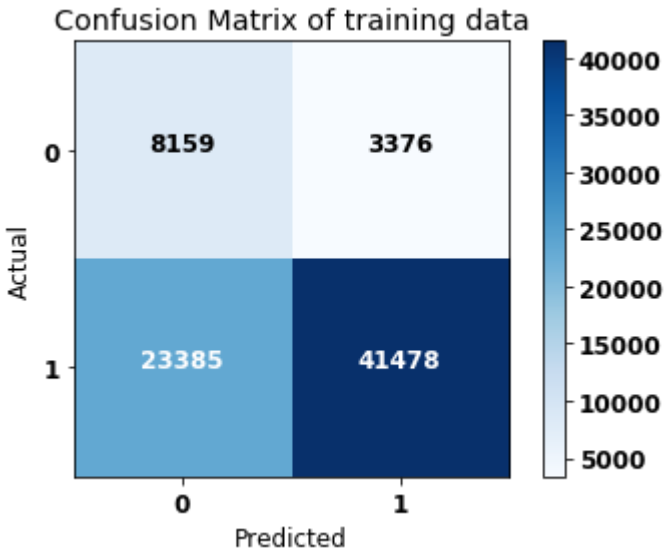
Confusion Matrix for training data (BOW)

We calculate the predicted value of class for training data using the threshold calculated using training data.

In [84]:
```
y_pred = (clf.predict_proba(X_tr_LR_BOW.toarray())[:,1] >= optimim_threshold)*1
cf=confusion_matrix(y_tr,y_pred)
```

Printing confusion matrix for training data

In [85]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of training data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



As we have balanced the data, it can be seen in the confusion matrix that our model is not baised towards the majority class

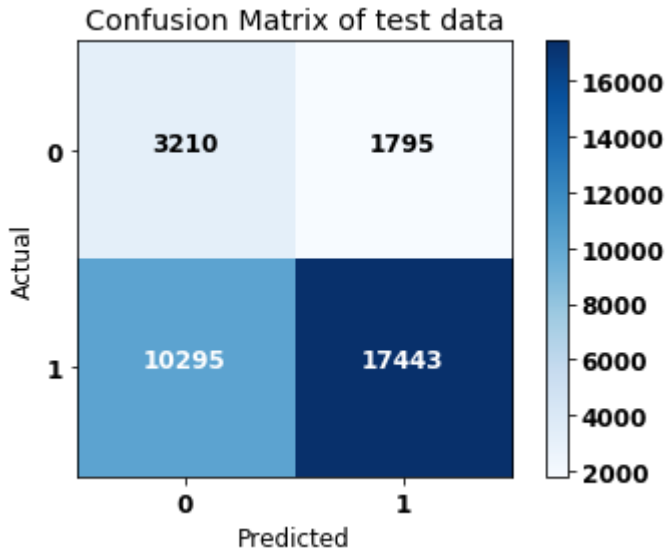
Confusion Matrix for Test data (BOW)

We calculate the predicted value of class for test data using the threshold calculated using training data.

In [86]:
```
y_pred = (clf.predict_proba(X_test_LR_BOW.toarray())[:,1] >= optimim_threshold)*
cf=confusion_matrix(y_test,y_pred)
```

Printing confusion matrix for test data

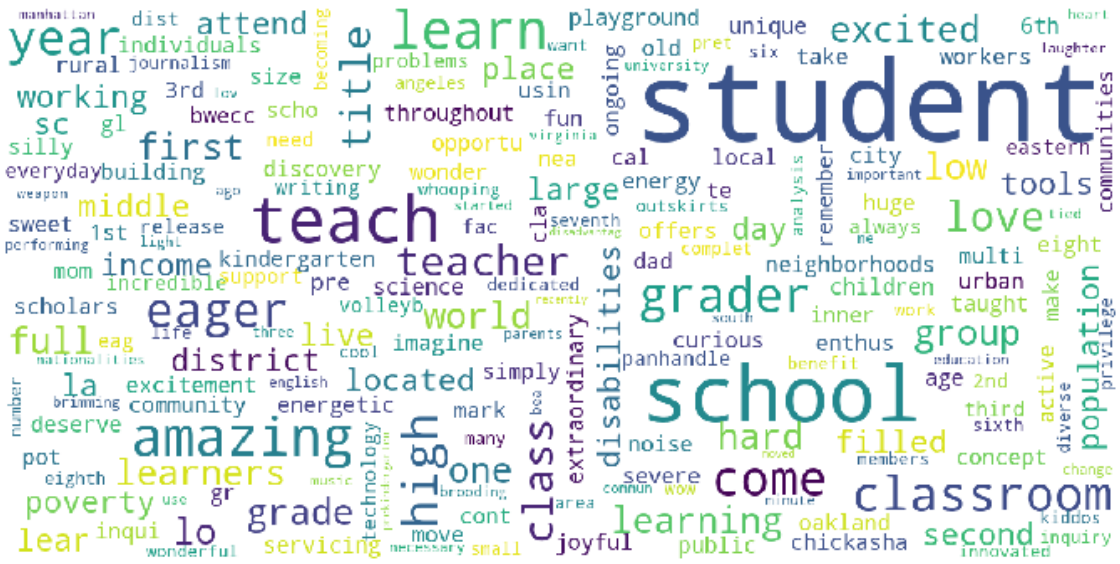
In [87]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of test data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



Wordcloud for False positive Essay

In [88]:
```
from wordcloud import WordCloud, STOPWORDS

print(len(X_test))
# Saving all false positive test data
X_test_FP = X_test[(y_test == 0) & (y_pred == 1)]
print(len(X_test_FP))

stopwords = set(STOPWORDS)

#https://stackoverflow.com/questions/16645799/how-to-create-a-word-cloud-from-a-

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()

show_wordcloud(X_test_FP['clean_essay'])
```

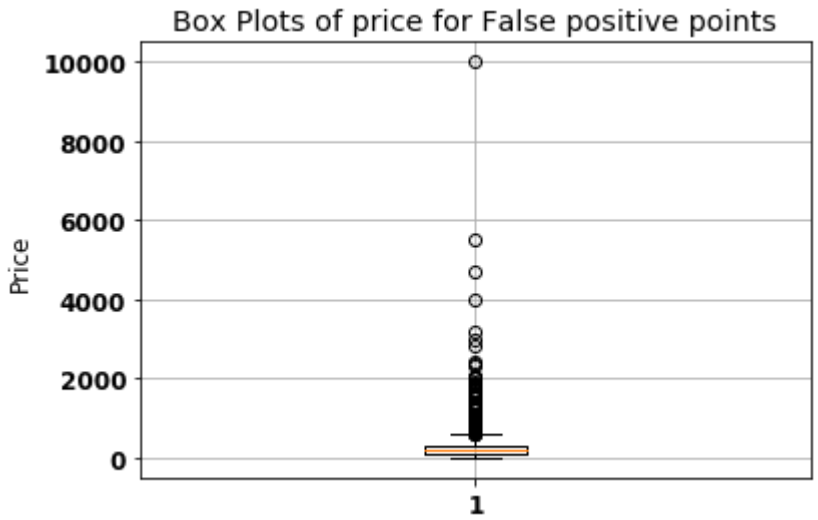
```
32743
1795
```



Box Plot with for price of false positive data points

In [89]:
```
price_FP = X_test_FP['price'].values
```

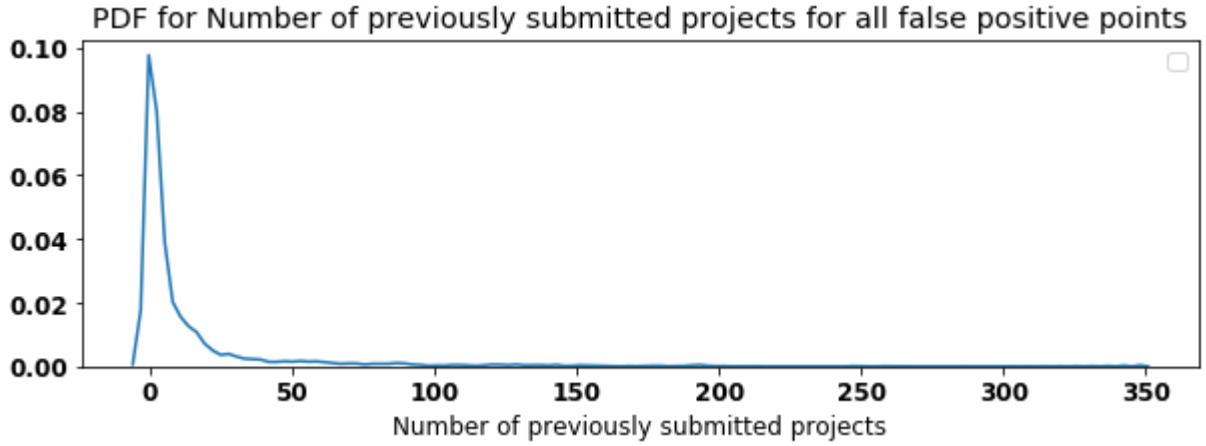
In [90]:
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot(price_FP)
plt.title('Box Plots of price for False positive points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



PDF with the teacher_number_of_previously_posted_projects of false positive data points

In [91]:
```
teacher_posted_projects_FP = X_test_FP['teacher_number_of_previously_posted_proje
plt.figure(figsize=(10,3))
sns.distplot(teacher_posted_projects_FP, hist=False)
plt.title('PDF for Number of previously submitted projects for all false positive
plt.xlabel('Number of previously submitted projects')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



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

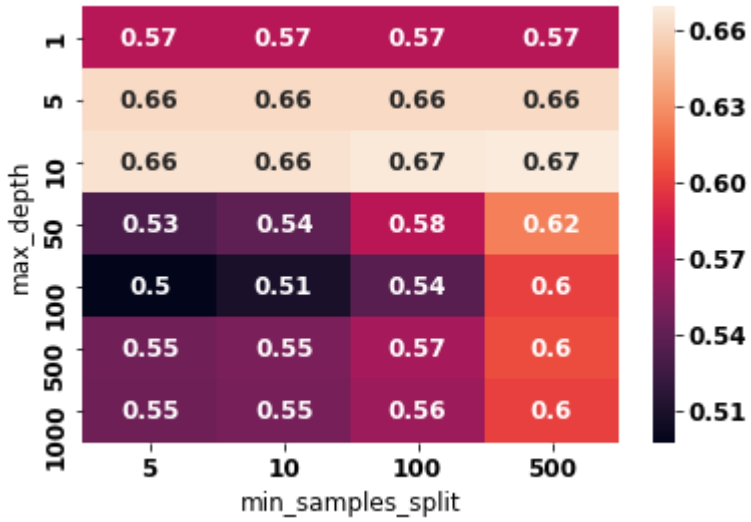
In [92]:
```
# First combine all features to create total matrix
X_tr_LR_TFIDF = hstack((X_tr_essay_tfidf,X_tr_project_title_tfidf,Tr_state_one_h
                        Tr_clean_grades_categories_one_hot,Tr_clean_categories_one
                        Tr_presence_of_numerical_digits_one_hot,
                        Tr_price_standardized, Tr_teacher_number_of_previously_pos
                        Tr_quantity_standardized
                       ))

X_test_LR_TFIDF = hstack((X_test_essay_tfidf,X_test_project_title_tfidf,Test_sta
                        Test_clean_grades_categories_one_hot,Test_clean_categories
                        Test_presence_of_numerical_digits_one_hot,
                        Test_price_standardized, Test_teacher_number_of_previously
                        Test_quantity_standardized
                       ))
print(X_tr_LR_TFIDF.shape)
print(X_test_LR_TFIDF.shape)
```

```
(76398, 7793)
(32743, 7793)
```

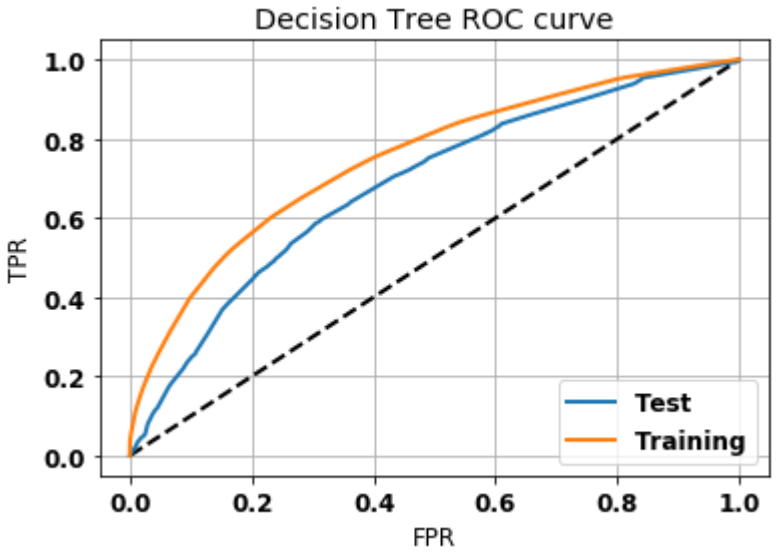
In [93]:
```
param_grid = {'max_depth':[ 1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500]}

#Hyper parameter Tuning for lamda with 3 fold cross validation
clf = DecisionTreeClassifier()

clf_cv= GridSearchCV(clf,param_grid,cv=2,scoring='roc_auc')

clf_cv.fit(X_tr_LR_TFIDF.toarray(),y_tr)

print(clf_cv.best_params_)

print(clf_cv.best_score_)

#https://www.kaggle.com/jinilcs/grid-search-to-find-best-tuning-parameters
results_df = pd.DataFrame(clf_cv.cv_results_)

scores = np.array(results_df.mean_test_score).reshape(7, 4)

sns.heatmap(scores, annot=True,
            yticklabels=param_grid['max_depth'], xticklabels=param_grid['min_sam
plt.ylabel('max_depth')
plt.xlabel('min_samples_split')
```

```
{'max_depth': 10, 'min_samples_split': 500}
0.6689275659951186
```

Out[93]:
```
Text(0.5, 12.0, 'min_samples_split')
```

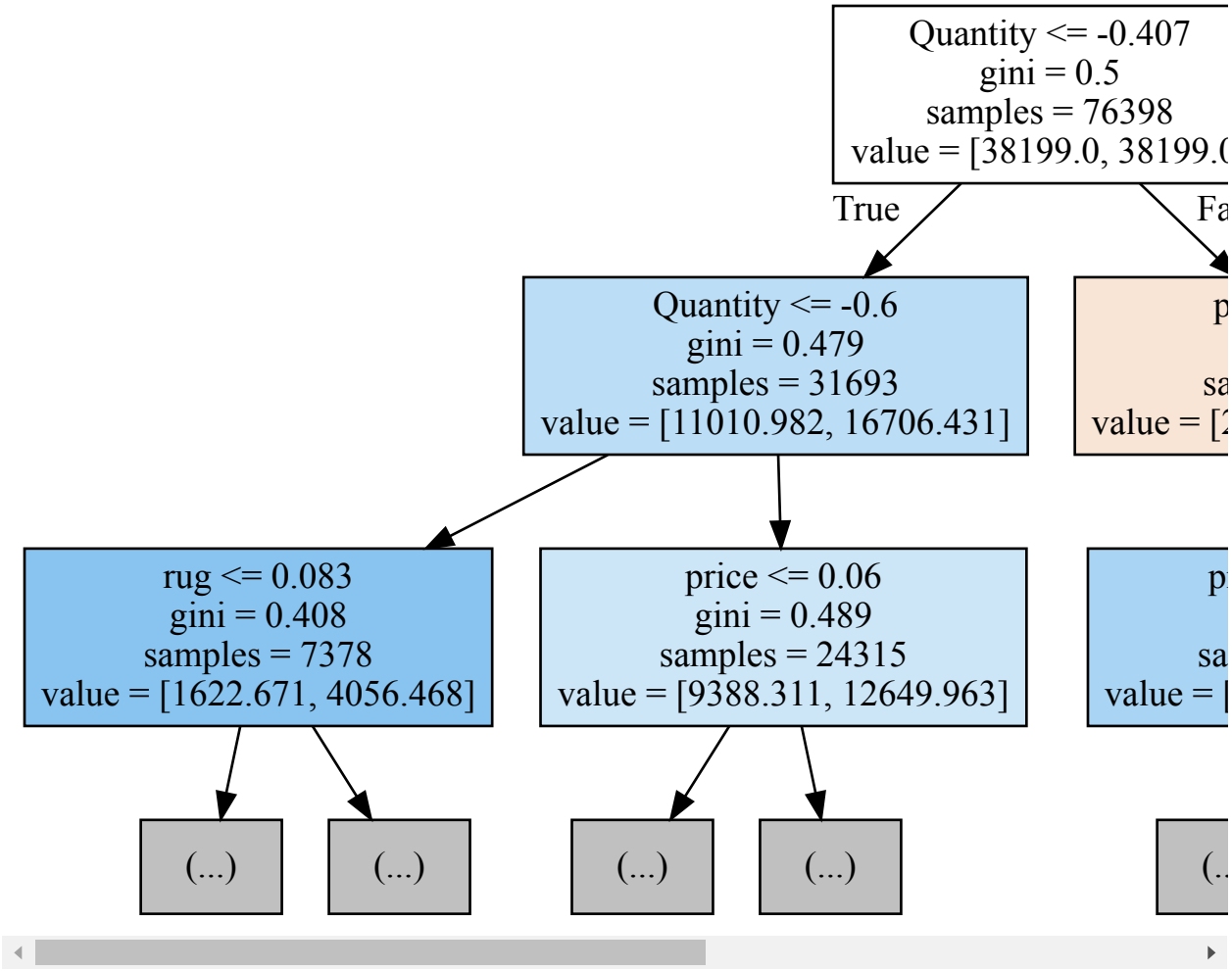


In [94]:
```
#Instantiate Classifier
clf = DecisionTreeClassifier(class_weight='balanced',max_depth=clf_cv.best_params
clf.fit(X_tr_LR_TFIDF.toarray(),y_tr)
y_pred_proba_test = clf.predict_proba(X_test_LR_TFIDF.toarray())[:,1]
y_pred_proba_tr = clf.predict_proba(X_tr_LR_TFIDF.toarray())[:,1]
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, y_pred_proba_test)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(y_tr, y_pred_proba_tr)
plt.plot([0,1],[0,1],'k--',linewidth=2.0)
plt.plot(fpr_test,tpr_test, label='Test',linewidth=2.0)
plt.plot(fpr_tr,tpr_tr, label='Training',linewidth=2.0)
plt.xlabel('FPR')
plt.ylabel('TPR')
pylab.legend(loc='lower right')
plt.title('Decision Tree ROC curve')
plt.grid()
plt.show()
#Area under ROC curve
print('The Training AUC (area under curve) for hypertuned parameter maximum depth
print('The Test AUC (area under curve) for hypertuned parameter maximum depth={}

test_AUC_TFIDF = roc_auc_score(y_test,y_pred_proba_test)
training_AUC_TFIDF = roc_auc_score(y_tr,y_pred_proba_tr)
depth_TFIDF = clf_cv.best_params_.get('max_depth')
split_TFIDF = clf_cv.best_params_.get('min_samples_split')
```




```
The Training AUC (area under curve) for hypertuned parameter maximum depth=10 a
nd min_samples_split =500 = 0.7478566371303043
The Test AUC (area under curve) for hypertuned parameter maximum depth=10 and m
in_samples_split =500 = 0.6824250052348689
```

In [95]:
```
from graphviz import Digraph
import os
os.environ["PATH"] += os.pathsep + 'J:/Program Files (x86)/Graphviz2.38/bin/'

from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn import tree
from IPython.display import SVG
from graphviz import Source
from IPython.display import display

graph = Source(tree.export_graphviz(clf, out_file=None, max_depth=2, filled = Tru
display(SVG(graph.pipe(format='svg')))
```



Finding optimum threshold value

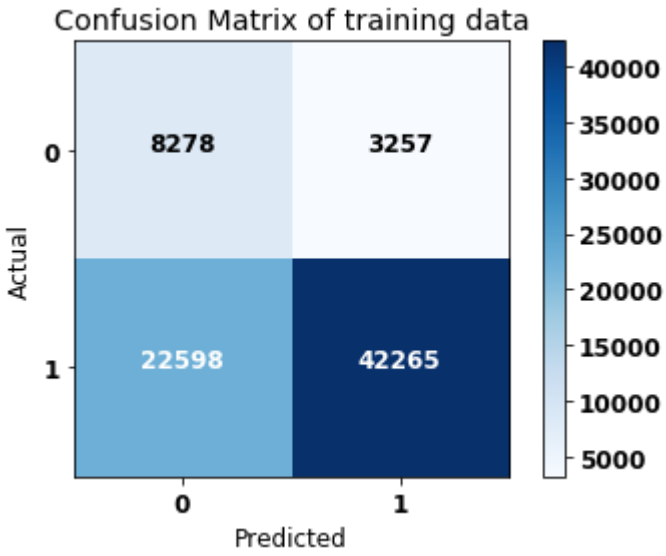
Finding optimum threshold using training data for high tpr and low fpr. For this we use maximum value of parameter tr=tpr*(1-fpr)

In [96]:
```
i = np.arange(0,len(tpr_tr)) # index for df
roc = pd.DataFrame({'fpr' : pd.Series(fpr_tr, index=i),'tpr' : pd.Series(tpr_tr,
roc.ix[(roc.tf-0).abs().argsort()[:1]]

index=roc['tf'].idxmax()

optimim_threshold=roc['thresholds'].iloc[index]
print(roc.iloc[index])
print(optimim_threshold)
```

```
fpr           0.282358
tpr           0.651604
1-fpr         0.717642
tf            0.467618
thresholds    0.476826
Name: 72, dtype: float64
0.47682638008789757
```

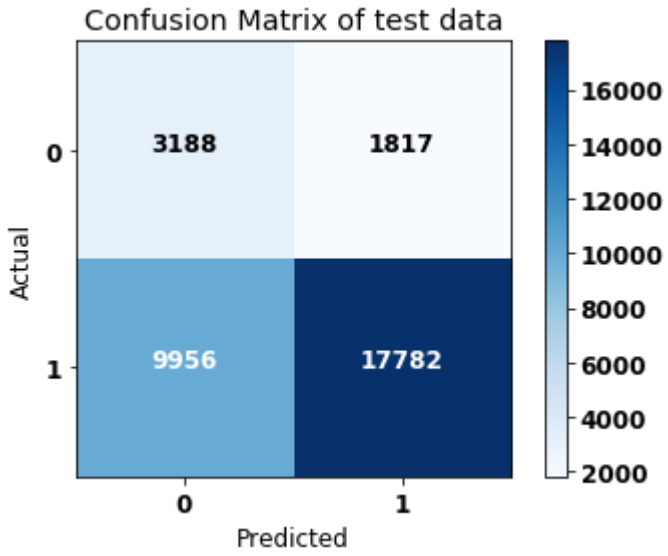
In [97]:
```
y_pred = (clf.predict_proba(X_tr_LR_TFIDF.toarray())[:,1] >= optimim_threshold)*1
cf=confusion_matrix(y_tr,y_pred)
```

In [98]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of training data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



In [99]:
```
y_pred = (clf.predict_proba(X_test_LR_TFIDF.toarray())[:,1] >= optimim_threshold
cf=confusion_matrix(y_test,y_pred)
```

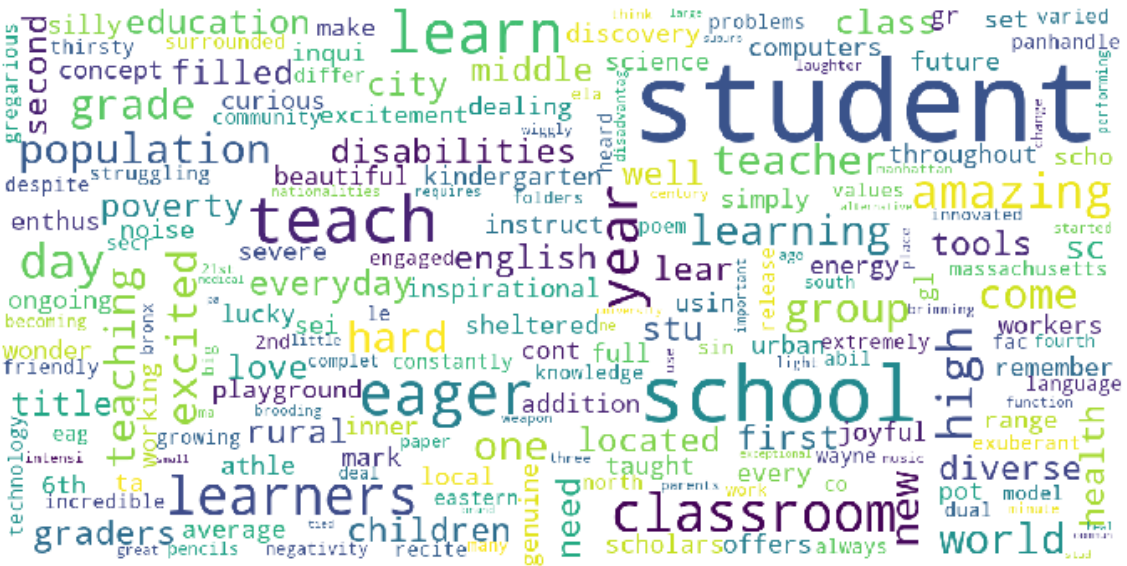
In [100]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of test data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



Wordcloud for False positive Essay

In [101]:
```
from wordcloud import WordCloud, STOPWORDS

print(len(X_test))
# Saving all false positive test data
X_test_FP = X_test[(y_test == 0) & (y_pred == 1)]
print(len(X_test_FP))

stopwords = set(STOPWORDS)

#https://stackoverflow.com/questions/16645799/how-to-create-a-word-cloud-from-a-

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()

show_wordcloud(X_test_FP['clean_essay'])
```

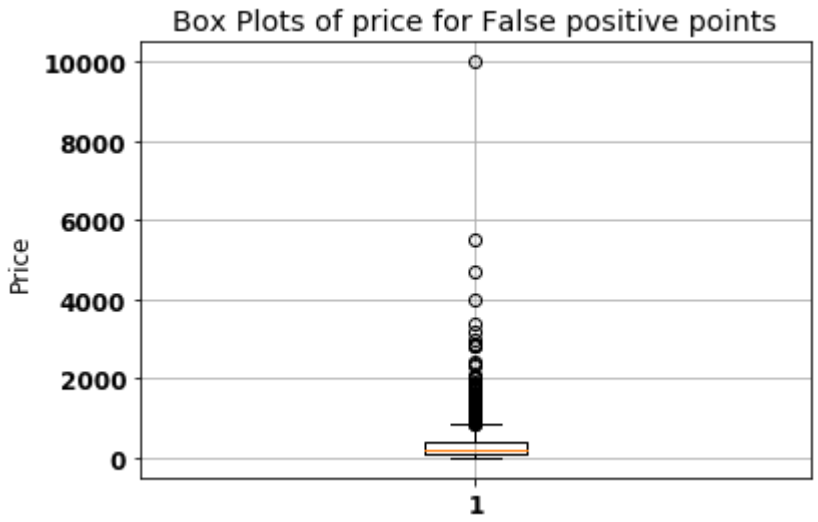
```
32743
1817
```



Box Plot with for price of false positive data points

In [102]:
```
price_FP = X_test_FP['price'].values
```

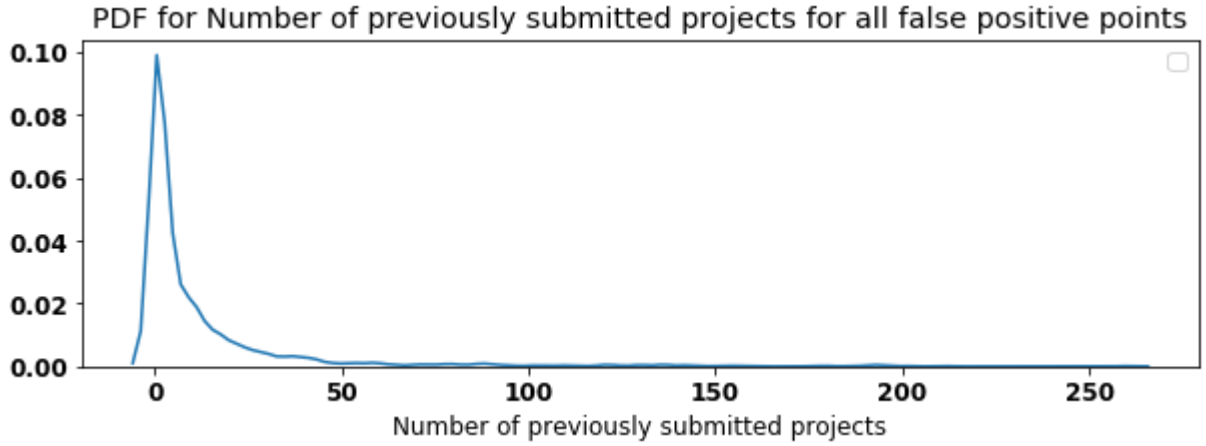
In [103]:
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot(price_FP)
plt.title('Box Plots of price for False positive points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



PDF with the teacher_number_of_previously_posted_projects of false positive data points

In [104]:
```
teacher_posted_projects_FP = X_test_FP['teacher_number_of_previously_posted_proje
plt.figure(figsize=(10,3))
sns.distplot(teacher_posted_projects_FP, hist=False)
plt.title('PDF for Number of previously submitted projects for all false positive
plt.xlabel('Number of previously submitted projects')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



Select 5000 best features using feature_importance

In [105]:
```
def selectKImportance(model, X, k):
     return X[:,model.feature_importances_.argsort()[::-1][:k]]
```

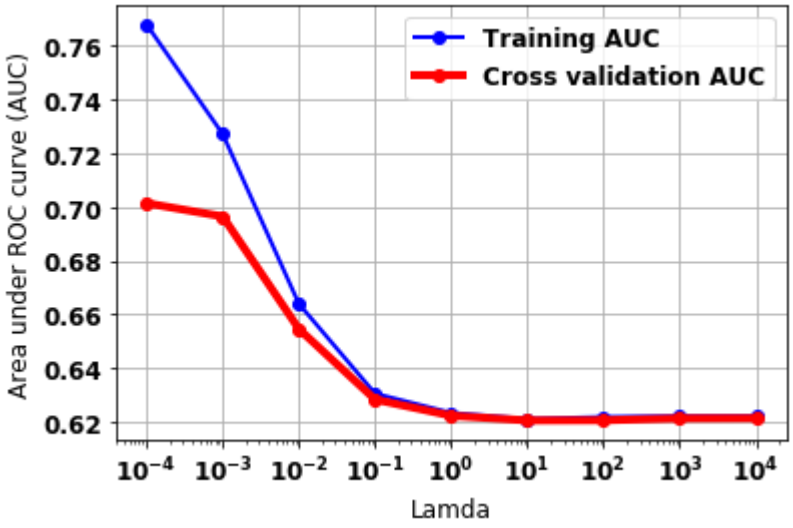
In [106]:
```
clf = DecisionTreeClassifier(class_weight='balanced',max_depth=clf_cv.best_params
clf.fit(X_tr_LR_TFIDF.toarray(),y_tr)
X_tr_LR_TFIDF_csr = X_tr_LR_TFIDF.tocsr()
X_tr_LR_TFIDF_selected = selectKImportance(clf,X_tr_LR_TFIDF_csr,5000)
X_tr_LR_TFIDF_selected.tocoo()
print(X_tr_LR_TFIDF_selected.shape)

X_test_LR_TFIDF_csr = X_test_LR_TFIDF.tocsr()
X_test_LR_TFIDF_selected = selectKImportance(clf,X_test_LR_TFIDF_csr,5000)
X_test_LR_TFIDF_selected.tocoo()
print(X_test_LR_TFIDF_selected.shape)
```

```
(76398, 5000)
(32743, 5000)
```

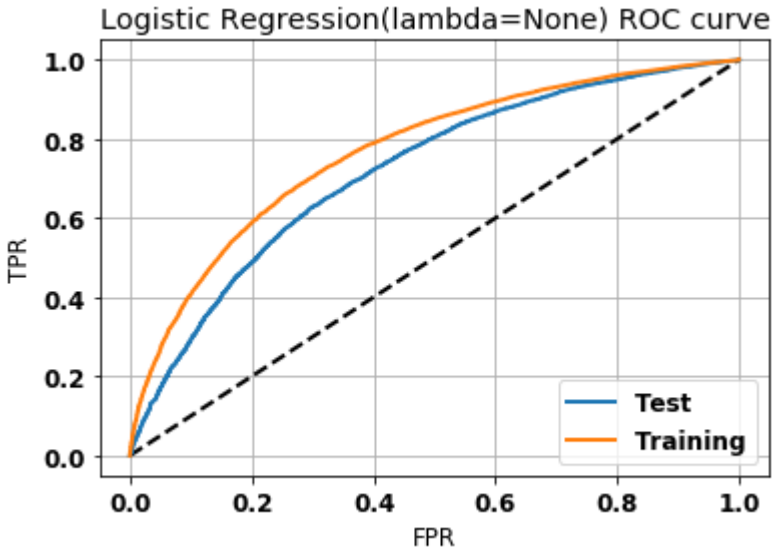
Apply Logistic Regression on the 5000 selected features

In [107]:
```
from sklearn.model_selection import GridSearchCV
from sklearn import linear_model

k=[ 0.0001,0.001,0.01,0.1,1,10,100,1000,10000]

param_grid = {'alpha':[ 0.0001,0.001,0.01,0.1,1,10,100,1000,10000]}

#Hyper parameter Tuning for lamda with 3 fold cross validation
clf = linear_model.SGDClassifier(loss='log',class_weight='balanced')

clf_cv= GridSearchCV(clf,param_grid,cv=3,scoring='roc_auc')

clf_cv.fit(X_tr_LR_TFIDF_selected.toarray(),y_tr)

print("The best value of AOC = {} is given by best lamda value of = {} ".format(

#Plotting AUC

train_AUC=clf_cv.cv_results_['mean_train_score']

cv_AUC=clf_cv.cv_results_['mean_test_score']



pylab.plot(k, train_AUC, '-b', label='Training AUC',linewidth=2.0,marker='o')
pylab.plot(k, cv_AUC, '-r', label='Cross validation AUC',linewidth=4.0,marker='o
pylab.legend(loc='upper right')
pylab.xlabel('Lamda')
pylab.ylabel('Area under ROC curve (AUC)')
pylab.xscale("log")
pylab.grid()
pylab.show()
```

```
The best value of AOC = 0.7013722370569303 is given by best lamda value of = 0.
0001
```



In [108]:
```
#Instantiate Classifier
clf = linear_model.SGDClassifier(loss='log',class_weight='balanced',alpha=clf_cv
clf.fit(X_tr_LR_TFIDF_selected.toarray(),y_tr)
y_pred_proba_test = clf.predict_proba(X_test_LR_TFIDF_selected.toarray())[:,1]
y_pred_proba_tr = clf.predict_proba(X_tr_LR_TFIDF_selected.toarray())[:,1]
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, y_pred_proba_test)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(y_tr, y_pred_proba_tr)
plt.plot([0,1],[0,1],'k--',linewidth=2.0)
plt.plot(fpr_test,tpr_test, label='Test',linewidth=2.0)
plt.plot(fpr_tr,tpr_tr, label='Training',linewidth=2.0)
plt.xlabel('FPR')
plt.ylabel('TPR')
pylab.legend(loc='lower right')
plt.title('Logistic Regression(lambda={}) ROC curve'.format(clf_cv.best_params_.
plt.grid()
plt.show()
#Area under ROC curve
print('The Training AUC (area under curve) for hypertuned parameter lamda={} = {
print('The Test AUC (area under curve) for hypertuned parameter lambda={} = {}'.

test_AUC_TFIDF_LR = roc_auc_score(y_test,y_pred_proba_test)
training_AUC_TFIDF_LR = roc_auc_score(y_tr,y_pred_proba_tr)
k_TFIDF_LR = clf_cv.best_params_.get('alpha')
```



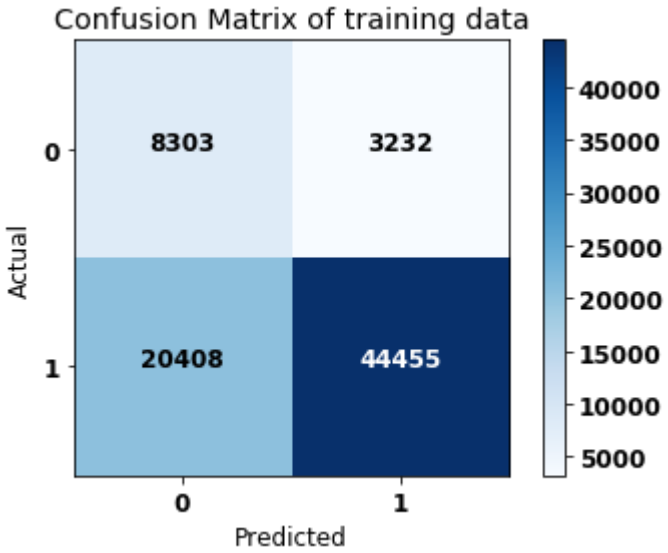

```
The Training AUC (area under curve) for hypertuned parameter lamda=0.0001 = 0.7
670774073441218
The Test AUC (area under curve) for hypertuned parameter lambda=0.0001 = 0.7181
030592451747
```

In [109]:
```
#https://stackoverflow.com/questions/28719067/roc-curve-and-cut-off-point-python
i = np.arange(0,len(tpr_tr))
roc = pd.DataFrame({'fpr' : pd.Series(fpr_tr, index=i),'tpr' : pd.Series(tpr_tr,
roc.ix[(roc.tf-0).abs().argsort()[:1]]

index=roc['tf'].idxmax()

optimim_threshold=roc['thresholds'].iloc[index]
print(roc.iloc[index])
print(optimim_threshold)
```

```
fpr           0.280191
tpr           0.685368
1-fpr         0.719809
tf            0.493334
thresholds    0.514016
Name: 5886, dtype: float64
0.5140158262216299
```

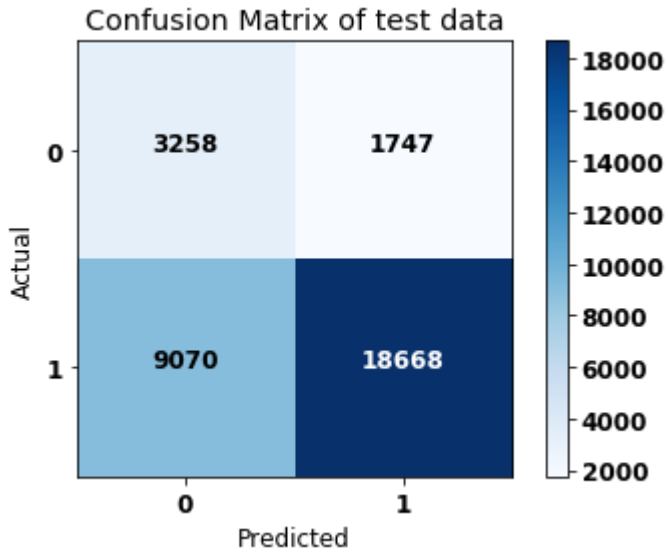
In [110]:
```
y_pred = (clf.predict_proba(X_tr_LR_TFIDF_selected.toarray())[:,1] >= optimim_thr
cf=confusion_matrix(y_tr,y_pred)
```

In [111]:
```
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of training data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' 
plt.show();
```



In [112]:
```
y_pred = (clf.predict_proba(X_test_LR_TFIDF_selected.toarray())[:,1] >= optimim_
cf=confusion_matrix(y_test,y_pred)
```

In [113]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of test data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



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

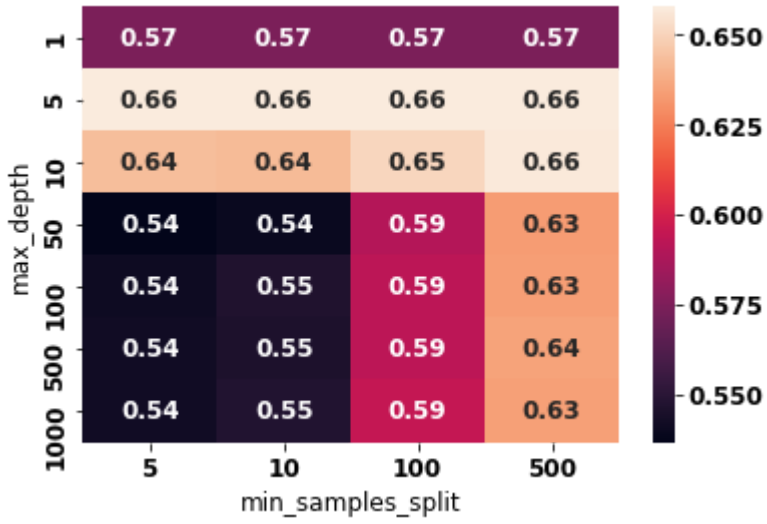
In [114]:
```
# First combine all features to create total matrix
X_tr_LR_avgw2v = hstack((Tr_quantity_standardized, Tr_teacher_number_of_previous
                         Tr_price_standardized,Tr_clean_subcategories_one_hot,Tr_c
                         Tr_clean_grades_categories_one_hot,Tr_clean_teacher_prefi
                         Tr_presence_of_numerical_digits_one_hot,
                         Tr_avg_w2v_vectors_essay, Tr_avg_w2v_vectors_project_titl


X_test_LR_avgw2v = hstack((Test_quantity_standardized, Test_teacher_number_of_pr
                         Test_price_standardized,Test_clean_subcategories_one_hot,
                         Test_clean_grades_categories_one_hot,Test_clean_teacher_p
                         Test_presence_of_numerical_digits_one_hot,Test_avg_w2v_ve
                         Test_avg_w2v_vectors_project_title))

print(X_tr_LR_avgw2v.shape)
print(X_test_LR_avgw2v.shape)
```

```
(76398, 204)
(32743, 204)
```

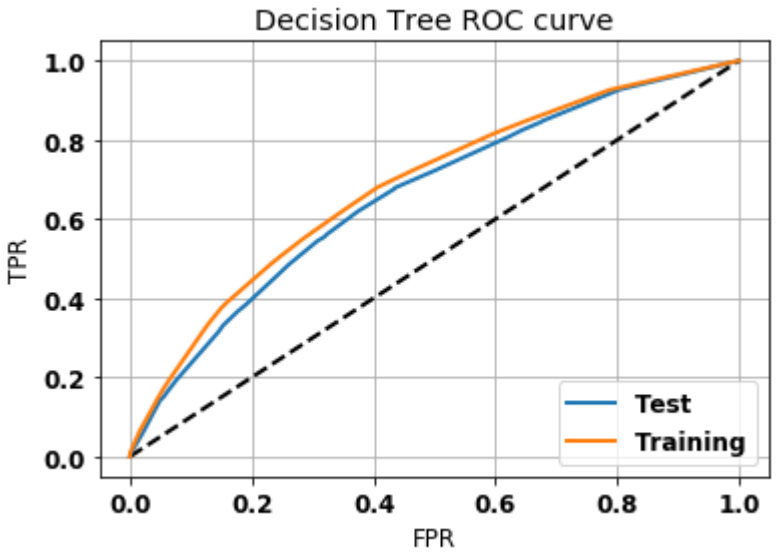
In [115]:
```
param_grid = {'max_depth':[ 1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500]}

#Hyper parameter Tuning for lamda with 3 fold cross validation
clf = DecisionTreeClassifier()

clf_cv= GridSearchCV(clf,param_grid,cv=2,scoring='roc_auc')

clf_cv.fit(X_tr_LR_avgw2v.toarray(),y_tr)

print(clf_cv.best_params_)

print(clf_cv.best_score_)

#https://www.kaggle.com/jinilcs/grid-search-to-find-best-tuning-parameters
results_df = pd.DataFrame(clf_cv.cv_results_)

scores = np.array(results_df.mean_test_score).reshape(7, 4)

sns.heatmap(scores, annot=True,
            yticklabels=param_grid['max_depth'], xticklabels=param_grid['min_sam
plt.ylabel('max_depth')
plt.xlabel('min_samples_split')
```

```
{'max_depth': 5, 'min_samples_split': 500}
0.6578551573231365
```

Out[115]:
```
Text(0.5, 12.0, 'min_samples_split')
```



In [116]:
```
#Instantiate Classifier
clf = DecisionTreeClassifier(class_weight='balanced',max_depth=clf_cv.best_params
clf.fit(X_tr_LR_avgw2v.toarray(),y_tr)
y_pred_proba_test = clf.predict_proba(X_test_LR_avgw2v.toarray())[:,1]
y_pred_proba_tr = clf.predict_proba(X_tr_LR_avgw2v.toarray())[:,1]
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, y_pred_proba_test)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(y_tr, y_pred_proba_tr)
plt.plot([0,1],[0,1],'k--',linewidth=2.0)
plt.plot(fpr_test,tpr_test, label='Test',linewidth=2.0)
plt.plot(fpr_tr,tpr_tr, label='Training',linewidth=2.0)
plt.xlabel('FPR')
plt.ylabel('TPR')
pylab.legend(loc='lower right')
plt.title('Decision Tree ROC curve')
plt.grid()
plt.show()
#Area under ROC curve
print('The Training AUC (area under curve) for hypertuned parameter maximum depth
print('The Test AUC (area under curve) for hypertuned parameter maximum depth={}

test_AUC_AVGW2V = roc_auc_score(y_test,y_pred_proba_test)
training_AUC_AVGW2V = roc_auc_score(y_tr,y_pred_proba_tr)
depth_AVGW2V = clf_cv.best_params_.get('max_depth')
split_AVGW2V = clf_cv.best_params_.get('min_samples_split')
```




```
The Training AUC (area under curve) for hypertuned parameter maximum depth=5 an
d min_samples_split =500 = 0.6825074049408034
The Test AUC (area under curve) for hypertuned parameter maximum depth=5 and mi
n_samples_split =500 = 0.6600198849387688
```

Finding optimum threshold value

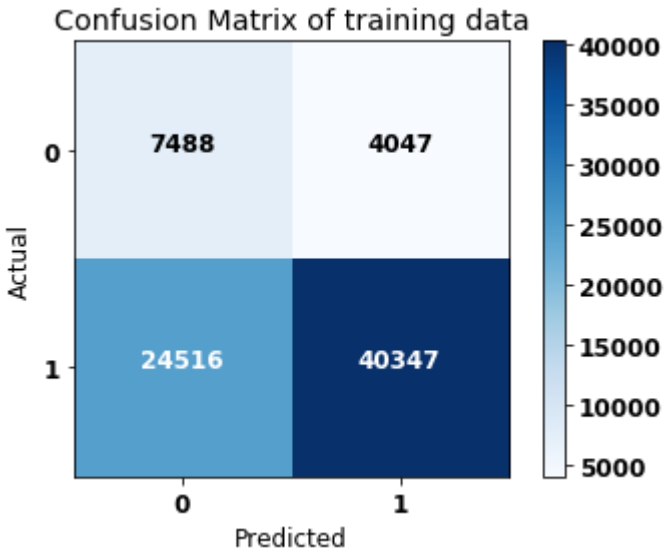
Finding optimum threshold using training data for high tpr and low fpr. For this we use maximum value of parameter tr=tpr*(1-fpr)

In [117]:
```
i = np.arange(0,len(tpr_tr)) # index for df
roc = pd.DataFrame({'fpr' : pd.Series(fpr_tr, index=i),'tpr' : pd.Series(tpr_tr,
roc.ix[(roc.tf-0).abs().argsort()[:1]]

index=roc['tf'].idxmax()

optimim_threshold=roc['thresholds'].iloc[index]
print(roc.iloc[index])
print(optimim_threshold)
```

```
fpr           0.350845
tpr           0.622034
1-fpr         0.649155
tf            0.403796
thresholds    0.519292
Name: 18, dtype: float64
0.5192918534600441
```

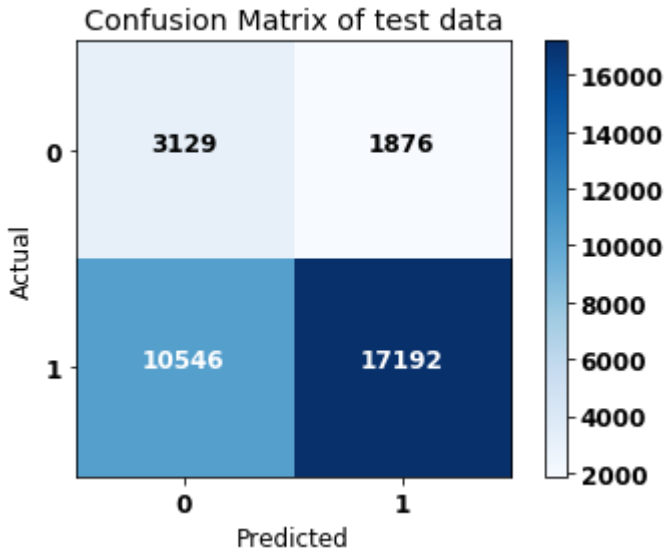
In [118]:
```
y_pred = (clf.predict_proba(X_tr_LR_avgw2v.toarray())[:,1] >= optimim_threshold)
cf=confusion_matrix(y_tr,y_pred)
```

In [119]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of training data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



In [120]:
```
y_pred = (clf.predict_proba(X_test_LR_avgw2v.toarray())[:,1] >= optimim_threshol
cf=confusion_matrix(y_test,y_pred)
```

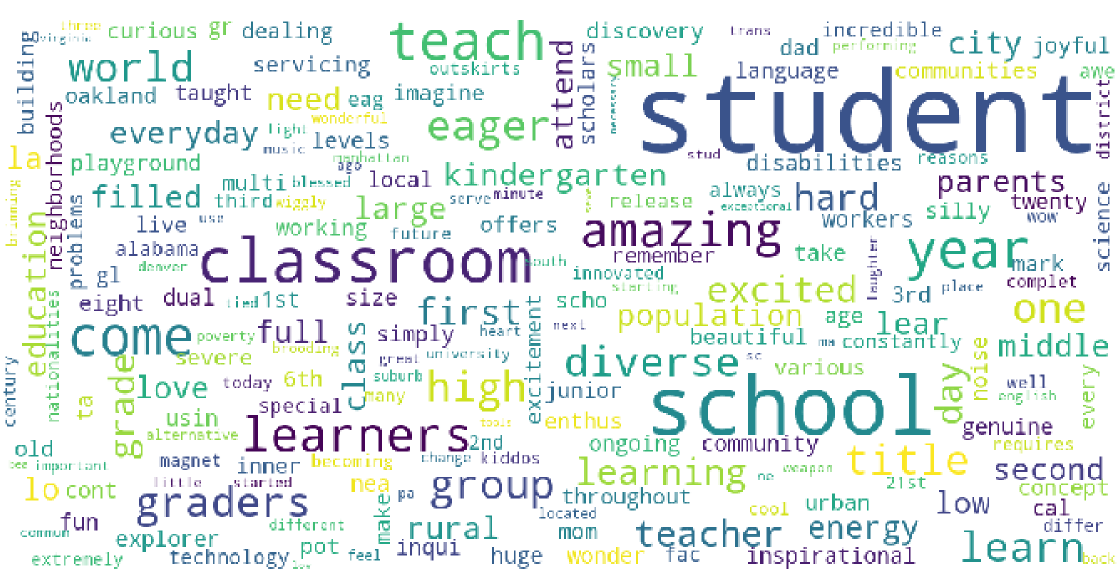
In [121]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of test data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



Wordcloud for False positive Essay

In [122]:
```
from wordcloud import WordCloud, STOPWORDS

print(len(X_test))
# Saving all false positive test data
X_test_FP = X_test[(y_test == 0) & (y_pred == 1)]
print(len(X_test_FP))

stopwords = set(STOPWORDS)

#https://stackoverflow.com/questions/16645799/how-to-create-a-word-cloud-from-a-c

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()

show_wordcloud(X_test_FP['clean_essay'])
```

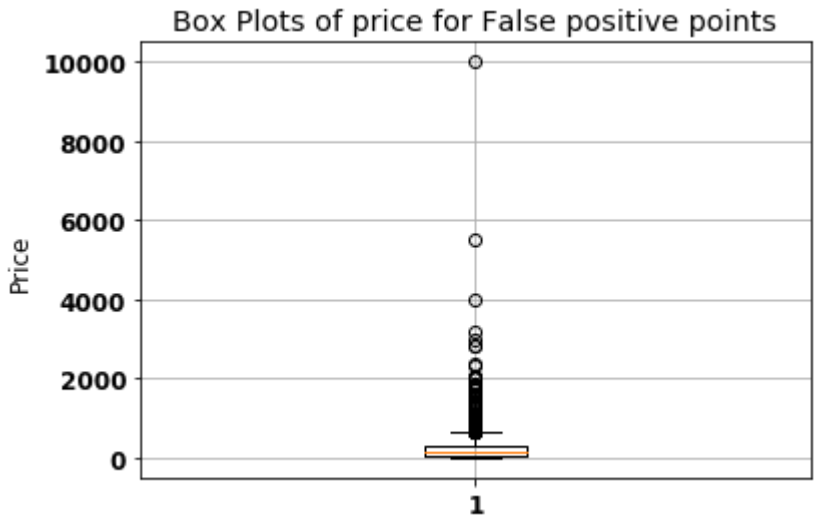
```
32743
1876
```



Box Plot with for price of false positive data points

In [123]:
```
price_FP = X_test_FP['price'].values
```

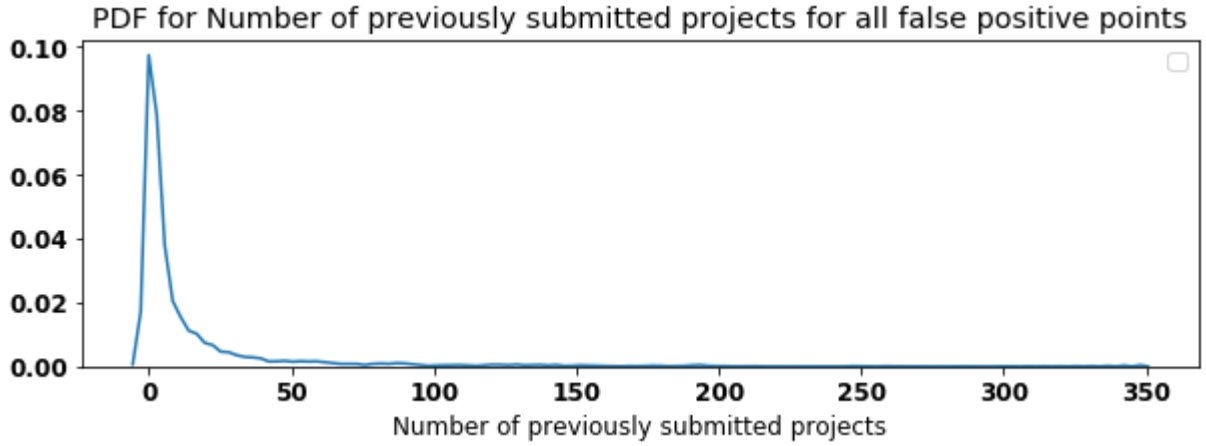
In [124]:
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot(price_FP)
plt.title('Box Plots of price for False positive points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



PDF with the teacher_number_of_previously_posted_projects of false positive data points

In [125]:
```
teacher_posted_projects_FP = X_test_FP['teacher_number_of_previously_posted_proje
plt.figure(figsize=(10,3))
sns.distplot(teacher_posted_projects_FP, hist=False)
plt.title('PDF for Number of previously submitted projects for all false positive
plt.xlabel('Number of previously submitted projects')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



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

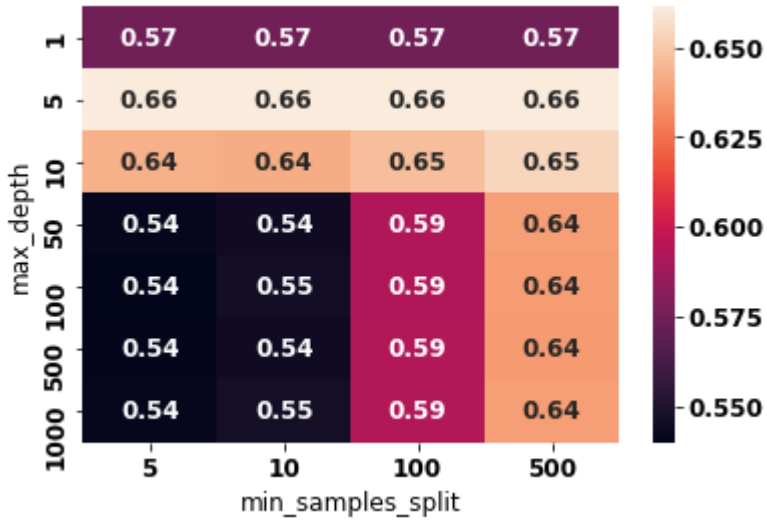
In [126]:
```
# First combine all features to create total matrix
X_tr_LR_tfidfw2v = hstack((Tr_quantity_standardized, Tr_teacher_number_of_previou
                        Tr_price_standardized,Tr_clean_subcategories_one_hot,Tr_c
                        Tr_clean_grades_categories_one_hot,Tr_clean_teacher_prefi
                        Tr_presence_of_numerical_digits_one_hot,tr_tfidf_w2v_vect


X_test_LR_tfidfw2v = hstack((Test_quantity_standardized, Test_teacher_number_of_
                        Test_price_standardized,Test_clean_subcategories_one_hot,
                        Test_clean_grades_categories_one_hot,Test_clean_teacher_p
                        Test_presence_of_numerical_digits_one_hot,Test_tfidf_w2v_
                        Test_tfidf_w2v_vectors_project_title))

print(X_tr_LR_tfidfw2v.shape)
print(X_test_LR_tfidfw2v.shape)
```

```
(76398, 204)
(32743, 204)
```

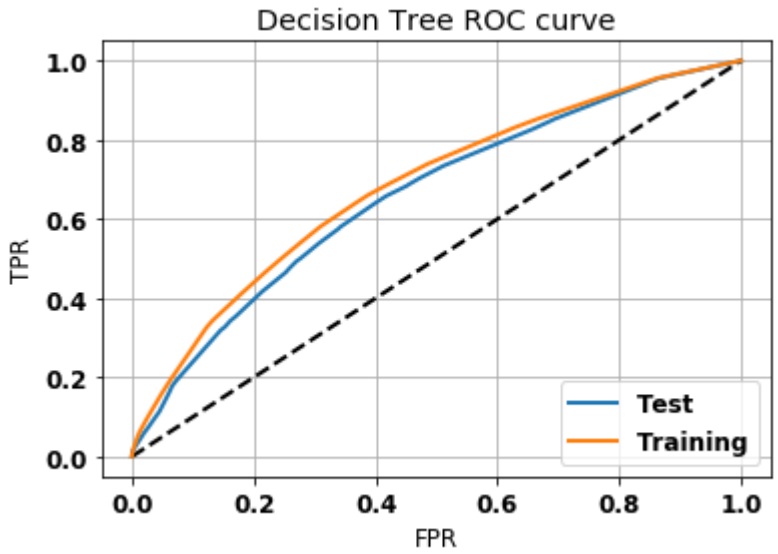
In [127]:
```
param_grid = {'max_depth':[ 1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500]}

#Hyper parameter Tuning for lamda with 3 fold cross validation
clf = DecisionTreeClassifier()

clf_cv= GridSearchCV(clf,param_grid,cv=2,scoring='roc_auc')

clf_cv.fit(X_tr_LR_tfidfw2v.toarray(),y_tr)

print(clf_cv.best_params_)

print(clf_cv.best_score_)

#https://www.kaggle.com/jinilcs/grid-search-to-find-best-tuning-parameters
results_df = pd.DataFrame(clf_cv.cv_results_)

scores = np.array(results_df.mean_test_score).reshape(7, 4)

sns.heatmap(scores, annot=True,
            yticklabels=param_grid['max_depth'], xticklabels=param_grid['min_sam
plt.ylabel('max_depth')
plt.xlabel('min_samples_split')
```

```
{'max_depth': 5, 'min_samples_split': 500}
0.6613760986655589
```

Out[127]:
```
Text(0.5, 12.0, 'min_samples_split')
```



In [128]:
```
#Instantiate Classifier
clf = DecisionTreeClassifier(class_weight='balanced',max_depth=clf_cv.best_params
clf.fit(X_tr_LR_tfidfw2v.toarray(),y_tr)
y_pred_proba_test = clf.predict_proba(X_test_LR_tfidfw2v.toarray())[:,1]
y_pred_proba_tr = clf.predict_proba(X_tr_LR_tfidfw2v.toarray())[:,1]
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, y_pred_proba_test)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(y_tr, y_pred_proba_tr)
plt.plot([0,1],[0,1],'k--',linewidth=2.0)
plt.plot(fpr_test,tpr_test, label='Test',linewidth=2.0)
plt.plot(fpr_tr,tpr_tr, label='Training',linewidth=2.0)
plt.xlabel('FPR')
plt.ylabel('TPR')
pylab.legend(loc='lower right')
plt.title('Decision Tree ROC curve')
plt.grid()
plt.show()
#Area under ROC curve
print('The Training AUC (area under curve) for hypertuned parameter maximum depth
print('The Test AUC (area under curve) for hypertuned parameter maximum depth={}

test_AUC_TFIDFW2V = roc_auc_score(y_test,y_pred_proba_test)
training_AUC_TFIDFW2V = roc_auc_score(y_tr,y_pred_proba_tr)
depth_TFIDFW2V = clf_cv.best_params_.get('max_depth')
split_TFIDFW2V = clf_cv.best_params_.get('min_samples_split')
```




```
The Training AUC (area under curve) for hypertuned parameter maximum depth=5 an
d min_samples_split =500 = 0.6812332753678069
The Test AUC (area under curve) for hypertuned parameter maximum depth=5 and mi
n_samples_split =500 = 0.6581967243226166
```

Finding optimum threshold value

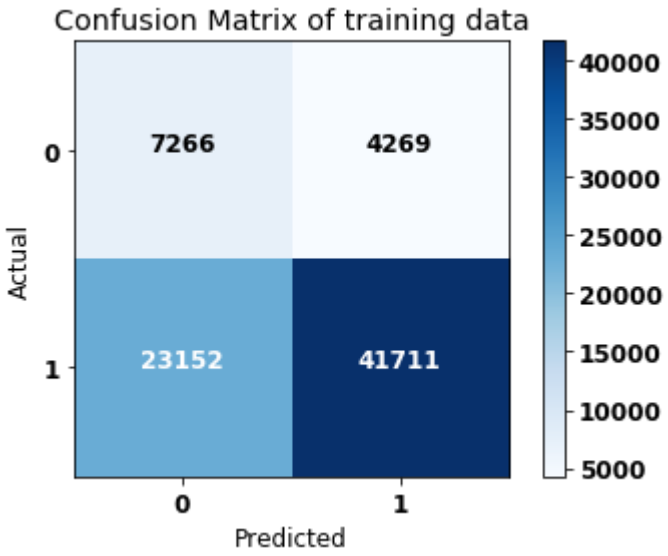
Finding optimum threshold using training data for high tpr and low fpr. For this we use maximum value of parameter tr=tpr*(1-fpr)

In [129]:
```
i = np.arange(0,len(tpr_tr)) # index for df
roc = pd.DataFrame({'fpr' : pd.Series(fpr_tr, index=i),'tpr' : pd.Series(tpr_tr,
roc.ix[(roc.tf-0).abs().argsort()[:1]]

index=roc['tf'].idxmax()

optimim_threshold=roc['thresholds'].iloc[index]
print(roc.iloc[index])
print(optimim_threshold)
```

```
fpr           0.370091
tpr           0.643063
1-fpr         0.629909
tf            0.405071
thresholds    0.506489
Name: 22, dtype: float64
0.5064887420408352
```

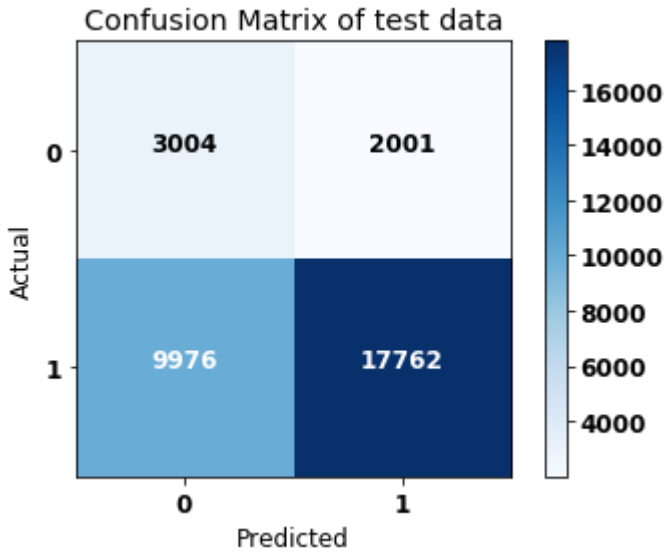
In [130]:
```
y_pred = (clf.predict_proba(X_tr_LR_tfidfw2v.toarray())[:,1] >= optimim_threshol
cf=confusion_matrix(y_tr,y_pred)
```

In [131]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of training data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



In [132]:
```
y_pred = (clf.predict_proba(X_test_LR_tfidfw2v.toarray())[:,1] >= optimim_thresh
cf=confusion_matrix(y_test,y_pred)
```

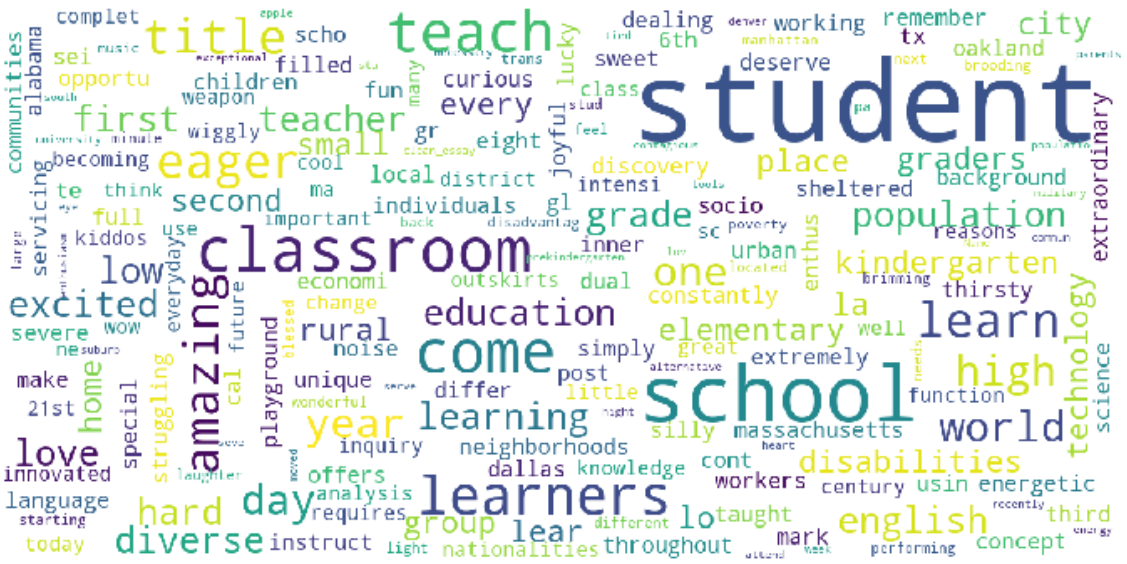
In [133]:
```
##https://www.kaggle.com/jprakashds/confusion-matrix-in-python-binary-class
import itertools
plt.imshow(cf,cmap=plt.cm.Blues,interpolation='nearest')
plt.colorbar()
plt.title('Confusion Matrix of test data')
plt.xlabel('Predicted')
plt.ylabel('Actual')
tick_marks = np.arange(len(set(y_test))) # length of classes
class_labels = ['0','1']
tick_marks
plt.xticks(tick_marks,class_labels)
plt.yticks(tick_marks,class_labels)
# plotting text value inside cells
thresh = cf.max() / 2.
for i,j in itertools.product(range(cf.shape[0]),range(cf.shape[1])):
    plt.text(j,i,format(cf[i,j],'d'),horizontalalignment='center',color='white' :
plt.show();
```



Wordcloud for False positive Essay

In [134]:
```
from wordcloud import WordCloud, STOPWORDS

print(len(X_test))
# Saving all false positive test data
X_test_FP = X_test[(y_test == 0) & (y_pred == 1)]
print(len(X_test_FP))

stopwords = set(STOPWORDS)

#https://stackoverflow.com/questions/16645799/how-to-create-a-word-cloud-from-a-

def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='white',
        stopwords=stopwords,
        max_words=200,
        max_font_size=40,
        scale=3,
        random_state=1 # chosen at random by flipping a coin; it was heads
    ).generate(str(data))

    fig = plt.figure(1, figsize=(12, 12))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()

show_wordcloud(X_test_FP['clean_essay'])
```

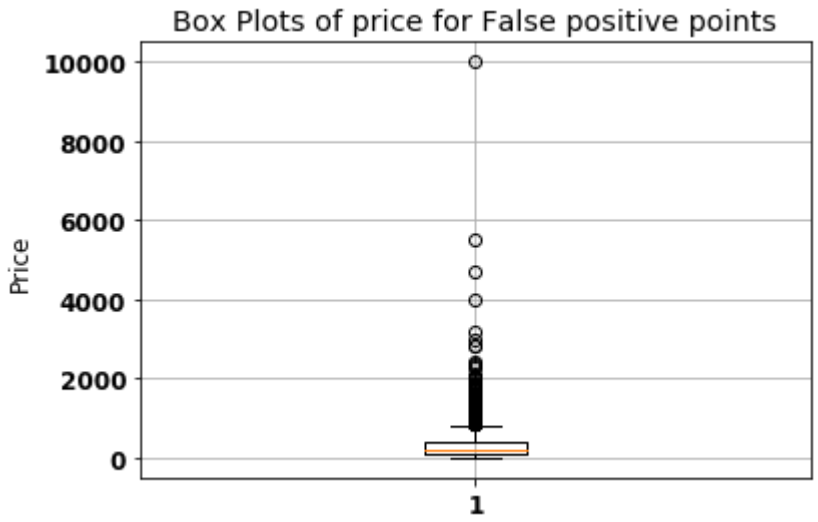
```
32743
2001
```



Box Plot with for price of false positive data points

In [135]:
```
price_FP = X_test_FP['price'].values
```

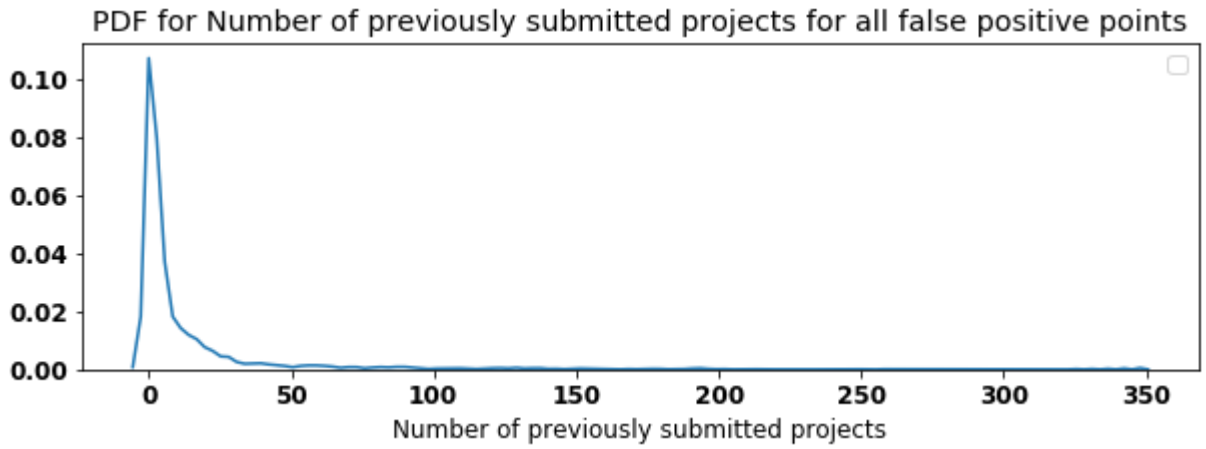
In [136]:
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot(price_FP)
plt.title('Box Plots of price for False positive points')
plt.ylabel('Price')
plt.grid()
plt.show()
```



PDF with the teacher_number_of_previously_posted_projects of false positive data points

In [137]:
```
teacher_posted_projects_FP = X_test_FP['teacher_number_of_previously_posted_proje
plt.figure(figsize=(10,3))
sns.distplot(teacher_posted_projects_FP, hist=False)
plt.title('PDF for Number of previously submitted projects for all false positive
plt.xlabel('Number of previously submitted projects')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```



9. Summarising results

In [138]:
```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Max_depth","min_samples_split","Test sc

x.add_row(["BOW", "Decision Tree", depth_BOW,split_BOW, test_AUC_BOW,training_AU
x.add_row(["TFIDF", "Decision Tree", depth_TFIDF,split_TFIDF, test_AUC_TFIDF,tra
x.add_row(["AVG W2V", "Decision Tree", depth_AVGW2V,split_AVGW2V, test_AUC_AVGW2
x.add_row(["TFIDF W2V", "Decision Tree", depth_TFIDFW2V,split_TFIDFW2V, test_AUC_


print(x)

from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "lamda","Test score (AUC)","Training sco

x.add_row(["TFIDF with 5000 selected features", "Logistic Regression", k_TFIDF_LI


print(x)
```

```
+------------+---------------+-----------+-------------------+-----------------
---+----------------------+
| Vectorizer |     Model     | Max_depth | min_samples_split |  Test score (AU
C)  | Training score (AUC) |
+------------+---------------+-----------+-------------------+-----------------
---+----------------------+
|    BOW     | Decision Tree |     10    |        500        | 0.68257372089299
42 |  0.7362523843308941  |
|   TFIDF    | Decision Tree |     10    |        500        | 0.68242500523486
89 |  0.7478566371303043  |
|  AVG W2V   | Decision Tree |     5     |        500        | 0.66001988493876
88 |  0.6825074049408034  |
| TFIDF W2V  | Decision Tree |     5     |        500        | 0.65819672432261
66 |  0.6812332753678069  |
+------------+---------------+-----------+-------------------+-----------------
---+----------------------+
+-----------------------------------+--------------------+--------+-----------
---------+----------------------+
|            Vectorizer             |       Model        | lamda  |  Test scor
e (AUC)  | Training score (AUC) |
+-----------------------------------+--------------------+--------+-----------
---------+----------------------+
| TFIDF with 5000 selected features | Logistic Regression | 0.0001 | 0.71810305
92451747 |  0.7670774073441218  |
+-----------------------------------+--------------------+--------+-----------
---------+----------------------+
```

10. Conclusion

1. Since we used class_weight ='balanced' now our confusion matrix is not baised towards majority class.

2. Although the time complexity of training phase is O(n* k* d) where n is the number of data points and k is the dimension and is the depth of the tree, the time complexity of test phase is just O(d). Therefore with two parameters to fit, it takes lot of time during training phase but is very quick for test phase for resonable depth.
3. Since we have done tuning of parameter using cross validation therefore we are not under or over fitting.
4. For DT, as the depth of the tree increases the impact of outliers increases however here since we obtain resonable depth using tuning therefore we should be affected by outliers.
5. We found 5000 best features using DT and fitted Logistic regression on it. This lead to imporvement of result.
6. DT have good interpretability of results specially for small depths.

In [ ]: