Assignment on DecisionTreeClassifier

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importing necessary libraries

In [1]:
```
import warnings
warnings.filterwarnings("ignore") # Ignore the Warnings

import sqlite3  # Lite database
import pandas as pd # Data processing
import numpy as np # Numerical Processing
import nltk # Natural Language Toolkit
import string # for strong processing
import matplotlib.pyplot as plt
import seaborn as sns # For visualization top on Matplotlib

# Text pre-processing using TFIDF concept
# TFIDF => Term Frequency- Inverse Document Frequency
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

# Text processing using BOW (Bag Of Words)
from sklearn.feature_extraction.text import CountVectorizer

# Metrics
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve, auc

# Stemming of word using PorterStemmer
from nltk.stem.porter import PorterStemmer
# Lemmatization of word using WordNetLemmatizer
from nltk.stem.wordnet import WordNetLemmatizer

# regular expression
import re

# stopwords
from nltk.corpus import stopwords


# Gensim models ###############
###############################

# change word to dense Vector
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
```

```
# to save the variable
import pickle

# to visualize the processing
from tqdm import tqdm

# operating system operation
import os

# Visualizations
from chart_studio import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()

# Counter
from collections import Counter
```

1. Loading Data

In [129]:
```
data  = pd.read_csv('preprocessed_data.csv', nrows=10000)
# data  = pd.read_csv('preprocessed_data.csv', nrows=50000) # you can take less number of rows like this
# I have preprocessed 50000 datapoints but it is taking a lot of time when using BOW, and TFIDF. so , finall
y, I decide to use
# just 10K datapoints because of I have resource constrained laptop.
# Thanks in advance to understand
data.head(2)
```

Out[129]:

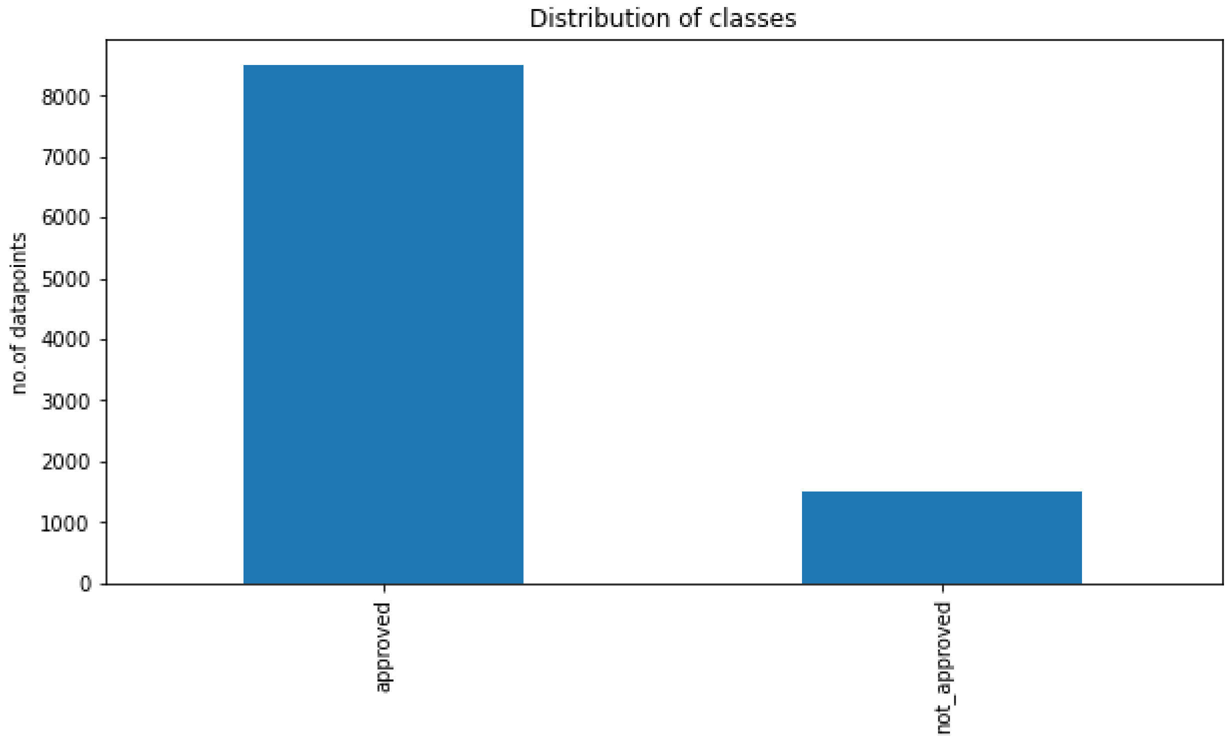
	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean
0	nv	ms	grades_prek_2	26	1	litera
1	ga	mrs	grades_3_5	1	0	music_arts_h

In [130]:
```
class_distribution = dict(data['project_is_approved'].value_counts())
class_distribution
```

Out[130]: {1: 8510, 0: 1490}

In [131]:
```
plt.figure(figsize=(10,5))
data['project_is_approved'].value_counts().plot(kind='bar')
plt.xticks([0,1],['approved','not_approved'])
plt.ylabel('no.of datapoints')
plt.title('Distribution of classes')
```

Out[131]: Text(0.5, 1.0, 'Distribution of classes')



1.2 Splitting into Train and Test dataset

In [132]:
```
x_columns = list(data.columns)
x_columns.remove('project_is_approved')
```

In [133]:
```
x_columns
```

Out[133]:
```
['school_state',
 'teacher_prefix',
 'project_grade_category',
 'teacher_number_of_previously_posted_projects',
 'clean_categories',
 'clean_subcategories',
 'essay',
 'price']
```

In [134]:
```
# X = data[x_columns].values
# Y = data['project_is_approved'].values
# Y = Y.reshape(-1,1)
```

In [135]:
```
# X.shape , Y.shape
```

In [136]:
```
# importing necessary libraries
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data[x_columns], data['project_is_approved'], test_size=
0.2, random_state=42)
```

In [137]:
```
type(X_train)
```

Out[137]:
```
pandas.core.frame.DataFrame
```

2. Vectorizing Text data

For both Train and Test

2.1 Bag of words

In [138]:
```
preprocessed_essays_train = X_train['essay'].values
preprocessed_essays_test  = X_test['essay'].values
```

In [139]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
text_bow_train = vectorizer.fit_transform(preprocessed_essays_train)
text_bow_test  = vectorizer.transform(preprocessed_essays_test)
print("Shape of train matrix after one hot encodig ",text_bow_train.shape)
print("Shape of test matrix after one hot encoding ", text_bow_test.shape)
```

```
Shape of train matrix after one hot encodig  (8000, 5752)
Shape of test matrix after one hot encoding  (2000, 5752)
```

In [140]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

2.2 TFIDF vectorizer

In [141]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf_train = vectorizer.fit_transform(preprocessed_essays_train)
text_tfidf_test = vectorizer.transform(preprocessed_essays_test)
print("Shape of matrix of train data after TFIDF encodig ",text_tfidf_train.shape)
print("Shape of matrix of test data after TFIDF encoding", text_tfidf_test.shape)
```

```
Shape of matrix of train data after TFIDF encodig  (8000, 5752)
Shape of matrix of test data after TFIDF encoding (2000, 5752)
```

2.3 Using Pretrained Models: Avg W2V

In [142]:
```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words Loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

# ============================

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

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

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

words_courpus = {}
words_glove = set(model.keys())
for i in words:
    if i in words_glove:
```

```
        words_courpus[i] = model[i]
print("word 2 vec length", len(words_courpus))


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load
-variables-in-python/

import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_courpus, f)


'''
```

Out[142]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef loadGloveModel(gloveF
ile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n
for line in tqdm(f):\n        splitLine = line.split()\n        word = splitLine[0]\n        embedding = np.a
rray([float(val) for val in splitLine[1:]])\n        model[word] = embedding\n    print ("Done.",len(model),"
words loaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.txt\')\n\n# =====================
======\nOutput:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n#
============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\' \'))\n\nfo
r i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the coupus", len(words))
\nwords = set(words)\nprint("the unique words in the coupus", len(words))\n\ninter_words = set(model.keys()).
intersection(words)\nprint("The number of words that are present in both glove vectors and our coupus",
len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = s
et(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\nprint("word
2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python: http://www.jessicayun
g.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pickle\nwith open(\'glove_vectors\',
\'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [143]:

```python
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load
-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

Avg W2V for Train data

In [144]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list of train dataset
for sentence in tqdm(preprocessed_essays_train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

print(len(avg_w2v_vectors_train))
print(len(avg_w2v_vectors_train[0])) # vector size
```

```
100%|██████████████████████████████████████████| 8000/8000 [00:04<00:00, 16
63.86it/s]

8000
300
```

AVG W2V for the test dataset

In [145]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list of train dataset
for sentence in tqdm(preprocessed_essays_test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)

print(len(avg_w2v_vectors_test))
print(len(avg_w2v_vectors_test[0])) # vector size
```

```
100%|██████████████████████████████| 2000/2000 [00:02<00:00, 9
69.09it/s]

2000
300
```

2.4 Using Pretrained Models: TFIDF weighted W2V

In [146]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_train)
# 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())
```

In [147]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

print(len(tfidf_w2v_vectors_train))
print(len(tfidf_w2v_vectors_train[0]))
```

```
100%|██████████████████████████████████████████████████| 8000/8000 [00:50<00:00, 158.61it/s]

8000
300
```

In [148]:
```
# average Word2Vec for test dataset
# compute average word2vec for each review.
tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)

print(len(tfidf_w2v_vectors_test))
print(len(tfidf_w2v_vectors_test[0]))
```

```
100%|██████████████████████████████████████████████████| 2000/2000 [00:12<00:00, 158.37it/s]

2000
300
```

In [ ]:
```
```

2. Vectorizing Categorical Features

In [149]:

```
# Vectorizing 'school_state' feature
vectorizer = CountVectorizer(binary=True)
school_state_ohe_train = vectorizer.fit_transform(X_train['school_state'].values)
school_state_ohe_test  = vectorizer.transform(X_test['school_state'].values)
print("Shape of matrix of 'school_state' of train dataset after one hot encodig ",school_state_ohe_train.shap
e)
print("Shape of matrix of 'school_state' of test dataset after one hot encoding",school_state_ohe_test.shape)
```

```
Shape of matrix of 'school_state' of train dataset after one hot encodig  (8000, 51)
Shape of matrix of 'school_state' of test dataset after one hot encoding (2000, 51)
```

In [150]:

```
# vectorizing 'teacher_prefix'
vectorizer = CountVectorizer(binary=True)
teacher_prefix_ohe_train = vectorizer.fit_transform(X_train['teacher_prefix'].values)
teacher_prefix_ohe_test = vectorizer.transform(X_test['teacher_prefix'].values)
print("teacher_prefix_ohe**********************")
print("Shape of matrix of train dataset after one hot encoding ",teacher_prefix_ohe_train.shape)
print("Shape of matrix of test dataset after one hot encoding ",teacher_prefix_ohe_test.shape)
```

```
teacher_prefix_ohe**********************
Shape of matrix of train dataset after one hot encoding  (8000, 5)
Shape of matrix of test dataset after one hot encoding  (2000, 5)
```

In [151]:

```
# vectorizing 'project_grade_category'
vectorizer = CountVectorizer(binary=True)
project_grade_category_ohe_train = vectorizer.fit_transform(X_train['project_grade_category'].values)
project_grade_category_ohe_test  = vectorizer.transform(X_test['project_grade_category'].values)

print("project_grade_category_ohe")
print("Shape of matrix of train data after one hot encoding ",project_grade_category_ohe_train.shape)
print("Shape of matrix of test data after one hot encoding",project_grade_category_ohe_test.shape)
```

```
project_grade_category_ohe
Shape of matrix of train data after one hot encoding  (8000, 4)
Shape of matrix of test data after one hot encoding (2000, 4)
```

In [152]:
```
# vectorizing 'clean_categories'
vectorizer = CountVectorizer(binary=True)
clean_categories_ohe_train = vectorizer.fit_transform(X_train['clean_categories'].values)
clean_categories_ohe_test  = vectorizer.transform(X_test['clean_categories'].values)

print('clean_categories_ohe')
print("Shape of matrix of train data after one hot encoding :",clean_categories_ohe_train.shape)
print("Shape of matrix of test data after one-hot encoding :",clean_categories_ohe_test.shape)
```

```
clean_categories_ohe
Shape of matrix of train data after one hot encoding : (8000, 47)
Shape of matrix of test data after one-hot encoding : (2000, 47)
```

In [153]:
```
# vectorizing 'clean_subcategories'
vectorizer = CountVectorizer(binary=True)
clean_subcategories_ohe_train = vectorizer.fit_transform(X_train['clean_subcategories'].values)
clean_subcategories_ohe_test  = vectorizer.transform(X_test['clean_subcategories'].values)

print("clean_subcategories_ohe")
print("Shape of matrix of train data after one hot encodig ",clean_subcategories_ohe_train.shape)
print("Shape of matrix of test data after one hot encoding : ",clean_subcategories_ohe_test.shape)
```

```
clean_subcategories_ohe
Shape of matrix of train data after one hot encodig  (8000, 275)
Shape of matrix of test data after one hot encoding :  (2000, 275)
```

In [ ]:

Let's calculate Sentiment scores of essay

```
sentiment scores of preprocessed_essays_train (Training dataset)
```

In [154]:
```
# a random essay example of train dataset
preprocessed_essays_train[0]
```

Out[154]:
```
'My students are a wonderful and exciting group of 4-5 year-old boys and girls in an ICT (integrated collabor
ative teaching) classroom. This means that 40% of my students are in special education, and the rest are in g
eneral education. \\r\\n\\r\\nWe are a Title I school and work hard to ensure that everyone learns and succee
ds. I want them to have everything they need to make their school year exciting and fun, as well as productiv
e and successful throughout the entire school year.My students are wonderful and deserve an amazing classroo
m. Fadeless paper and border will allow me to dress up the classrooms bulletin boards in a way that students
will love. Colorful paper and border will help make the classroom bright and cheerful so that we can display
the students work throughout the year. Tape will allow me to hang learning charts and student work on the wal
ls throughout the classroom for the students to see and be proud of. Glue will be a great resource for use du
ring art projects and other learning activities. Please help my students receive these much-needed materials
in order to enjoy learning throughout the school year.nannan'
```

In [155]:
```
len(preprocessed_essays_train) # no.of essays
```

Out[155]:
```
8000
```

Let's start finding sentiment scores

In [156]:
```
import nltk # Natural Language ToolKit library
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\localadmin\AppData\Roaming\nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

Out[156]:
```
True
```

In [157]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

sentiment_list_train = [] # list to store sentiments
for i in tqdm(range(len(preprocessed_essays_train))): # for every essay in preprocessed_essays
    essay = preprocessed_essays_train[i]

    ss = sid.polarity_scores(essay)

    temp = [] # temporary list to store all four columns['neg','neutral','pos','compound']

    for k in ss:
        temp.append(ss[k])

    sentiment_list_train.append(temp)
```

```
100%|██████████████████████████████████████████████████| 8000/8000 [00:34<00:00, 2
32.75it/s]
```

In [158]:
```
# an example of sentiment score
sentiment_list_train[0]
```

Out[158]:
```
[0.006, 0.697, 0.297, 0.9964]
```

In [159]:
```
sentiment_list_array_train = np.array(sentiment_list_train)
```

In [160]:
```
sentiment_list_array_train.shape
```

Out[160]:
```
(8000, 4)
```

In [ ]:

sentiment scores of preprocessed_essays_test (Test dataset)

In [161]:
```
# a random essay example of train dataset
preprocessed_essays_test[0]
```

Out[161]:
```
"Approximately 60% of the students at our school receive free or reduced-price lunch, and we have a high numb
er of military families. There is an amazing group of hardworking young adults in this class. They strive eve
ry day to do their best and succeed. Their goals and dreams are to achieve a high school diploma and go to co
llege. These students take any obstacle in their path head-on and don't let it slow them down. These students
overcome so many different setbacks during their time in school.This project holds a special place in the hea
rts of our student green team. They work hard each week to promote recycling within our school and community.
The student green team is requesting a new recycling bin with lid so that we can add a bin to our office area
to help collect bottles and cans. They are also requesting recycling bags to place in our bins to make collec
tion easier and faster for the team. Finally the students would like a table to use as a place for our studen
t green team meetings and also to use as a workspace when sorting recycling and weighing our bottles and can
s. These students are always striving to find ways to promote recycling to help the Earth. Having these suppl
ies will aid them in their goals and make the green team function more effectively. These students learn so m
uch more than just ways to save the Earth, but they also learn teamwork, collaboration and critical thinking
skills, which are skills they will take with them throughout their lives.  Thank you for taking the time to c
onsider helping our student green team save the Earth.nannan"
```

In [162]:
```
len(preprocessed_essays_test) # no.of essays
```

Out[162]:
```
2000
```

Let's start finding sentiment scores

In [163]:
```
import nltk # Natural Language ToolKit library
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\localadmin\AppData\Roaming\nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

Out[163]:
```
True
```

In [164]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

sentiment_list_test = [] # list to store sentiments
for i in tqdm(range(len(preprocessed_essays_test))): # for every essay in preprocessed_essays
    essay = preprocessed_essays_test[i]

    ss = sid.polarity_scores(essay)

    temp = [] # temporary list to store all four columns['neg','neutral','pos','compound']

    for k in ss:
        temp.append(ss[k])

    sentiment_list_test.append(temp)
```

```
100%|██████████████████████████████████████████████████| 2000/2000 [00:08<00:00, 2
27.07it/s]
```

In [165]:
```
# an example of sentiment score
sentiment_list_test[0]
```

Out[165]:
```
[0.02, 0.846, 0.134, 0.9792]
```

In [166]:
```
sentiment_list_array_test = np.array(sentiment_list_test)
```

In [167]:
```
sentiment_list_array_test.shape
```

Out[167]:
```
(2000, 4)
```

In [ ]:

Creating training and test dataset1:

    containing TFIDF(text)

Creating Train

In [168]:
```
# creating dataset using numpy horizontal stacking method 'hstack()'
X_train1= np.hstack(
    (school_state_ohe_train.toarray(),
    teacher_prefix_ohe_train.toarray(),
    project_grade_category_ohe_train.toarray(),
    X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1),
    clean_categories_ohe_train.toarray(),
    clean_subcategories_ohe_train.toarray(),
    text_tfidf_train.toarray(),
    X_train['price'].values.reshape(-1,1),
    sentiment_list_array_train # sentiment score
    )
)
y_train1 = y_train.values.reshape(-1,1)
```

In [169]:
```
X_train1.shape
```

Out[169]:
```
(8000, 6140)
```

In [170]:
```
y_train1.shape
```

Out[170]:
```
(8000, 1)
```

Creating test dataset

In [171]:
```
# creating dataset using numpy horizontal stacking method 'hstack()'
X_test1= np.hstack(
    (school_state_ohe_test.toarray(),
    teacher_prefix_ohe_test.toarray(),
    project_grade_category_ohe_test.toarray(),
    X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1),
    clean_categories_ohe_test.toarray(),
    clean_subcategories_ohe_test.toarray(),
    text_tfidf_test.toarray(),
    X_test['price'].values.reshape(-1,1),
    sentiment_list_array_test # sentiment score
    )
)
y_test1 = y_test.values.reshape(-1,1)
```

In [172]:
```
X_test1.shape
```

Out[172]:
```
(2000, 6140)
```

In [173]:
```
y_test1.shape
```

Out[173]:
```
(2000, 1)
```

Creating dataset2:

```
Containing TFIDF W2V
```

Train dataset

In [174]:
```
X_train2= np.hstack(
    (school_state_ohe_train.toarray(),
    teacher_prefix_ohe_train.toarray(),
    project_grade_category_ohe_train.toarray(),
    X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1),
    clean_categories_ohe_train.toarray(),
    clean_subcategories_ohe_train.toarray(),
    np.array(tfidf_w2v_vectors_train),
    X_train['price'].values.reshape(-1,1),
    sentiment_list_array_train # sentiment score
    )
)
y_train2 = y_train.values.reshape(-1,1)
```

In [175]:
```
X_train2.shape
```

Out[175]:
```
(8000, 688)
```

In [176]:
```
y_train2.shape
```

Out[176]:
```
(8000, 1)
```

Test dataset

In [177]:
```
# creating dataset using numpy horizontal stacking method 'hstack()'
X_test2= np.hstack(
    (school_state_ohe_test.toarray(),
    teacher_prefix_ohe_test.toarray(),
    project_grade_category_ohe_test.toarray(),
    X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1),
    clean_categories_ohe_test.toarray(),
    clean_subcategories_ohe_test.toarray(),
    np.array(tfidf_w2v_vectors_test),
    X_test['price'].values.reshape(-1,1),
    sentiment_list_array_test # sentiment score
    )
)
y_test2 = y_test.values.reshape(-1,1)
```

In [178]:
```
X_test2.shape
```

Out[178]:
```
(2000, 688)
```

In [179]:
```
y_test2.shape
```

Out[179]:
```
(2000, 1)
```

In [ ]:

Task-1

1.**Apply Decision Tree Classifier on above datasets (set1 and set2).**

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**

- Set 1: categorical, numerical features + preprocessed_essay (TFIDF) + Sentiment scores(preprocessed_essay)
- Set 2: categorical, numerical features + preprocessed_essay (TFIDF W2V) + Sentiment scores(preprocessed_essay)

SET 2

In [180]:
```
from sklearn.tree import DecisionTreeClassifier
```

Hyper parameter tuning on the dataset to find 'depth' and 'min_samples_split'

In [181]:
```
depth = [1,5,10,15] # list of depth parameters
min_samples_split = [5,10,100,500] # list of minimum samples split
```

In [182]:
```
from sklearn.model_selection import GridSearchCV # GridSearchCV for cross validation
```

In [183]:
```
clf_set2 = DecisionTreeClassifier(class_weight='balanced') # initializing Classifier
```

In [184]:
```
# making the dictionary of parameters
param_grid = dict(max_depth = depth, min_samples_split=min_samples_split)
```

In [185]:
```
from sklearn.model_selection import KFold # importing KFold
kfold = KFold(n_splits=10, random_state=42) # initializing object of 10-fold cross-validation
```

In [186]:
```
# performing GridSearchCV using 'roc_auc' scoring and also parallelizing the task using n_jobs=-1
grid_search2 = GridSearchCV(clf_set2, param_grid,scoring='roc_auc',n_jobs=-1, cv=kfold)
```

In [187]:
```
grid_search2.return_train_score=True # making train score true to get train score
```

In [188]:
```
%%time
# %%time to track the time taken to fit the classifier
grid_result2 = grid_search2.fit(X_train2,y_train2)
```

```
Wall time: 2min 22s
```

best parameters

In [189]:
```
# best parameter
grid_result2.best_params_
```

Out[189]:
```
{'max_depth': 5, 'min_samples_split': 500}
```

We get best parameters as:

1. max_depth = 15
2. min_samples_split = 500

In [190]:
```
# best score
grid_result2.best_score_
```

Out[190]:
```
0.5686008250325683
```

Tracing the mean and standard deviation test score of auc_score for each hyper parameter

In [191]:
```
means2 = grid_result2.cv_results_['mean_test_score']
stds2 = grid_result2.cv_results_['std_test_score']
params2 = grid_result2.cv_results_['params']
```

In [192]:
```
for mean, stdev, param in zip(means2, stds2, params2):
    print("mean = ",mean," stddev = ",stdev," param = ",param)
```

```
mean =  0.5437583515741204  stddev =  0.018509841223056357  param =  {'max_depth': 1, 'min_samples_split': 5}
mean =  0.5437583515741204  stddev =  0.018509841223056357  param =  {'max_depth': 1, 'min_samples_split': 1
0}
mean =  0.5437583515741204  stddev =  0.018509841223056357  param =  {'max_depth': 1, 'min_samples_split': 10
0}
mean =  0.5437583515741204  stddev =  0.018509841223056357  param =  {'max_depth': 1, 'min_samples_split': 50
0}
mean =  0.5547804362039349  stddev =  0.017665713550407282  param =  {'max_depth': 5, 'min_samples_split': 5}
mean =  0.5546323723773358  stddev =  0.017751099781224484  param =  {'max_depth': 5, 'min_samples_split': 1
0}
mean =  0.5571421161702835  stddev =  0.017508860723733  param =  {'max_depth': 5, 'min_samples_split': 100}
mean =  0.5686008250325683  stddev =  0.018623287281580622  param =  {'max_depth': 5, 'min_samples_split': 50
0}
mean =  0.5518549495937768  stddev =  0.02952521056017626  param =  {'max_depth': 10, 'min_samples_split': 5}
mean =  0.5546680075651318  stddev =  0.028503955872261445  param =  {'max_depth': 10, 'min_samples_split': 1
0}
mean =  0.5589333764391838  stddev =  0.019748876654202913  param =  {'max_depth': 10, 'min_samples_split': 1
00}
mean =  0.563728927179221  stddev =  0.021467765768521024  param =  {'max_depth': 10, 'min_samples_split': 50
0}
mean =  0.5382524046542528  stddev =  0.01853542617133142  param =  {'max_depth': 15, 'min_samples_split': 5}
mean =  0.542847247434595  stddev =  0.020688247158486616  param =  {'max_depth': 15, 'min_samples_split': 1
0}
mean =  0.5528000789556289  stddev =  0.025430312745068684  param =  {'max_depth': 15, 'min_samples_split': 1
00}
mean =  0.5665233908696822  stddev =  0.018578444215212937  param =  {'max_depth': 15, 'min_samples_split': 5
00}
```

In [ ]:

Plot the result in 3d using plotly

In [193]:
```
import plotly.offline as offline # to use plotly in offline model
import plotly.graph_objs as go # importing graph objects
offline.init_notebook_mode()  # initialize plotly in notebook mode
import numpy as np
```

In [194]:
```
grid_result2.cv_results_ # see the complete description of findings
```

Out[194]:
```
{'mean_fit_time': array([0.86609674, 0.6266048 , 0.63082769, 0.62009501, 2.40593555,
        2.30777938, 2.29098277, 2.1453953 , 3.77244093, 4.3548799 ,
        5.33894441, 4.09401059, 6.7840169 , 6.36183434, 6.09581497,
        4.66123316]),
 'std_fit_time': array([0.18105722, 0.0281852 , 0.01923413, 0.03078112, 0.02214053,
        0.05533389, 0.01865646, 0.05255246, 0.14452757, 0.50697027,
        0.297709  , 0.33451408, 0.30338171, 0.41387165, 0.33598626,
        0.30161769]),
 'mean_score_time': array([0.00807586, 0.00684342, 0.00755446, 0.00581055, 0.00559952,
        0.00399988, 0.00399992, 0.00720053, 0.0055994 , 0.0071995 ,
        0.00959969, 0.0103987 , 0.01279118, 0.01205451, 0.01249611,
        0.00736756]),
 'std_score_time': array([0.00315038, 0.00375117, 0.00239686, 0.00251082, 0.00366575,
        0.00399988, 0.00399992, 0.00240018, 0.00366567, 0.00239983,
        0.00598573, 0.00366397, 0.01265006, 0.00562968, 0.01032573,
        0.00201948]),
 'param_max_depth': masked_array(data=[1, 1, 1, 1, 5, 5, 5, 5, 10, 10, 10, 10, 15, 15, 15, 15],
              mask=[False, False, False, False, False, False, False, False,
                    False, False, False, False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'param_min_samples_split': masked_array(data=[5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5,
                    10, 100, 500],
              mask=[False, False, False, False, False, False, False, False,
                    False, False, False, False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'params': [{'max_depth': 1, 'min_samples_split': 5},
  {'max_depth': 1, 'min_samples_split': 10},
  {'max_depth': 1, 'min_samples_split': 100},
  {'max_depth': 1, 'min_samples_split': 500},
  {'max_depth': 5, 'min_samples_split': 5},
  {'max_depth': 5, 'min_samples_split': 10},
  {'max_depth': 5, 'min_samples_split': 100},
  {'max_depth': 5, 'min_samples_split': 500},
  {'max_depth': 10, 'min_samples_split': 5},
  {'max_depth': 10, 'min_samples_split': 10},
  {'max_depth': 10, 'min_samples_split': 100},
  {'max_depth': 10, 'min_samples_split': 500},
  {'max_depth': 15, 'min_samples_split': 5},
  {'max_depth': 15, 'min_samples_split': 10},
  {'max_depth': 15, 'min_samples_split': 100},
  {'max_depth': 15, 'min_samples_split': 500}],
```

```
'split0_test_score': array([0.53991697, 0.53991697, 0.53991697, 0.53991697, 0.58053779,
       0.57914798, 0.57485326, 0.58886476, 0.55423268, 0.56718243,
       0.56641296, 0.57762693, 0.54673483, 0.54446817, 0.55924318,
       0.58449847]),
'split1_test_score': array([0.56115581, 0.56115581, 0.56115581, 0.56115581, 0.5732543 ,
       0.5732543 , 0.57938266, 0.59027009, 0.53017929, 0.52337541,
       0.5446634 , 0.59708614, 0.51114911, 0.50199613, 0.5220548 ,
       0.58188391]),
'split2_test_score': array([0.56118519, 0.56118519, 0.56118519, 0.56118519, 0.56439111,
       0.56439111, 0.57034667, 0.57384296, 0.57998815, 0.56981926,
       0.56641185, 0.57832296, 0.57892148, 0.58504296, 0.58796444,
       0.57954963]),
'split3_test_score': array([0.52457181, 0.52457181, 0.52457181, 0.52457181, 0.55255599,
       0.55536891, 0.54954545, 0.54212121, 0.55081686, 0.57049407,
       0.57695652, 0.54181159, 0.52316864, 0.55275362, 0.56716733,
       0.54216074]),
'split4_test_score': array([0.54613095, 0.54613095, 0.54613095, 0.54613095, 0.539109  ,
       0.53764997, 0.55184501, 0.55669294, 0.51504371, 0.51173619,
       0.55183919, 0.55474563, 0.54628209, 0.55872163, 0.55833217,
       0.55558268]),
'split5_test_score': array([0.53423827, 0.53423827, 0.53423827, 0.53423827, 0.55660877,
       0.55660877, 0.55910908, 0.56226407, 0.563657  , 0.55515315,
       0.56071095, 0.56082239, 0.54271427, 0.53842404, 0.59311056,
       0.57409007]),
'split6_test_score': array([0.56148417, 0.56148417, 0.56148417, 0.56148417, 0.57783066,
       0.57783066, 0.58060788, 0.59660644, 0.61843904, 0.61727099,
       0.60370794, 0.59734579, 0.54306253, 0.55016402, 0.55558179,
       0.59765023]),
'split7_test_score': array([0.54947048, 0.54947048, 0.54947048, 0.54947048, 0.53582136,
       0.53437666, 0.53583345, 0.57323855, 0.55006891, 0.55209996,
       0.54502152, 0.54925891, 0.54717346, 0.53212196, 0.54612771,
       0.55935369]),
'split8_test_score': array([0.50143626, 0.50143626, 0.50143626, 0.50143626, 0.53269005,
       0.53269005, 0.53627058, 0.53974323, 0.51416704, 0.52760583,
       0.54059284, 0.5343286 , 0.5194468 , 0.52642581, 0.51317582,
       0.54166498]),
'split9_test_score': array([0.55799362, 0.55799362, 0.55799362, 0.55799362, 0.53500532,
       0.53500532, 0.53362711, 0.56236399, 0.54195682, 0.55194279,
       0.53301659, 0.54594033, 0.52387084, 0.53835413, 0.525243  ,
       0.54879951]),
'mean_test_score': array([0.54375835, 0.54375835, 0.54375835, 0.54375835, 0.55478044,
       0.55463237, 0.55714212, 0.56860083, 0.55185495, 0.55466801,
       0.55893338, 0.56372893, 0.5382524 , 0.54284725, 0.55280008,
```

```
       0.56652339]),
 'std_test_score': array([0.01850984, 0.01850984, 0.01850984, 0.01850984, 0.01766571,
       0.0177511 , 0.01750886, 0.01862329, 0.02952521, 0.02850396,
       0.01974888, 0.02146777, 0.01853543, 0.02068825, 0.02543031,
       0.01857844]),
 'rank_test_score': array([11, 11, 11, 11,  6,  8,  5,  1, 10,  7,  4,  3, 16, 15,  9,  2]),
 'split0_train_score': array([0.55445076, 0.55445076, 0.55445076, 0.55445076, 0.692613  ,
       0.69197167, 0.68586739, 0.65304619, 0.88557866, 0.88197319,
       0.81603179, 0.70328753, 0.96171693, 0.95618577, 0.85686955,
       0.71757423]),
 'split1_train_score': array([0.55194202, 0.55194202, 0.55194202, 0.55194202, 0.66908482,
       0.66908482, 0.66062237, 0.64192307, 0.85561096, 0.85411188,
       0.78355106, 0.68822689, 0.93154941, 0.9340682 , 0.83186393,
       0.70434673]),
 'split2_train_score': array([0.54572322, 0.54572322, 0.54572322, 0.54572322, 0.68000077,
       0.68000077, 0.66886992, 0.64880992, 0.87403954, 0.86878054,
       0.80765297, 0.69657179, 0.95320297, 0.9446973 , 0.85581326,
       0.71648533]),
 'split3_train_score': array([0.54968898, 0.54968898, 0.54968898, 0.54968898, 0.6940177 ,
       0.69354111, 0.68457723, 0.66147901, 0.8768841 , 0.87070147,
       0.81322133, 0.70469241, 0.94652917, 0.94136543, 0.86628394,
       0.72278026]),
 'split4_train_score': array([0.55362899, 0.55362899, 0.55362899, 0.55362899, 0.70843783,
       0.70843783, 0.69938051, 0.68478628, 0.91325203, 0.90609794,
       0.83733427, 0.72645182, 0.97084456, 0.9631201 , 0.87804784,
       0.72912433]),
 'split5_train_score': array([0.55473085, 0.55473085, 0.55473085, 0.55473085, 0.69846581,
       0.69846581, 0.68856266, 0.66483301, 0.88729308, 0.88383534,
       0.81802627, 0.71565422, 0.96994975, 0.96628752, 0.86397218,
       0.73122931]),
 'split6_train_score': array([0.55193267, 0.55193267, 0.55193267, 0.55193267, 0.69410365,
       0.69410365, 0.68622445, 0.66274954, 0.86819872, 0.86656355,
       0.80754119, 0.70210465, 0.96052953, 0.95527683, 0.86391526,
       0.71318525]),
 'split7_train_score': array([0.55328123, 0.55328123, 0.55328123, 0.55328123, 0.69271676,
       0.69271676, 0.69015037, 0.64665234, 0.87890698, 0.87496561,
       0.8045892 , 0.69212483, 0.95403714, 0.94560485, 0.86785168,
       0.70825613]),
 'split8_train_score': array([0.55269489, 0.55269489, 0.55269489, 0.55269489, 0.69354275,
       0.69354275, 0.68387658, 0.66833395, 0.87990387, 0.87297702,
       0.79741358, 0.70847574, 0.95998066, 0.95489249, 0.86046042,
       0.72327403]),
 'split9_train_score': array([0.5523202 , 0.5523202 , 0.5523202 , 0.5523202 , 0.69792787,
```

```
       0.69792787, 0.6897705 , 0.65832481, 0.89419375, 0.88714522,
       0.82103928, 0.71744763, 0.95899187, 0.95598059, 0.87048793,
       0.72245152]),
'mean_train_score': array([0.55203938, 0.55203938, 0.55203938, 0.55203938, 0.6920911 ,
       0.6919793 , 0.6837902 , 0.65909381, 0.88138617, 0.87671517,
       0.81064009, 0.70550375, 0.9567332 , 0.95174791, 0.8615566 ,
       0.71887071]),
'std_train_score': array([0.00251148, 0.00251148, 0.00251148, 0.00251148, 0.01013863,
       0.0101288 , 0.01054647, 0.01178992, 0.01467239, 0.01334391,
       0.01369272, 0.01125936, 0.01089395, 0.0095315 , 0.01167439,
       0.00817728])}
```

In [ ]:

In [195]:

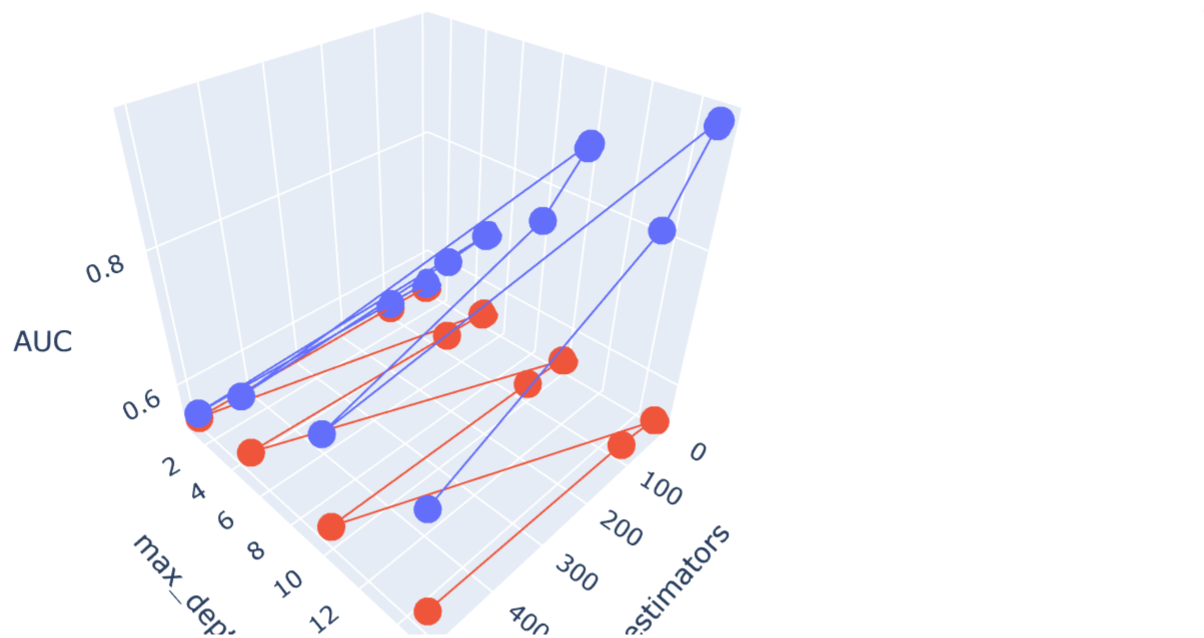
```
x1_set2 = list(grid_result2.cv_results_['param_min_samples_split'])
y1_set2 = list(grid_result2.cv_results_['param_max_depth'])
z1_set2 = list(grid_result2.cv_results_['mean_train_score']) # accuracy on X_train

x2_set2 = list(grid_result2.cv_results_['param_min_samples_split'])
y2_set2 = list(grid_result2.cv_results_['param_max_depth'])
z2_set2 = list(grid_result2.cv_results_['mean_test_score'])
```

In [196]:
```
x1_set2, y1_set2, z1_set2
```

Out[196]:
```
([5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500],
 [1, 1, 1, 1, 5, 5, 5, 5, 10, 10, 10, 10, 15, 15, 15, 15],
 [0.5520393802542105,
  0.5520393802542105,
  0.5520393802542105,
  0.5520393802542105,
  0.6920910955676214,
  0.6919793034372005,
  0.683790198310094,
  0.6590938132492127,
  0.8813861693776428,
  0.8767151735430619,
  0.8106400941157773,
  0.7055037505848805,
  0.9567331993989345,
  0.9517479089106805,
  0.861556599744277,
  0.7188707134388606])
```

In [ ]:

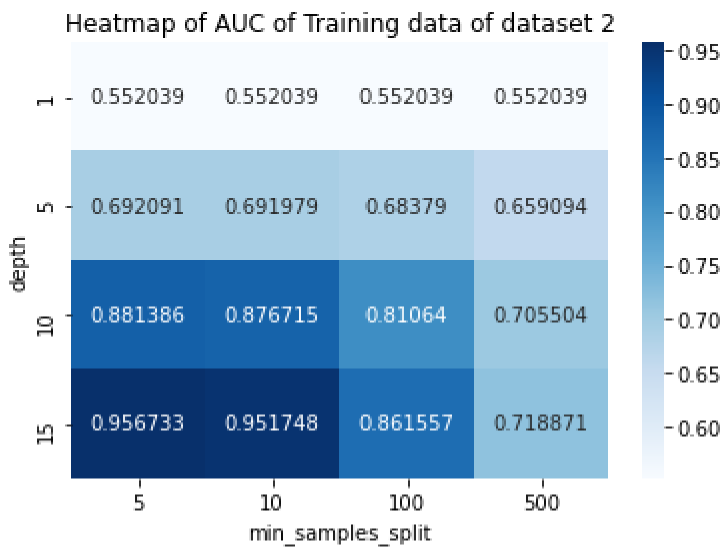
In [197]:
```
# https://plot.ly/python/3d-axes/
trace12 = go.Scatter3d(x=x1_set2,y=y1_set2,z=z1_set2, name = 'train')
trace22 = go.Scatter3d(x=x2_set2,y=y2_set2,z=z2_set2, name = 'Cross validation')
data2 = [trace12, trace22]

layout = go.Layout(scene = dict(
        xaxis = dict(title='n_estimators'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data=data2, layout=layout)
offline.iplot(fig, filename='3d-scatter-colorscale')
```



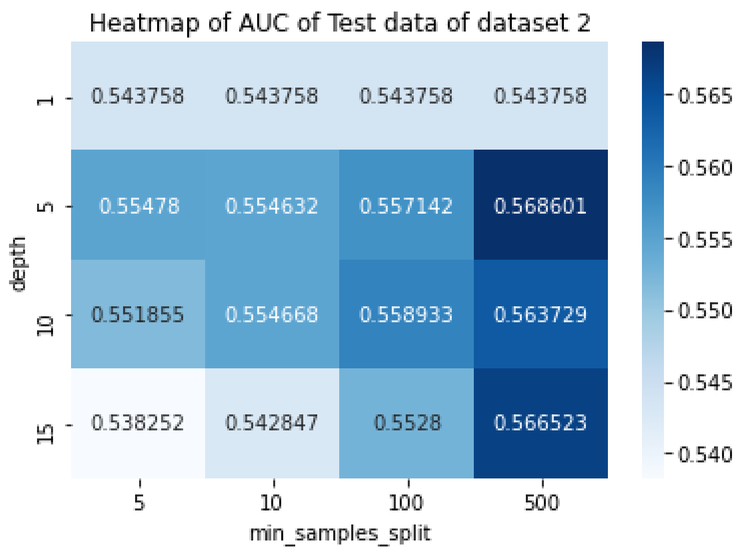
Let's plot the heatmap

In [198]:
```
# creating utility function for plotting heatmap
def plot_heatmap(dataframe, title="Title", xlabel="xlabel", ylabel="ylabel"):
    sns.heatmap(
        data=dataframe,
        annot=True,
        xticklabels=dataframe.columns,
        yticklabels=dataframe.index,
        cmap='Blues',
        fmt='g'
    )
    plt.xlabel(xlabel)
    plt.ylabel(ylabel)
    plt.title(title)

# creating dataset
def dataset_creation(data, index, columns):
    t=np.array(data).reshape(len(index),len(columns))

    dataset = pd.DataFrame(t,
                         index=index,
                         columns=columns
                        )
    return dataset
```

In [199]:
```
# creating a dataset to plot heatmap of training dataset of set2
train_data_set2 = dataset_creation(z1_set2, index = depth, columns=min_samples_split)

# print(train_data_set1)
# plotting the heatmap
plot_heatmap(
    train_data_set2,
    title='Heatmap of AUC of Training data of dataset 2',
    xlabel='min_samples_split',
    ylabel='depth'
)
```



In [200]:
```
# creating a dataset to plot heatmap of training dataset of set2
test_data_set2 = dataset_creation(z2_set2, index = depth, columns=min_samples_split)

# plotting the heatmap
plot_heatmap(
    test_data_set2,
    title='Heatmap of AUC of Test data of dataset 2',
    xlabel='min_samples_split',
    ylabel='depth'
)
```



In [ ]:

Once after you found the best hyper-parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.

finding best parameter

In [201]:
```
best_parameter2 = grid_result2.best_params_
```

In [202]:
```
best_parameter2
```

Out[202]:
```
{'max_depth': 5, 'min_samples_split': 500}
```

Initializing Classifier

In [203]:
```
from sklearn.multiclass import OneVsOneClassifier
```

In [204]:
```
# used OneVsOneClassifier to get y_score using decision_function()
best_clf2 = OneVsOneClassifier(DecisionTreeClassifier(max_depth=best_parameter2['max_depth'], min_samples_spl
it=best_parameter2['min_samples_split'],
                                                     class_weight='balanced'))
```

fitting classifier

In [205]:
```
y_score2 = best_clf2.fit(X_train2,y_train2).decision_function(X_test2)
# actually it is score given by decision function
```

In [206]:
```
x_score2 = best_clf2.decision_function(X_train2)
# score of training dataset by decision function
```

In [207]:
```
# help(auc) ############# uncomment to see the description of auc ############
```

In [208]:
```
y_test2.shape # shape of dependent variable
```

Out[208]:
```
(2000, 1)
```

In [209]:
```
y_score2.shape
```

Out[209]:
```
(2000,)
```

In [210]:
```
x_score2.shape
```

Out[210]:
```
(8000,)
```

In [211]:
```
# y_score1 # uncomment this to see the result
```

In [ ]:

In [212]:
```
# getting fpr, tpr, and thresholds
fpr2_test, tpr2_test, thresholds2_test = roc_curve(y_test2, y_score2)
# getting fpr, tpr, and thresholds for training data
fpr2_train, tpr2_train, thresholds2_train = roc_curve(y_train2, x_score2)
```

In [213]:
```
fpr2_train # showing False positive rate of train dataset
```

Out[213]:
```
array([0.00000000e+00, 8.47457627e-04, 1.69491525e-03, 1.86440678e-02,
       3.22033898e-02, 6.10169492e-02, 7.11864407e-02, 7.71186441e-02,
       1.31355932e-01, 1.45762712e-01, 1.69491525e-01, 1.95762712e-01,
       2.05932203e-01, 2.33898305e-01, 6.94915254e-01, 7.50847458e-01,
       8.67796610e-01, 9.93220339e-01, 9.95762712e-01, 1.00000000e+00])
```

In [214]:
```
tpr2_train # showing True Positive rate of train dataset
```

Out[214]:
```
array([0.        , 0.01099707, 0.02008798, 0.12668622, 0.19706745,
       0.27140762, 0.2941349 , 0.3058651 , 0.3755132 , 0.39384164,
       0.42346041, 0.45      , 0.45909091, 0.4829912 , 0.83211144,
       0.87360704, 0.95219941, 0.99853372, 0.99912023, 1.        ])
```

In [215]:
```
fpr2_test # fpr of test
```

Out[215]:
```
array([0.        , 0.00322581, 0.00645161, 0.07741935, 0.10967742,
       0.16129032, 0.16451613, 0.18387097, 0.2516129 , 0.26129032,
       0.27419355, 0.28064516, 0.28387097, 0.29677419, 0.78064516,
       0.80967742, 0.89354839, 1.        , 1.        ])
```

In [216]:
```
tpr2_test
```

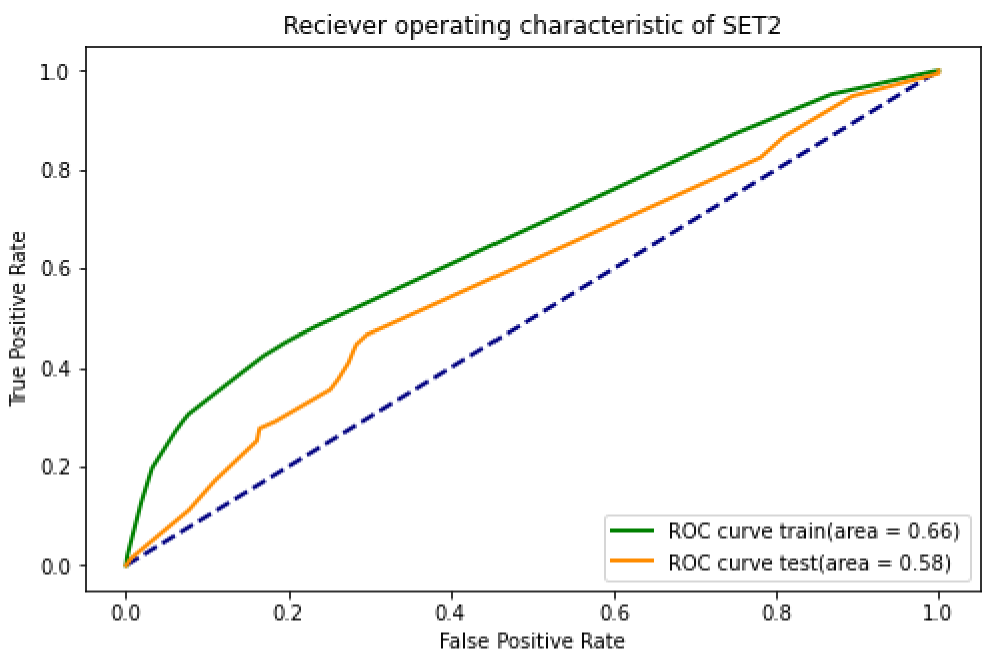
Out[216]:
```
array([0.        , 0.00710059, 0.0147929 , 0.11183432, 0.17159763,
       0.25207101, 0.27692308, 0.29112426, 0.3556213 , 0.37633136,
       0.41005917, 0.43550296, 0.44674556, 0.46627219, 0.82426036,
       0.86686391, 0.94852071, 0.99467456, 1.        ])
```

In [ ]:

In [217]:
```
roc_auc_train2 = auc(fpr2_train, tpr2_train) # getting Area Under Curve of train data
roc_auc_test2  = auc(fpr2_test, tpr2_test) # getting AUC of test data
```

In [218]:
```
# plotting ROC Curve
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
plt.figure(figsize=(8,5))
plt.plot([0,1],[0,1], color='navy', lw = 2, linestyle='--')
plt.plot(fpr2_train, tpr2_train, color='green', lw=2, label="ROC curve train(area = %0.2f)"%roc_auc_train2)
plt.plot(fpr2_test, tpr2_test, color='darkorange', lw=2, label='ROC curve test(area = %0.2f)'%roc_auc_test2)
plt.title('Reciever operating characteristic of SET2')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc="lower right")
```

Out[218]: <matplotlib.legend.Legend at 0x29933fd7f70>



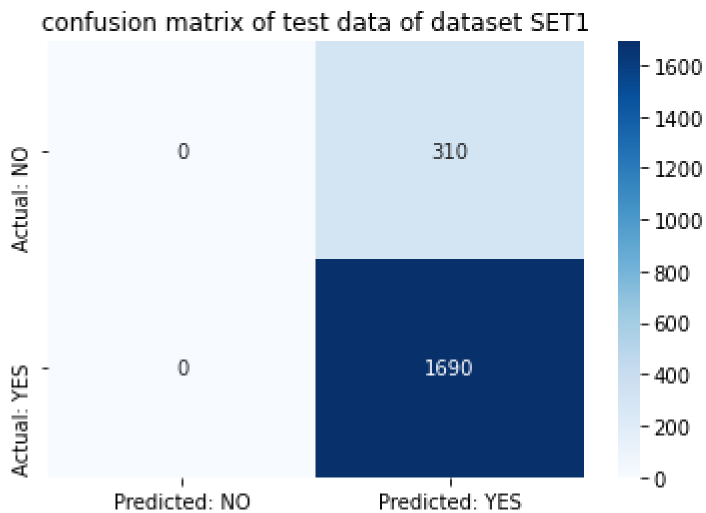
print the confusion matrix

In [219]:
```
from sklearn.metrics import confusion_matrix
```

In [220]:
```
y_predicted2 = best_clf2.predict(X_test2)
```

In [221]:
```
cm2 = confusion_matrix(y_test2, y_predicted2)
xlabels = ['Predicted: NO', 'Predicted: YES']
ylabels = ['Actual: NO', 'Actual: YES']
sns.heatmap(
    data=cm2,
    xticklabels=xlabels,
    yticklabels=ylabels,
    annot=True,
    fmt='g',
    cmap='Blues'
)
plt.title('confusion matrix of test data of dataset SET1')
```

Out[221]:
```
Text(0.5, 1.0, 'confusion matrix of test data of dataset SET1')
```



Getting False positive datapoints of SET1...

In [ ]:

In [222]:
```
# getting false positive data to plot the WordCloud
fp_essay2 = [] # list to store false positive data from the training dataset
fp_price2 = [] # to store price of False positive
fp_teacher_project_posted2= [] # to store teacher_number_of_previously_posted_projects

for i in tqdm(range(len(y_test2))): # for each datapoint in test dataset

    if y_test2[i]==0 and y_predicted2[i]==1: # checking for false positive

        fp_essay2.append(X_test['essay'].iloc[i]) # appending the essay of desired location
        fp_price2.append(X_test['price'].iloc[i]) # appending price
        fp_teacher_project_posted2.append(X_test['teacher_number_of_previously_posted_projects'].iloc[i])
```

```
100%|██████████| 2000/2000 [00:00<00:00, 573
67.03it/s]
```

In [223]:
```
len(fp_essay2)
```

Out[223]:
```
310
```

In [224]:
```
fp_essay2[0:2]
```

Out[224]:
```
['The students in my classroom come from quite a diverse group of backgrounds and academic abilities. Ninety-
percent of our student body receives free and reduced price breakfast/lunch. Many students come from time-poo
r families, meaning their parents or guardians are unable to spend much quality time with them to help them w
ith their homework. Over years of being in this situation, the achievement gap between them and their higher 
SES peers widens.\\r\\nDespite the high poverty level and the obstacles that face them, my students come to s
chool ready to learn and work hard. What they lack in grade level academic achievement, they make up for in h
eart and character. Our school has a hyphenated name because we are a hyphenated community. Half of our build
ing is composed of general education K-4 classrooms, while the other half consists of self-contained classroo
ms for students with various disabilities. My students participate in a program called \\"Project Unify\\" in
which they take turns going to eat lunch and play with students in the special education building. I could no
t be more proud to teach in a school that values empathy as being equally as important as academics.I took ov
er this classroom mid-year, right after Christmas, and have been getting to know these students over the past
few weeks. I have already found teaching to be emotionally draining as I hear the heart wrenching stories of 
the broken homes many of my students come from. Just when I think I\'ve heard the worst of it, I find out mor
e. As I am a brand new teacher hired straight out of student teaching, I don\'t have much to offer my student
s aside from giving them my time, my attention, and my unconditional love. I am financially struggling to sto
ck my classroom with the materials it needs; and so far, I am running on borrowed  supplies. \\r\\n\\"Ohana m
eans family; and family means nobody gets left behind or forgotten.\\" I encourage my students to look at mys
elf and their classmates as family; we continuously quote the Disney movie Lilo and Stitch to remind us so. I
f this project is funded, I will be sent cushions, blankets, pillows, and carpet that will allow me to create
a warm, cozy environment for my students to read and learn. I want them to come into my classroom feeling lik
e they\'ve walked into a family room filled with the people and furnishings that make them feel like they\'re
home. I want them to know that they are safe, valued, and far from harm when they are at school... far from f
ighting, drug abuse, cold, and hunger.  The 7 hours a day they spend with me will be 7 hours where they can l
et their guards down and learn.\\r\\n\\r\\nnannan',
 "Funds are tight, but the future is bright!  \\r\\n\\r\\nMy students applied and interviewed for a college-r
eadiness elective called AVID.  Many of these special students will be the first generation in their families
to graduate or even attend college. Many have English as a second language, economical disadvantages, and mos
t have limited resources to pursue a college education. \\r\\nHaving said that, all of these students have pr
oven to be  highly motivated to succeed, and all are dedicated to their own education. \\r\\nMy AVID students
apply to be a part of this wonderful college readiness program. Many of them have never been and may never be
introduced to the resources that are available online in regards to colleges, careers, financial aid, and any
thing regarding those things. Technology at our campus has been limited for a while now. I do not see an impr
ovement happening soon. For these scholars  to be able to utilize the AVID program properly, they must have a
consistent access to the resources provided online and the program's we can utilize through the Internet. Ple
ase help make this happen!!!nannan"]
```

In [225]:
```
# importing necessary modules
from wordcloud import WordCloud, STOPWORDS

stopwords = set(STOPWORDS)

comment_words2 = ''
for essay in fp_essay2: # for each essay
    # joining all essays into single variable called comment_words
    essay = essay + ' ' # adding space at the end of sentence.
    comment_words2 += "".join(essay)+""
```

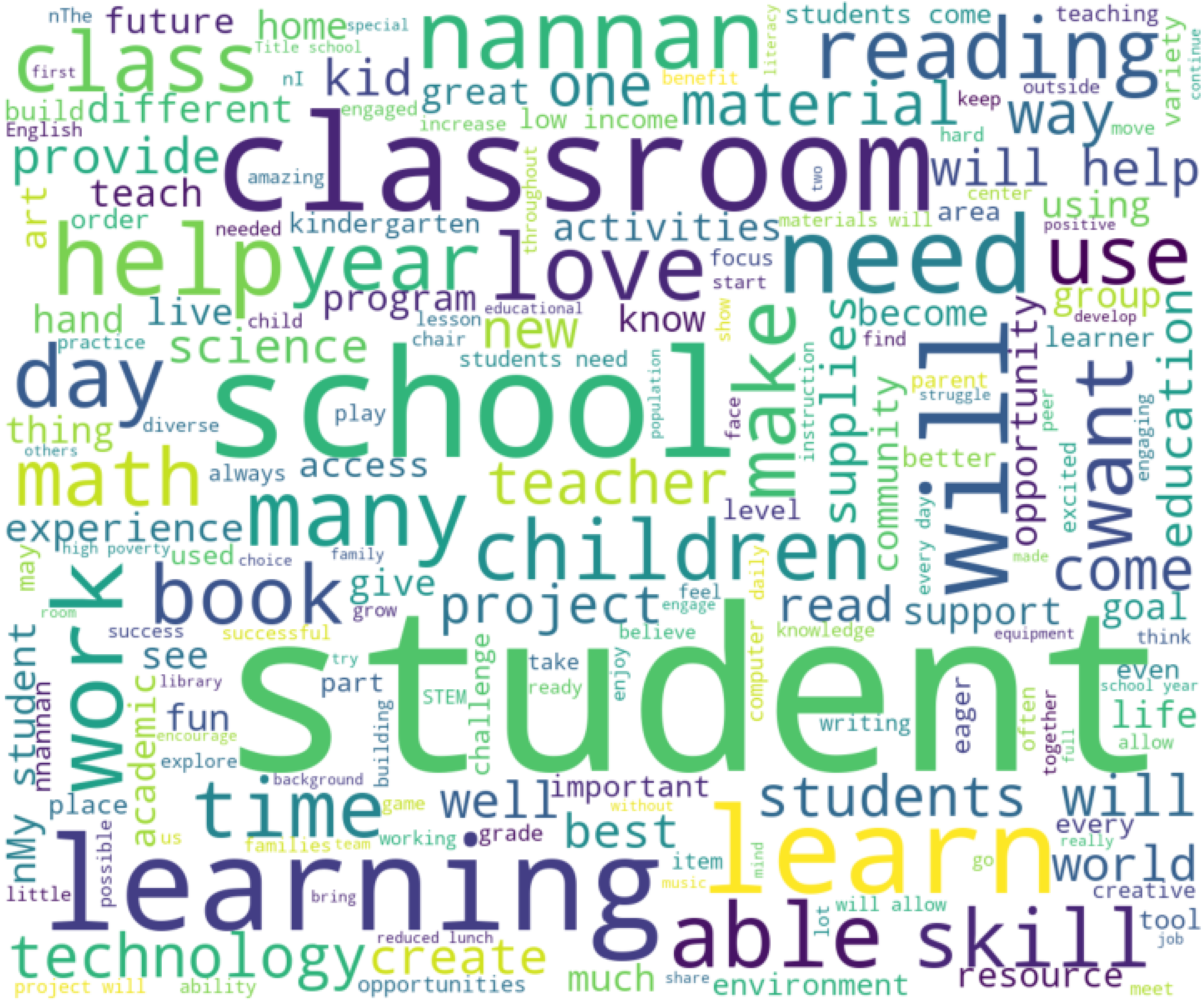
In [226]:
```
comment_words2[0:100]
```

Out[226]:
```
'The students in my classroom come from quite a diverse group of backgrounds and academic abilities. '
```

WordCloud

In [227]:
```
wordcloud2 = WordCloud(width=1200, height=1000,
                     background_color='white',
                     stopwords = stopwords,
                     min_font_size = 10
                     ).generate(comment_words2)

plt.figure(figsize=(10,10), facecolor=None)
plt.imshow(wordcloud2)
plt.axis(False)
plt.tight_layout(pad=0)
plt.title('Word Cloud of false positive datapoint of test data set of SET 2')
plt.show()
```

Word Cloud of false positive datapoint of test data set of SET 2

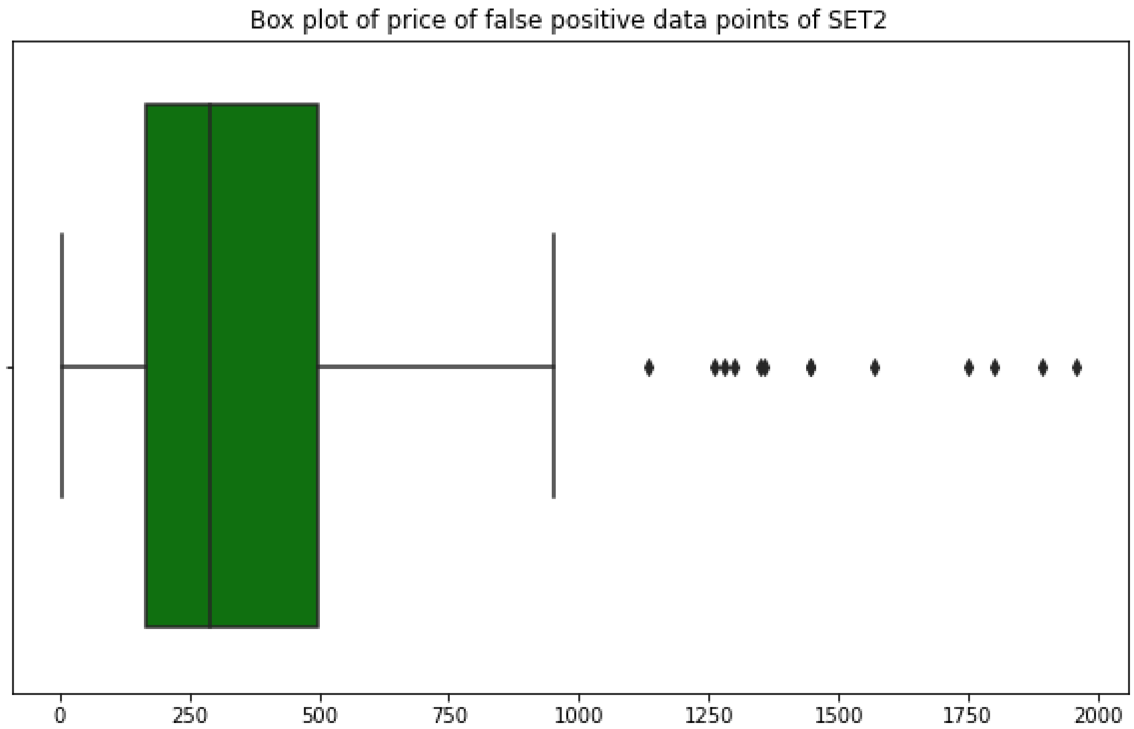


Box-plot

Plot the box plot with the 'price' of these false positive data points'

In [228]:
```
plt.figure(figsize=(10,6))
sns.boxplot(fp_price2,color='green')
plt.title('Box plot of price of false positive data points of SET2')
```

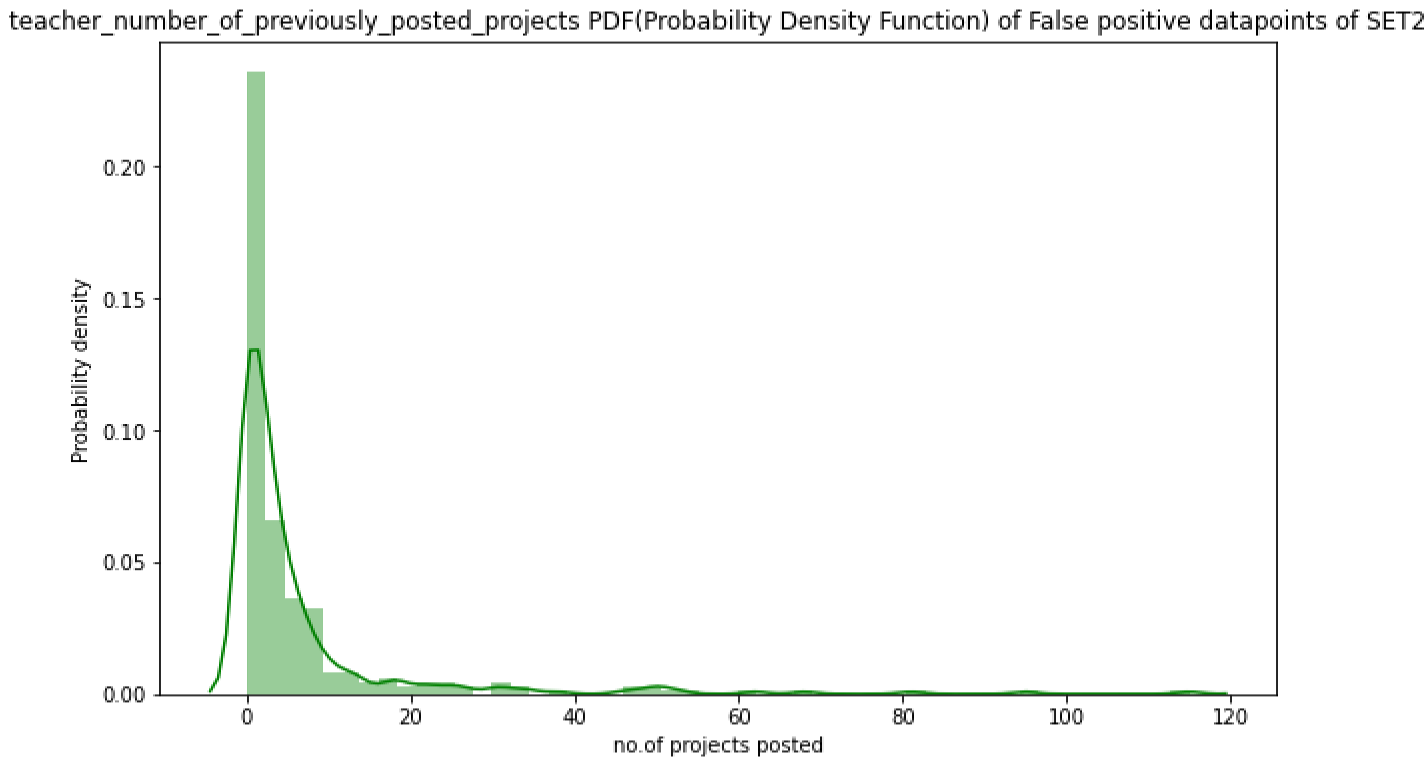
Out[228]:
```
Text(0.5, 1.0, 'Box plot of price of false positive data points of SET2')
```



PDF(Porbability Density Function)

In [229]:
```
plt.figure(figsize=(10,6))
sns.distplot(fp_teacher_project_posted2,
            color='green',
        )
plt.title('teacher_number_of_previously_posted_projects PDF(Probability Density Function) of False positive d
atapoints of SET2')
plt.xlabel('no.of projects posted')
plt.ylabel('Probability density')
```

Out[229]: Text(0, 0.5, 'Probability density')



In [ ]:

In [ ]:

SET 1

In [230]:
```
from sklearn.tree import DecisionTreeClassifier
```

Hyper parameter tuning on the dataset to find 'depth' and 'min_samples_split'

In [231]:
```
depth = [1,5,10,15] # list of depth parameters
min_samples_split = [5,10,100,500] # list of minimum samples split
```

In [232]:
```
from sklearn.model_selection import GridSearchCV # GridSearchCV for cross validation
```

In [233]:
```
clf_set1 = DecisionTreeClassifier(class_weight='balanced') # initializing Classifier
```

In [234]:
```
# making the dictionary of parameters
param_grid = dict(max_depth = depth, min_samples_split=min_samples_split)
```

In [235]:
```
from sklearn.model_selection import KFold # importing KFold
kfold = KFold(n_splits=10, random_state=42) # initializing object of 10-fold cross-validation
```

In [236]:
```
# performing GridSearchCV using 'roc_auc' scoring and also parallelizing the task using n_jobs=-1
grid_search1 = GridSearchCV(clf_set1, param_grid,scoring='roc_auc',n_jobs=-1, cv=kfold)
```

In [237]:
```
grid_search1.return_train_score=True # making train score true to get train score
```

In [238]:
```
X_train1.shape, y_train1.shape
```

Out[238]:
```
((8000, 6140), (8000, 1))
```

In [239]:
```
X_test1.shape, y_test1.shape
```

Out[239]:
```
((2000, 6140), (2000, 1))
```

In [119]:
```
# let's save the dataset for further use using Dask framerwork
# because it is difficult to fit into memory
# pd.DataFrame(X_train1).to_csv('X_train1.csv',index=False)
# pd.DataFrame(y_train1).to_csv('y_train1.csv',index=False)
# pd.DataFrame(X_test1).to_csv('X_test1.csv',index=False)
# pd.DataFrame(y_test1).to_csv('y_test1.csv',index=False)
```

In [120]:
```
# import dask.dataframe as dd
```

In [121]:
```
# X_train1 = dd.read_csv('X_train1.csv',)
# y_train1 = dd.read_csv('y_train1.csv')
# X_test1 = dd.read_csv('X_test1.csv')
# y_test1 = dd.read_csv('y_test1.csv')
```

In [240]:
```
%%time
# %%time to track the time taken to fit the classifier
grid_result1 = grid_search1.fit(X_train1,y_train1) # it will take very long time,
```

```
Wall time: 21min 21s
```

In [ ]:

best parameters

In [241]:
```
# best parameter
grid_result1.best_params_
```

Out[241]:
```
{'max_depth': 5, 'min_samples_split': 500}
```

We get best parameters as:

1. max_depth = 10
2. min_samples_split = 5

In [242]:
```
# best score
grid_result1.best_score_
```

Out[242]:
```
0.611862390790589
```

Tracing the mean and standard deviation test score of auc_score for each hyper parameter

In [243]:
```
means1 = grid_result1.cv_results_['mean_test_score']
stds1 = grid_result1.cv_results_['std_test_score']
params1 = grid_result1.cv_results_['params']
```

In [244]:
```
for mean, stdev, param in zip(means1, stds1, params1):
    print("mean = ",mean," stddev = ",stdev," param = ",param)
```

```
mean =  0.5333632575686382  stddev =  0.020480885563178543  param =  {'max_depth': 1, 'min_samples_split': 5}
mean =  0.5333632575686382  stddev =  0.020480885563178543  param =  {'max_depth': 1, 'min_samples_split': 1
0}
mean =  0.5333632575686382  stddev =  0.020480885563178543  param =  {'max_depth': 1, 'min_samples_split': 10
0}
mean =  0.5333632575686382  stddev =  0.020480885563178543  param =  {'max_depth': 1, 'min_samples_split': 50
0}
mean =  0.6115706902303784  stddev =  0.025625111962890038  param =  {'max_depth': 5, 'min_samples_split': 5}
mean =  0.6109908761322314  stddev =  0.025514683637779107  param =  {'max_depth': 5, 'min_samples_split': 1
0}
mean =  0.6096877684610952  stddev =  0.02511952963391889  param =  {'max_depth': 5, 'min_samples_split': 10
0}
mean =  0.611862390790589  stddev =  0.02404907718490784  param =  {'max_depth': 5, 'min_samples_split': 500}
mean =  0.5916837440086538  stddev =  0.027551632062225495  param =  {'max_depth': 10, 'min_samples_split':
5}
mean =  0.5852384725751316  stddev =  0.029946479976718857  param =  {'max_depth': 10, 'min_samples_split': 1
0}
mean =  0.5980070873282092  stddev =  0.029407330278366315  param =  {'max_depth': 10, 'min_samples_split': 1
00}
mean =  0.6093969960339638  stddev =  0.023466142337502004  param =  {'max_depth': 10, 'min_samples_split': 5
00}
mean =  0.5740602773998331  stddev =  0.03162455039158077  param =  {'max_depth': 15, 'min_samples_split': 5}
mean =  0.5695203206472359  stddev =  0.027689971518738362  param =  {'max_depth': 15, 'min_samples_split': 1
0}
mean =  0.5851117366787358  stddev =  0.0330266272424429  param =  {'max_depth': 15, 'min_samples_split': 10
0}
mean =  0.6033388386690157  stddev =  0.02498078733949382  param =  {'max_depth': 15, 'min_samples_split': 50
0}
```

In [ ]:

Plot the result in 3d using plotly

In [245]:
```
import plotly.offline as offline # to use plotly in offline model
import plotly.graph_objs as go # importing graph objects
offline.init_notebook_mode()  # initialize plotly in notebook mode
import numpy as np
```

In [246]:
```
grid_result1.cv_results_ # see the complete description of findings
```

Out[246]:
```
{'mean_fit_time': array([11.00319858,  7.06102128,  6.62656646,  6.55857553, 26.70664766,
        32.78893604, 28.84695308, 24.6396862 , 40.45973177, 41.41908832,
        44.66792932, 39.80487278, 47.48352504, 48.98964305, 47.6044157 ,
        40.99921353]),
 'std_fit_time': array([2.97932103, 0.58256113, 0.32149003, 0.15112147, 1.25524744,
        3.48329675, 2.27188713, 1.00880796, 2.27733208, 3.20624277,
        1.02425432, 3.00112902, 1.90177469, 2.93218425, 1.39440218,
        3.18923165]),
 'mean_score_time': array([0.14148436, 0.06318259, 0.06159482, 0.05439382, 0.06309071,
        0.09051127, 0.06388378, 0.0611546 , 0.04780338, 0.06345003,
        0.07367349, 0.06159453, 0.05706539, 0.06479409, 0.06399434,
        0.05279486]),
 'std_score_time': array([0.07289424, 0.01353376, 0.0051219 , 0.02524596, 0.01488537,
        0.01436958, 0.00936062, 0.00707476, 0.00613127, 0.00652725,
        0.02198905, 0.01189194, 0.01060653, 0.01617633, 0.01959464,
        0.01483679]),
 'param_max_depth': masked_array(data=[1, 1, 1, 1, 5, 5, 5, 5, 10, 10, 10, 10, 15, 15, 15, 15],
              mask=[False, False, False, False, False, False, False, False,
                    False, False, False, False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'param_min_samples_split': masked_array(data=[5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5,
                    10, 100, 500],
              mask=[False, False, False, False, False, False, False, False,
                    False, False, False, False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'params': [{'max_depth': 1, 'min_samples_split': 5},
  {'max_depth': 1, 'min_samples_split': 10},
  {'max_depth': 1, 'min_samples_split': 100},
  {'max_depth': 1, 'min_samples_split': 500},
  {'max_depth': 5, 'min_samples_split': 5},
  {'max_depth': 5, 'min_samples_split': 10},
  {'max_depth': 5, 'min_samples_split': 100},
  {'max_depth': 5, 'min_samples_split': 500},
  {'max_depth': 10, 'min_samples_split': 5},
  {'max_depth': 10, 'min_samples_split': 10},
  {'max_depth': 10, 'min_samples_split': 100},
  {'max_depth': 10, 'min_samples_split': 500},
  {'max_depth': 15, 'min_samples_split': 5},
  {'max_depth': 15, 'min_samples_split': 10},
  {'max_depth': 15, 'min_samples_split': 100},
  {'max_depth': 15, 'min_samples_split': 500}],
```

```
 'split0_test_score': array([0.53991697, 0.53991697, 0.53991697, 0.53991697, 0.61584988,
        0.61584988, 0.60934816, 0.6133148 , 0.59160861, 0.58699179,
        0.58123568, 0.58257778, 0.60083628, 0.57696483, 0.56531542,
        0.59902295]),
 'split1_test_score': array([0.56115581, 0.56115581, 0.56115581, 0.56115581, 0.60289195,
        0.60289195, 0.60404825, 0.61195974, 0.60507674, 0.57560949,
        0.62105795, 0.63640015, 0.57983301, 0.58075196, 0.6089412 ,
        0.62798963]),
 'split2_test_score': array([0.51644444, 0.51644444, 0.51644444, 0.51644444, 0.63444148,
        0.63590519, 0.63400296, 0.63803259, 0.60266074, 0.60789333,
        0.60926815, 0.61598222, 0.56257778, 0.5466963 , 0.60229333,
        0.59678815]),
 'split3_test_score': array([0.52457181, 0.52457181, 0.52457181, 0.52457181, 0.58342556,
        0.58204216, 0.57744401, 0.57602767, 0.56065876, 0.55413702,
        0.54924901, 0.56612648, 0.53496706, 0.54747036, 0.53249671,
        0.5520224 ]),
 'split4_test_score': array([0.54613095, 0.54613095, 0.54613095, 0.54613095, 0.63134766,
        0.6252267 , 0.63052223, 0.61766416, 0.62817383, 0.62121001,
        0.64076451, 0.62863305, 0.61873372, 0.60235305, 0.61782692,
        0.61432757]),
 'split5_test_score': array([0.53423827, 0.53423827, 0.53423827, 0.53423827, 0.66456798,
        0.66456798, 0.66057027, 0.65790977, 0.59573623, 0.57640233,
        0.6184271 , 0.63559499, 0.55213049, 0.53914836, 0.58901534,
        0.63436225]),
 'split6_test_score': array([0.50227397, 0.50227397, 0.50227397, 0.50227397, 0.6084112 ,
        0.61510264, 0.60966624, 0.59274815, 0.63586038, 0.63541304,
        0.63218848, 0.63197102, 0.62385059, 0.62486953, 0.6454036 ,
        0.63598464]),
 'split7_test_score': array([0.54947048, 0.54947048, 0.54947048, 0.54947048, 0.58385318,
        0.5824508 , 0.58181005, 0.60238043, 0.53991368, 0.52689323,
        0.55997026, 0.58905169, 0.52358069, 0.53405629, 0.54595846,
        0.57681706]),
 'split8_test_score': array([0.50143626, 0.50143626, 0.50143626, 0.50143626, 0.57728824,
        0.57869752, 0.58059905, 0.58096317, 0.58017424, 0.59078772,
        0.59011342, 0.59673504, 0.57831991, 0.58009332, 0.58383569,
        0.59421316]),
 'split9_test_score': array([0.55799362, 0.55799362, 0.55799362, 0.55799362, 0.61362977,
        0.60717394, 0.60886648, 0.62762343, 0.57697423, 0.57704676,
        0.57779632, 0.61089753, 0.56577325, 0.56279922, 0.56003071,
        0.60186058]),
 'mean_test_score': array([0.53336326, 0.53336326, 0.53336326, 0.53336326, 0.61157069,
        0.61099088, 0.60968777, 0.61186239, 0.59168374, 0.58523847,
        0.59800709, 0.609397  , 0.57406028, 0.56952032, 0.58511174,
```

```
        0.60333884]),
 'std_test_score': array([0.02048089, 0.02048089, 0.02048089, 0.02048089, 0.02562511,
        0.02551468, 0.02511953, 0.02404908, 0.02755163, 0.02994648,
        0.02940733, 0.02346614, 0.03162455, 0.02768997, 0.03302663,
        0.02498079]),
 'rank_test_score': array([13, 13, 13, 13,  2,  3,  4,  1,  8,  9,  7,  5, 11, 12, 10,  6]),
 'split0_train_score': array([0.55445076, 0.55445076, 0.55445076, 0.55445076, 0.70226642,
        0.70178184, 0.69117575, 0.67050024, 0.84913427, 0.84633367,
        0.79230915, 0.71448864, 0.91872244, 0.91550684, 0.83655325,
        0.73592246]),
 'split1_train_score': array([0.55194202, 0.55194202, 0.55194202, 0.55194202, 0.68415166,
        0.68350584, 0.6751754 , 0.66062913, 0.87627471, 0.8698839 ,
        0.82602453, 0.7201176 , 0.95922667, 0.95096488, 0.8825339 ,
        0.73597558]),
 'split2_train_score': array([0.52141802, 0.52141802, 0.52141802, 0.52141802, 0.67026126,
        0.67026126, 0.66633421, 0.65851712, 0.81194274, 0.8096839 ,
        0.78999819, 0.73321492, 0.90342088, 0.8985155 , 0.84622276,
        0.74875755]),
 'split3_train_score': array([0.54968898, 0.54968898, 0.54968898, 0.54968898, 0.68592246,
        0.68592246, 0.67637069, 0.67037581, 0.82609535, 0.82400749,
        0.78221616, 0.74660243, 0.91453164, 0.90556593, 0.83402731,
        0.77464149]),
 'split4_train_score': array([0.55362899, 0.55362899, 0.55362899, 0.55362899, 0.67283581,
        0.67251298, 0.67010795, 0.65405192, 0.82280406, 0.8204073 ,
        0.78402958, 0.7284894 , 0.90584599, 0.90011814, 0.84255398,
        0.76291735]),
 'split5_train_score': array([0.55473085, 0.55473085, 0.55473085, 0.55473085, 0.69477082,
        0.69477082, 0.68871203, 0.67001424, 0.82707923, 0.82375501,
        0.78112566, 0.73877791, 0.90861708, 0.90192898, 0.83224303,
        0.76686644]),
 'split6_train_score': array([0.5226541 , 0.5226541 , 0.5226541 , 0.5226541 , 0.67260456,
        0.6722801 , 0.66798483, 0.66052113, 0.81993297, 0.81595188,
        0.78374912, 0.73089201, 0.90740534, 0.89997593, 0.84181313,
        0.75829302]),
 'split7_train_score': array([0.55328123, 0.55328123, 0.55328123, 0.55328123, 0.68416975,
        0.68416975, 0.68080807, 0.65817108, 0.82848745, 0.8233726 ,
        0.78301496, 0.72092796, 0.90132899, 0.89571932, 0.83658958,
        0.75173816]),
 'split8_train_score': array([0.55269489, 0.55269489, 0.55269489, 0.55269489, 0.69027258,
        0.68978462, 0.6862265 , 0.66592798, 0.82799652, 0.82441544,
        0.78658744, 0.72831627, 0.90213037, 0.89567383, 0.83787716,
        0.74147096]),
 'split9_train_score': array([0.5523202 , 0.5523202 , 0.5523202 , 0.5523202 , 0.69281363,
```

```
        0.69265113, 0.68509285, 0.67035969, 0.83988586, 0.83600596,
        0.78822999, 0.72082785, 0.91988841, 0.91471409, 0.84829668,
        0.74497879]),
 'mean_train_score': array([0.546681  , 0.546681  , 0.546681  , 0.546681  , 0.6850069 ,
        0.68476408, 0.67879883, 0.66390684, 0.83296332, 0.82938171,
        0.78972848, 0.7282655 , 0.91411178, 0.90786834, 0.84387108,
        0.75215618]),
 'std_train_score': array([0.01239843, 0.01239843, 0.01239843, 0.01239843, 0.01001776,
        0.00998348, 0.00846846, 0.00591286, 0.01739729, 0.01655867,
        0.01256977, 0.0091845 , 0.01629386, 0.01584057, 0.0137859 ,
        0.01256266])}
```

In [ ]:

In [247]:

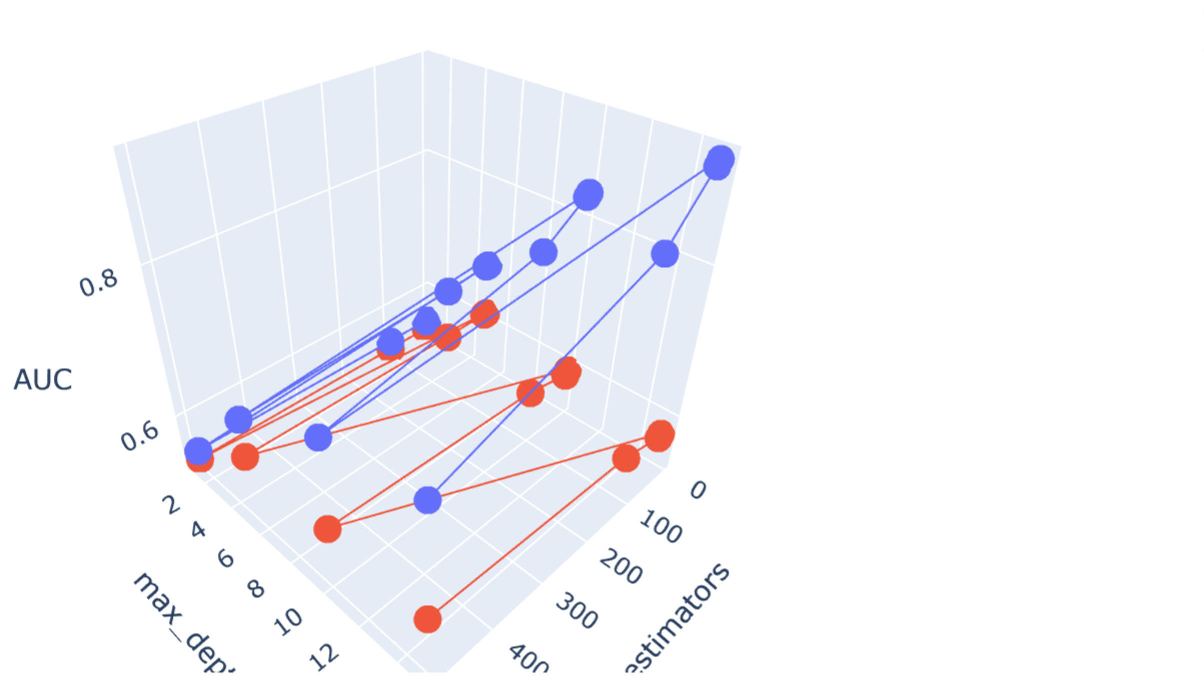
```
x1_set1 = list(grid_result1.cv_results_['param_min_samples_split'])
y1_set1 = list(grid_result1.cv_results_['param_max_depth'])
z1_set1 = list(grid_result1.cv_results_['mean_train_score']) # accuracy on X_train

x2_set1 = list(grid_result1.cv_results_['param_min_samples_split'])
y2_set1 = list(grid_result1.cv_results_['param_max_depth'])
z2_set1 = list(grid_result1.cv_results_['mean_test_score'])
```

In [248]:
```
x1_set1, y1_set1, z1_set1
```

Out[248]:
```
([5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500, 5, 10, 100, 500],
 [1, 1, 1, 1, 5, 5, 5, 5, 10, 10, 10, 10, 15, 15, 15, 15],
 [0.5466810032869895,
  0.5466810032869895,
  0.5466810032869895,
  0.5466810032869895,
  0.685006896020924,
  0.6847640791921089,
  0.6787988268597542,
  0.6639068360769576,
  0.8329633164009895,
  0.8293817135387078,
  0.7897284774183136,
  0.7282654988923862,
  0.9141117814220723,
  0.9078683440122772,
  0.8438710755644874,
  0.7521561804543327])
```

In [ ]:

In [249]:
```
# https://plot.ly/python/3d-axes/
trace1 = go.Scatter3d(x=x1_set1,y=y1_set1,z=z1_set1, name = 'train')
trace2 = go.Scatter3d(x=x2_set1,y=y2_set1,z=z2_set1, name = 'Cross validation')
data1 = [trace1, trace2]

layout = go.Layout(scene = dict(
        xaxis = dict(title='n_estimators'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data=data1, layout=layout)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

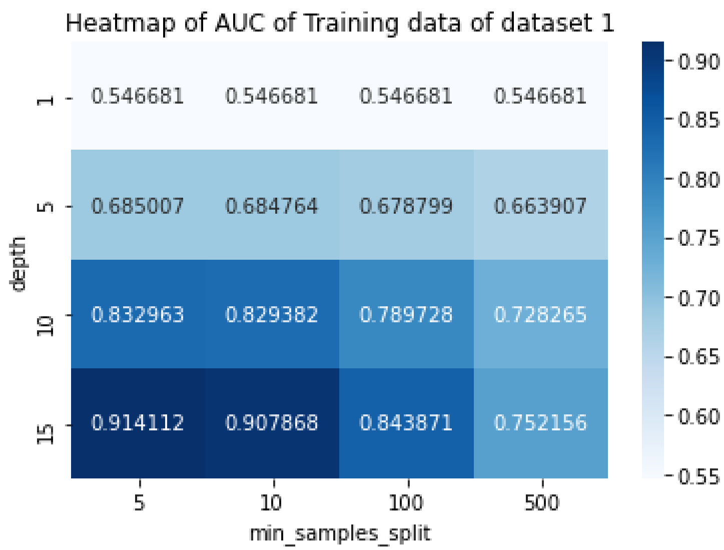


Let's plot the heatmap

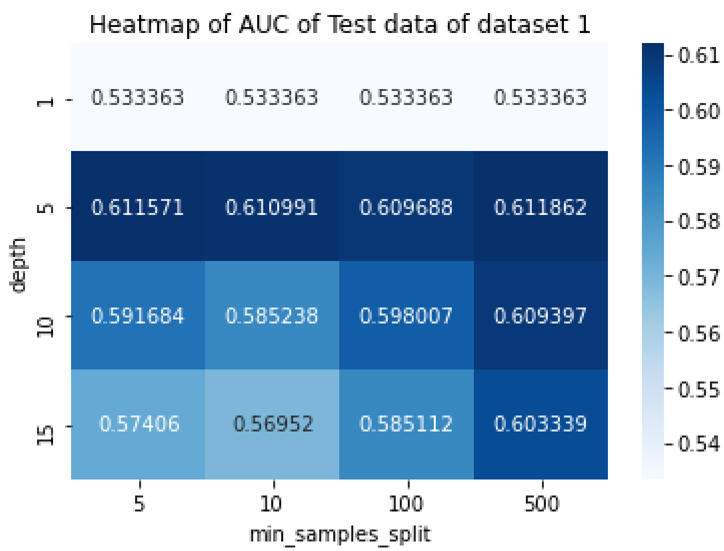
In [250]:
```
# creating utility function for plotting heatmap
def plot_heatmap(dataframe, title="Title", xlabel="xlabel", ylabel="ylabel"):
    sns.heatmap(
        data=dataframe,
        annot=True,
        xticklabels=dataframe.columns,
        yticklabels=dataframe.index,
        cmap='Blues',
        fmt='g'
    )
    plt.xlabel(xlabel)
    plt.ylabel(ylabel)
    plt.title(title)

# creating dataset
def dataset_creation(data, index, columns):
    t=np.array(data).reshape(len(index),len(columns))

    dataset = pd.DataFrame(t,
                           index=index,
                           columns=columns
                          )
    return dataset
```

In [251]:
```python
# creating a dataset to plot heatmap of training dataset of set2
train_data_set1 = dataset_creation(z1_set1, index = depth, columns=min_samples_split)

print(train_data_set1)
# plotting the heatmap
plot_heatmap(
    train_data_set1,
    title='Heatmap of AUC of Training data of dataset 1',
    xlabel='min_samples_split',
    ylabel='depth'
)
```

```
          5        10       100       500
1   0.546681  0.546681  0.546681  0.546681
5   0.685007  0.684764  0.678799  0.663907
10  0.832963  0.829382  0.789728  0.728265
15  0.914112  0.907868  0.843871  0.752156
```



In [252]:
```
# creating a dataset to plot heatmap of training dataset of set2
test_data_set1 = dataset_creation(z2_set1, index = depth, columns=min_samples_split)

# plotting the heatmap
plot_heatmap(
    test_data_set1,
    title='Heatmap of AUC of Test data of dataset 1',
    xlabel='min_samples_split',
    ylabel='depth'
)
```



In [ ]:

Once after you found the best hyper-parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.

finding best parameter

In [253]:
```
best_parameter1 = grid_result1.best_params_
```

In [254]:
```
best_parameter1
```

Out[254]:
```
{'max_depth': 5, 'min_samples_split': 500}
```

Initializing Classifier

In [255]:
```
from sklearn.multiclass import OneVsOneClassifier
```

In [256]:
```
# used OneVsOneClassifier to get y_score using decision_function()
best_clf1 = OneVsOneClassifier(DecisionTreeClassifier(max_depth=best_parameter1['max_depth'], min_samples_spl
it=best_parameter1['min_samples_split'],
                                                      class_weight='balanced'))
```

fitting classifier

In [257]:
```
y_score1 = best_clf1.fit(X_train1,y_train1).decision_function(X_test1)
# actually it is score given by decision function
```

In [258]:
```
x_score1 = best_clf1.decision_function(X_train1)
# score of training dataset by decision function
```

In [259]:
```
# help(auc) ############# uncomment to see the description of auc ############
```

In [260]:
```
y_test1.shape # shape of dependent variable
```

Out[260]:
```
(2000, 1)
```

In [261]:
```
y_score1.shape
```

Out[261]:
```
(2000,)
```

In [262]:
```
x_score1.shape
```

Out[262]:
```
(8000,)
```

In [263]:
```
# y_score1 # uncomment this to see the result
```

In [ ]:

In [264]:
```
# getting fpr, tpr, and thresholds
fpr1_test, tpr1_test, thresholds1_test = roc_curve(y_test1, y_score1)
# getting fpr, tpr, and thresholds for training data
fpr1_train, tpr1_train, thresholds1_train = roc_curve(y_train1, x_score1)
```

In [265]:
```
fpr1_train # showing False positive rate of train dataset
```

Out[265]:
```
array([0.        , 0.        , 0.00762712, 0.01525424, 0.02542373,
       0.04152542, 0.08983051, 0.18050847, 0.20254237, 0.77288136,
       0.79491525, 0.93813559, 1.        ])
```

In [266]:
```
tpr1_train # showing True Positive rate of train dataset
```

Out[266]:
```
array([0.        , 0.01495601, 0.0585044 , 0.10043988, 0.14384164,
       0.1840176 , 0.29706745, 0.38856305, 0.40938416, 0.91612903,
       0.9313783 , 0.98167155, 1.        ])
```

In [267]:
```
fpr1_test # fpr of test
```

Out[267]:
```
array([0.        , 0.00645161, 0.01612903, 0.04193548, 0.05806452,
       0.07419355, 0.13548387, 0.21612903, 0.21935484, 0.81290323,
       0.82258065, 0.94516129, 1.        ])
```

In [268]:
```
tpr1_test
```

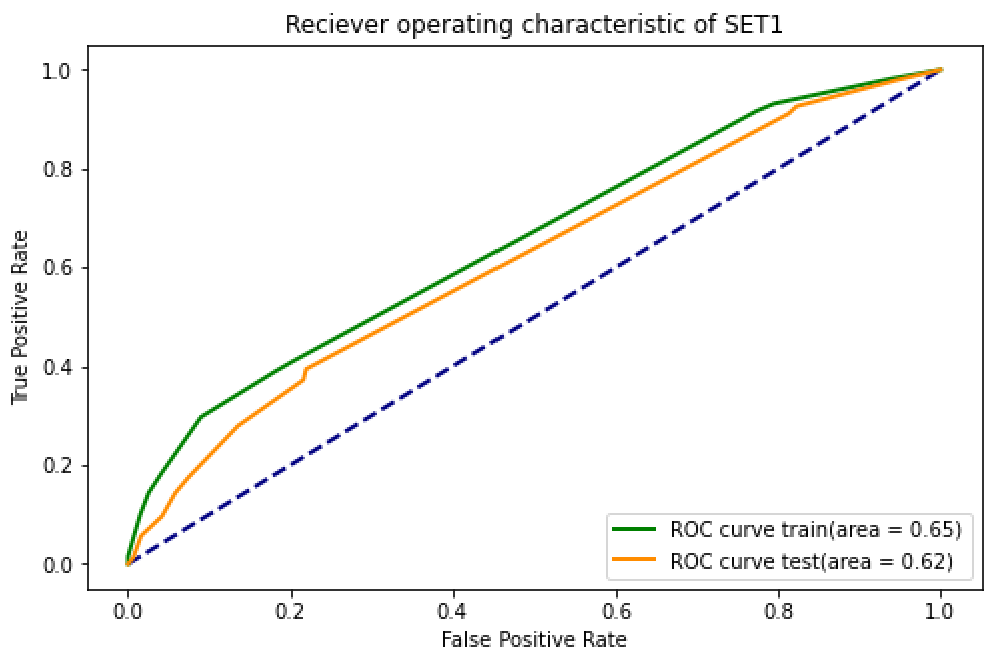
Out[268]:
```
array([0.        , 0.01242604, 0.05680473, 0.0964497 , 0.14319527,
       0.17455621, 0.27928994, 0.37218935, 0.39408284, 0.9112426 ,
       0.9260355 , 0.97869822, 1.        ])
```

In [ ]:

In [269]:
```
roc_auc_train = auc(fpr1_train, tpr1_train) # getting Area Under Curve of train data
roc_auc_test  = auc(fpr1_test, tpr1_test) # getting AUC of test data
```

In [270]:
```
# plotting ROC Curve
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
plt.figure(figsize=(8,5))
plt.plot([0,1],[0,1], color='navy', lw = 2, linestyle='--')
plt.plot(fpr1_train, tpr1_train, color='green', lw=2, label="ROC curve train(area = %0.2f)"%roc_auc_train)
plt.plot(fpr1_test, tpr1_test, color='darkorange', lw=2, label='ROC curve test(area = %0.2f)'%roc_auc_test)
plt.title('Reciever operating characteristic of SET1')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc="lower right")
```

Out[270]: <matplotlib.legend.Legend at 0x299349cae80>



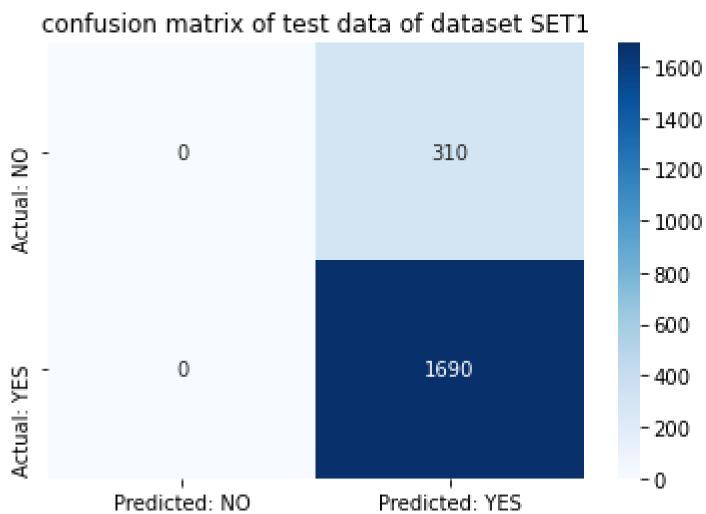
print the confusion matrix

In [271]:
```
from sklearn.metrics import confusion_matrix
```

In [272]:
```
y_predicted1 = best_clf1.predict(X_test1)
```

In [273]:
```
cm1 = confusion_matrix(y_test1, y_predicted1)
xlabels = ['Predicted: NO', 'Predicted: YES']
ylabels = ['Actual: NO', 'Actual: YES']
sns.heatmap(
    data=cm1,
    xticklabels=xlabels,
    yticklabels=ylabels,
    annot=True,
    fmt='g',
    cmap='Blues'
)
plt.title('confusion matrix of test data of dataset SET1')
```

Out[273]:
```
Text(0.5, 1.0, 'confusion matrix of test data of dataset SET1')
```



Getting False positive datapoints of SET1...

In [274]:
```
type(X_train)
```

Out[274]:
```
pandas.core.frame.DataFrame
```

In [ ]:

In [275]:
```
# getting false positive data to plot the WordCloud
fp_essay1 = [] # list to store false positive data from the training dataset
fp_price1 = [] # to store price of False positive
fp_teacher_project_posted1= [] # to store teacher_number_of_previously_posted_projects

for i in tqdm(range(len(y_test1))): # for each datapoint in test dataset

    if y_test1[i]==0 and y_predicted1[i]==1: # checking for false positive

        fp_essay1.append(X_test['essay'].iloc[i]) # appending the essay of desired location
        fp_price1.append(X_test['price'].iloc[i]) # appending price
        fp_teacher_project_posted1.append(X_test['teacher_number_of_previously_posted_projects'].iloc[i])
```

```
100%|██████████████████████████████████████████████████| 2000/2000 [00:00<00:00, 1248
65.78it/s]
```

In [276]:
```
len(fp_essay1)
```

Out[276]:
```
310
```

In [277]:
```
fp_essay1[0:2]
```

Out[277]:
```
['The students in my classroom come from quite a diverse group of backgrounds and academic abilities. Ninety-
percent of our student body receives free and reduced price breakfast/lunch. Many students come from time-poo
r families, meaning their parents or guardians are unable to spend much quality time with them to help them w
ith their homework. Over years of being in this situation, the achievement gap between them and their higher 
SES peers widens.\\r\\nDespite the high poverty level and the obstacles that face them, my students come to s
chool ready to learn and work hard. What they lack in grade level academic achievement, they make up for in h
eart and character. Our school has a hyphenated name because we are a hyphenated community. Half of our build
ing is composed of general education K-4 classrooms, while the other half consists of self-contained classroo
ms for students with various disabilities. My students participate in a program called \\"Project Unify\\" in
which they take turns going to eat lunch and play with students in the special education building. I could no
t be more proud to teach in a school that values empathy as being equally as important as academics.I took ov
er this classroom mid-year, right after Christmas, and have been getting to know these students over the past
few weeks. I have already found teaching to be emotionally draining as I hear the heart wrenching stories of 
the broken homes many of my students come from. Just when I think I\'ve heard the worst of it, I find out mor
e. As I am a brand new teacher hired straight out of student teaching, I don\'t have much to offer my student
s aside from giving them my time, my attention, and my unconditional love. I am financially struggling to sto
ck my classroom with the materials it needs; and so far, I am running on borrowed  supplies. \\r\\n\\"Ohana m
eans family; and family means nobody gets left behind or forgotten.\\" I encourage my students to look at mys
elf and their classmates as family; we continuously quote the Disney movie Lilo and Stitch to remind us so. I
f this project is funded, I will be sent cushions, blankets, pillows, and carpet that will allow me to create
a warm, cozy environment for my students to read and learn. I want them to come into my classroom feeling lik
e they\'ve walked into a family room filled with the people and furnishings that make them feel like they\'re
home. I want them to know that they are safe, valued, and far from harm when they are at school... far from f
ighting, drug abuse, cold, and hunger.  The 7 hours a day they spend with me will be 7 hours where they can l
et their guards down and learn.\\r\\n\\r\\nnannan',
 "Funds are tight, but the future is bright!  \\r\\n\\r\\nMy students applied and interviewed for a college-r
eadiness elective called AVID.  Many of these special students will be the first generation in their families
to graduate or even attend college. Many have English as a second language, economical disadvantages, and mos
t have limited resources to pursue a college education. \\r\\nHaving said that, all of these students have pr
oven to be  highly motivated to succeed, and all are dedicated to their own education. \\r\\nMy AVID students
apply to be a part of this wonderful college readiness program. Many of them have never been and may never be
introduced to the resources that are available online in regards to colleges, careers, financial aid, and any
thing regarding those things. Technology at our campus has been limited for a while now. I do not see an impr
ovement happening soon. For these scholars  to be able to utilize the AVID program properly, they must have a
consistent access to the resources provided online and the program's we can utilize through the Internet. Ple
ase help make this happen!!!nannan"]
```

In [278]:
```
# importing necessary modules
from wordcloud import WordCloud, STOPWORDS

stopwords = set(STOPWORDS)

comment_words1 = ''
for essay in fp_essay1: # for each essay
    # joining all essays into single variable called comment_words
    essay = essay + ' ' # adding space at the end of sentence.
    comment_words1 += "".join(essay)+""
```

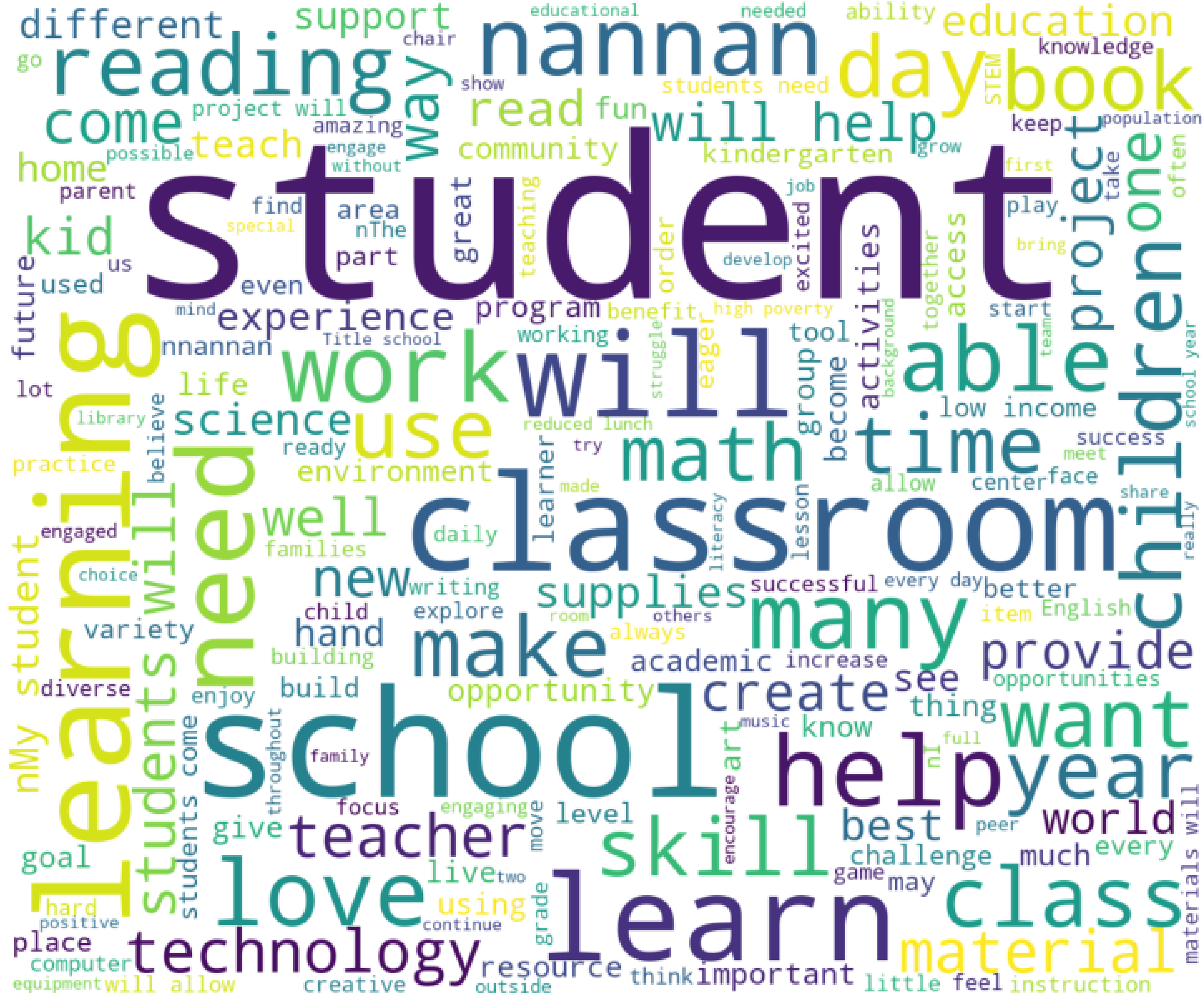
In [279]:
```
comment_words1[0:100]
```

Out[279]:
```
'The students in my classroom come from quite a diverse group of backgrounds and academic abilities. '
```

WordCloud

In [280]:
```
wordcloud1 = WordCloud(width=1200, height=1000,
                     background_color='white',
                     stopwords = stopwords,
                     min_font_size = 10
                     ).generate(comment_words1)

plt.figure(figsize=(10,10), facecolor=None)
plt.imshow(wordcloud1)
plt.axis(False)
plt.tight_layout(pad=0)
plt.title('Word Cloud of false positive datapoint of test data set of SET 1')
plt.show()
```

Word Cloud of false positive datapoint of test data set of SET 1

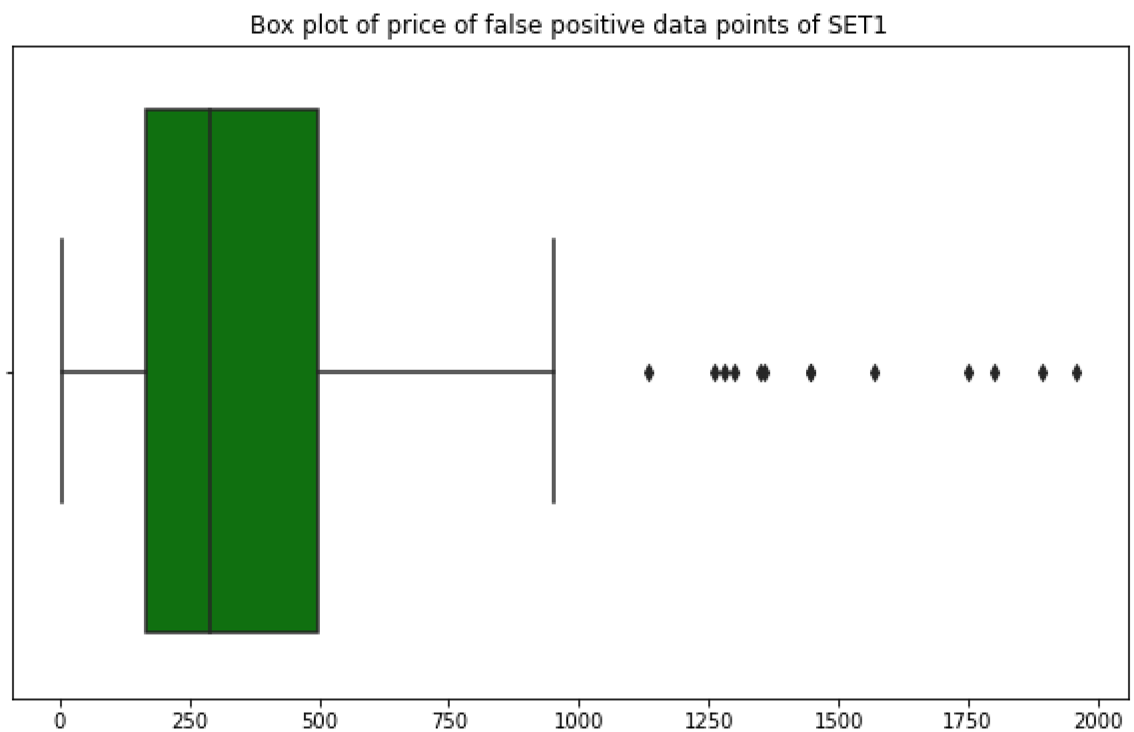


Box-plot

Plot the box plot with the 'price' of these false positive data points'

In [281]:
```
plt.figure(figsize=(10,6))
sns.boxplot(fp_price1,color='green')
plt.title('Box plot of price of false positive data points of SET1')
```

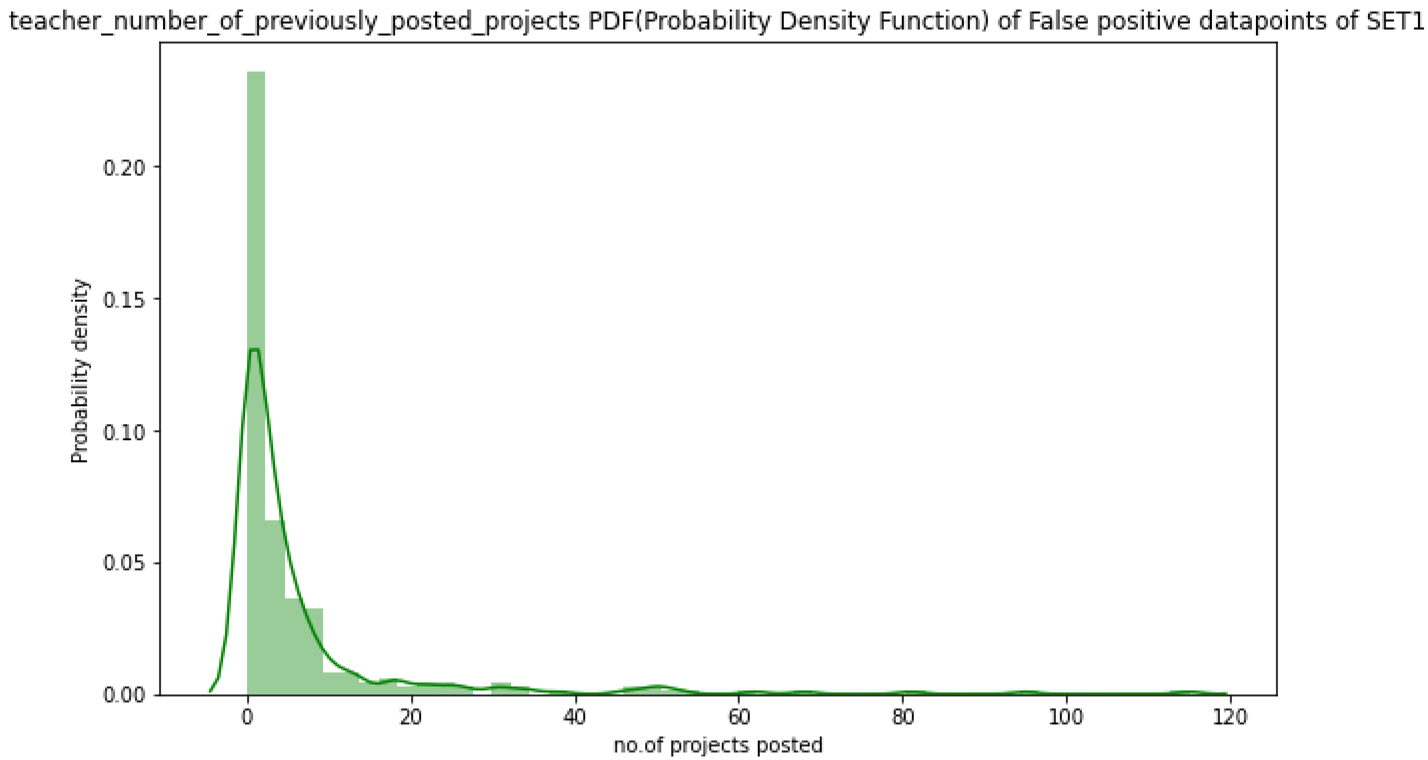
Out[281]: Text(0.5, 1.0, 'Box plot of price of false positive data points of SET1')



PDF(Porbability Density Function)

In [282]:
```
plt.figure(figsize=(10,6))
sns.distplot(fp_teacher_project_posted1,
            color='green',
        )
plt.title('teacher_number_of_previously_posted_projects PDF(Probability Density Function) of False positive datapoints of SET1')
plt.xlabel('no.of projects posted')
plt.ylabel('Probability density')
```

Out[282]: Text(0, 0.5, 'Probability density')



In [ ]:

In [ ]:

Task - 2

For this task consider set-1 features.

- **Select all the features which are having non-zero feature importance.You can get the feature importance using 'feature*importances*` ([https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html)](https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html)), discard the all other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM).**
- **You need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3**
  **Note: when you want to find the feature importance make sure you don't use max_depth parameter keep it None. **
  You need to summarize the results at the end of the notebook, summarize it in the table format

```
<img src='http://i.imgur.com/YVpIGGE.jpg' width=400px>
```

** **

In [283]:
```
grid_result1.best_params_
best_max_depth = grid_result1.best_params_['max_depth']
best_min_split = grid_result1.best_params_['min_samples_split']
```

In [284]:
```
clf = DecisionTreeClassifier(max_depth=best_max_depth,
                             min_samples_split=best_min_split,
                             class_weight='balanced'
                            ).fit(X_train1, y_train1)
```

In [285]:
```
# get feature importance
important_features = clf.feature_importances_
```

In [286]:
```
len(important_features)
```

Out[286]:
```
6140
```

In [287]:
```
important_features
```
Out[287]:
```
array([0., 0., 0., ..., 0., 0., 0.])
```

In [288]:
```
X_train1.shape
```
Out[288]:
```
(8000, 6140)
```

In [289]:
```
non_zero_index = important_features!=0.0
```

In [290]:
```
non_zero_index
```
Out[290]:
```
array([False, False, False, ..., False, False, False])
```

In [291]:
```
non_zero_dataset1 = X_train1[:,non_zero_index]
```

In [292]:
```
non_zero_dataset1.shape
```
Out[292]:
```
(8000, 10)
```

Using Logistic Regression() to classify the new datapoints

In [293]:
```
from sklearn.linear_model import LogisticRegression
```

In [294]:
```
log_clf = LogisticRegression(class_weight='balanced')
```

In [295]:
```
kfold = KFold(n_splits=10, random_state=42)
```

In [296]:
```
alpha = [100,10,1.0,0.1,0.01]
grid = dict(C=alpha)

grid_search3 = GridSearchCV(estimator=log_clf, param_grid=grid, n_jobs=-1, scoring='roc_auc', cv=kfold)
```

In [297]:
```
grid_search3.return_train_score=True # to get train score
```

In [298]:
```
grid_result3 = grid_search3.fit(non_zero_dataset1, y_train1)
```

In [299]:
```
grid_result3.best_params_
```

Out[299]:
```
{'C': 10}
```

In [300]:
```
grid_result3.best_score_
```

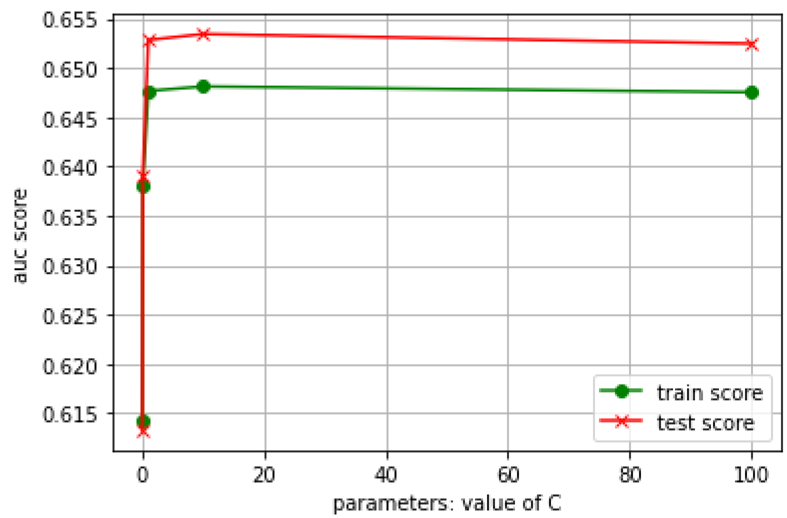
Out[300]:
```
0.6534313797760514
```

In [301]:
```
grid_result3.cv_results_
```

Out[301]:
```
{'mean_fit_time': array([0.22348568, 0.09359026, 0.07919304, 0.06559398, 0.05919473]),
 'std_fit_time': array([0.15880389, 0.04396622, 0.02827067, 0.00999031, 0.0095982 ]),
 'mean_score_time': array([0.00239983, 0.00399981, 0.00159962, 0.00159976, 0.00319958]),
 'std_score_time': array([0.00366579, 0.00399981, 0.00319924, 0.00319953, 0.00391867]),
 'param_C': masked_array(data=[100, 10, 1.0, 0.1, 0.01],
              mask=[False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'params': [{'C': 100}, {'C': 10}, {'C': 1.0}, {'C': 0.1}, {'C': 0.01}],
 'split0_test_score': array([0.66960536, 0.67907759, 0.67621445, 0.66677801, 0.63360136]),
 'split1_test_score': array([0.66512494, 0.66513711, 0.66288538, 0.6445429 , 0.62037026]),
 'split2_test_score': array([0.66343111, 0.66343111, 0.66341926, 0.66340741, 0.66337185]),
 'split3_test_score': array([0.60361001, 0.60384717, 0.6086693 , 0.62173913, 0.61263505]),
 'split4_test_score': array([0.66308594, 0.66314407, 0.65983073, 0.64258975, 0.61238607]),
 'split5_test_score': array([0.67593431, 0.67739689, 0.67841373, 0.64395258, 0.59245588]),
 'split6_test_score': array([0.63558079, 0.63558079, 0.63556837, 0.63554352, 0.63523286]),
 'split7_test_score': array([0.67803085, 0.67829682, 0.67956623, 0.64918516, 0.60103245]),
 'split8_test_score': array([0.6158919 , 0.61671454, 0.61535246, 0.5961484 , 0.55973621]),
 'split9_test_score': array([0.65433532, 0.6516877 , 0.64837516, 0.62733933, 0.60196334]),
 'mean_test_score': array([0.65246305, 0.65343138, 0.65282951, 0.63912262, 0.61327853]),
 'std_test_score': array([0.02429923, 0.02511996, 0.0241888 , 0.01954784, 0.0265221 ]),
 'rank_test_score': array([3, 1, 2, 4, 5]),
 'split0_train_score': array([0.6561677 , 0.65749398, 0.6585644 , 0.64320898, 0.61386941]),
 'split1_train_score': array([0.65490367, 0.65518461, 0.65622023, 0.64610693, 0.61552117]),
 'split2_train_score': array([0.60275568, 0.60275537, 0.60275491, 0.60275213, 0.60271604]),
 'split3_train_score': array([0.66177966, 0.66197771, 0.66241497, 0.64927947, 0.61672043]),
 'split4_train_score': array([0.65835523, 0.65875058, 0.65734003, 0.64586485, 0.61610866]),
 'split5_train_score': array([0.65836175, 0.65976217, 0.65611351, 0.64391405, 0.61733329]),
 'split6_train_score': array([0.60615342, 0.60615403, 0.60615511, 0.60615618, 0.60612519]),
 'split7_train_score': array([0.65378851, 0.65405827, 0.65475046, 0.64506383, 0.61694897]),
 'split8_train_score': array([0.66433845, 0.66453969, 0.66158271, 0.64918209, 0.62075445]),
 'split9_train_score': array([0.6586776 , 0.66046424, 0.66071261, 0.6479907 , 0.61716726]),
 'mean_train_score': array([0.64752817, 0.64811406, 0.64766089, 0.63795192, 0.61432649]),
 'std_train_score': array([0.02174688, 0.0220334 , 0.0217455 , 0.01687626, 0.00527176])}
```

In [302]:
```
plt.plot(alpha, grid_result3.cv_results_['mean_train_score'],
         color='green', marker='o', label='train score'
        )
plt.plot(alpha, grid_result3.cv_results_['mean_test_score'],
        color='red', label='test score', marker='x',
        )
plt.title('Performance of model both on train data and cross validation data for each hyper-parameter\n')
plt.xlabel('parameters: value of C')
plt.ylabel('auc score')
plt.legend()
plt.grid(True, which='major')
plt.show()
```

Performance of model both on train data and cross validation data for each hyper-parameter



In [303]:
```
best_log_clf = LogisticRegression(C=grid_result3.best_params_['C'])
```

In [304]:
```
best_log_clf.fit(non_zero_dataset1, y_train1)
```

Out[304]:
```
LogisticRegression(C=10)
```

In [305]:
```
non_zero_dataset1_test = X_test1[:,non_zero_index]
y_predicted3 = best_log_clf.predict_proba(non_zero_dataset1_test)
```

In [306]:
```
y_score3 = best_log_clf.decision_function(non_zero_dataset1_test)
```

In [307]:
```
fpr, tpr, thresh = roc_curve(y_test1, y_score3)
```

In [308]:
```
auc_score3 = auc(fpr, tpr)
```

In [309]:
```
auc_score3
```

Out[309]: 0.6406241649169688

plot the roc auc

In [310]:
```
x_score3 = best_log_clf.decision_function(non_zero_dataset1)
```

In [311]:
```
fpr3, tpr3, thresh3 = roc_curve(y_train1, x_score3)
```

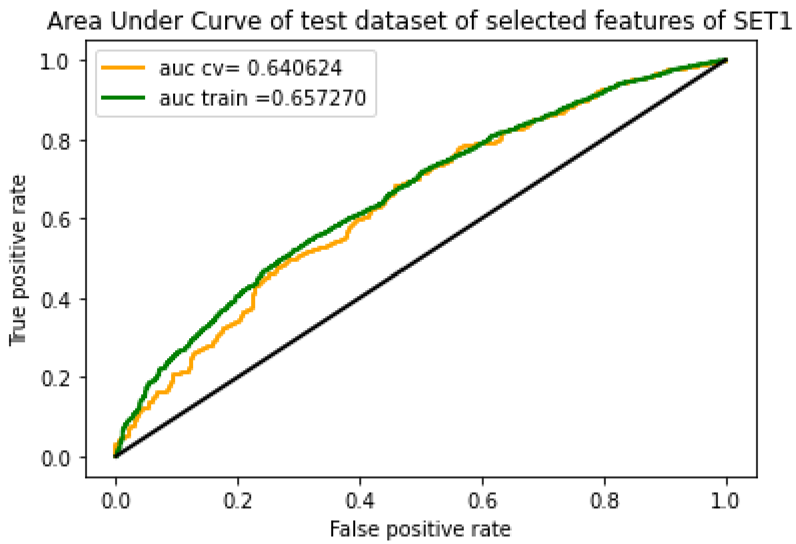
In [312]:
```
auc_score_train3 = auc(fpr3, tpr3)
auc_score_train3
```

Out[312]: 0.6572698071474725

In [ ]:

In [313]:
```
plt.plot(fpr, tpr, color='orange', lw=2, label='auc cv= %f'%auc_score3, animated=True)
plt.plot(fpr3, tpr3, color='green', lw=2, label='auc train =%f'%auc_score_train3, animated=True)
plt.plot([0,1],[0,1], color='black', lw=2, animated=True)
plt.title('Area Under Curve of test dataset of selected features of SET1')
plt.xlabel('False positive rate')
plt.ylabel('True positive rate')
plt.legend()
```

Out[313]: <matplotlib.legend.Legend at 0x29932cafbb0>



In [ ]:

In [ ]:

Summary:

In [314]:
```
from prettytable import PrettyTable
```

In [315]:
```
summary = PrettyTable() # creating object of prettytable
```

In [316]:
```
summary.field_names = ["Vectorizer", "Model", "Depth (hyper-parameter)", "min_samples_split","AUC"]
```

In [317]:
```
summary.add_row(["TFIDF","DecisionTreeClassifier",grid_result1.best_params_['max_depth'],grid_result1.best_params_['min_samples_split'],"%.2f"%grid_result1.best_score_])
summary.add_row(["TFIDF W2V","DecisionTreeClassifier", grid_result2.best_params_['max_depth'],grid_result2.best_params_['min_samples_split'],"%.2f"%grid_result2.best_score_])
```

In [318]:
```
print(summary)
```

```
+------------+------------------------+-------------------------+-------------------+------+
| Vectorizer |         Model          | Depth (hyper-parameter) | min_samples_split | AUC  |
+------------+------------------------+-------------------------+-------------------+------+
|   TFIDF    | DecisionTreeClassifier |            5            |        500        | 0.61 |
| TFIDF W2V  | DecisionTreeClassifier |            5            |        500        | 0.57 |
+------------+------------------------+-------------------------+-------------------+------+
```

In [319]:
```
summary.add_row(["TFIDF(non-zero features only)","LogisticRegression","No depth (C=%.2f)"%best_log_clf.C,"No
 height(C=%.2f)"%(best_log_clf.C),"%.2f"%auc_score3])
```

In [320]:
```
print(summary)
```

```
+-------------------------------+------------------------+-------------------------+--------------------+----
--+
|          Vectorizer           |         Model          | Depth (hyper-parameter) | min_samples_split  | AUC
|
+-------------------------------+------------------------+-------------------------+--------------------+----
--+
|             TFIDF             | DecisionTreeClassifier |            5            |        500         | 0.6
1 |
|           TFIDF W2V           | DecisionTreeClassifier |            5            |        500         | 0.5
7 |
| TFIDF(non-zero features only) |   LogisticRegression   |    No depth (C=10.00)   | No height(C=10.00) | 0.6
4 |
+-------------------------------+------------------------+-------------------------+--------------------+----
--+
```

In [ ]:

In [ ]:

In [ ]:

```

```