Assignment : DT

In [119]:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

In [120]:

```
!pip install plotly --upgrade
```

```
Requirement already up-to-date: plotly in /usr/local/lib/python3.6/dist-packages (4.9.0)
Requirement already satisfied, skipping upgrade: six in /usr/local/lib/python3.6/dist-packages (fr
om plotly) (1.15.0)
Requirement already satisfied, skipping upgrade: retrying>=1.3.3 in /usr/local/lib/python3.6/dist-
packages (from plotly) (1.3.3)
```

In [121]:

```
path = '/content/drive/My Drive/AAIC/ASSIGN_11/ASSIGN_11/'
```

In [122]:

```
from IPython.display import YouTubeVideo
YouTubeVideo('ZhLXULFjIjQ', width="1000",height="500")
```

Out[122]:

Please check below video before attempting this assignment

TF-IDFW2V

Tfidf w2v (w1,w2..) = (tfidf(w1) * w2v(w1) + tfidf(w2) * w2v(w2) + …) / (tfidf(w1) + tfidf(w2) + …)

(Optional) Please check course video on AVgw2V and TF-IDFW2V for more details.

Glove vectors

In this assignment you will be working with glove vectors , please check [this] (https://en.wikipedia.org/wiki/GloVe_(machine_learning)) and [this](https://en.wikipedia.org/wiki/GloVe_(machine_learning)) for more details.

Download glove vectors from this link

In [123]:

```
#please use below code to load glove vectors
import pickle
import warnings
warnings.filterwarnings("ignore")
with open(path+'glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

or else , you can use below code

In [124]:

```
'''
# 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))
```

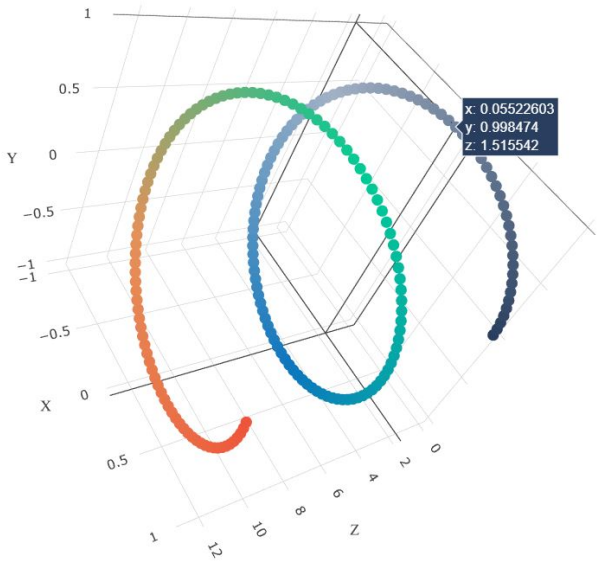
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/

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


'''
```

Out[124]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef
loadGloveModel(gloveFile):\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.array([float(val) for val in splitLine[1:]])\n        m
odel[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel =
loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love 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\nfor 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 tha
t 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 =
set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\n
print("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python
: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pic
kle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

Task - 1

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)**
    ** **
    - **The hyper paramter tuning (best `depth` in range [1, 5, 10, 50], and the best `min_samples_split` in range [5, 10, 100, 500])**
        - **Find the best hyper parameter which will give the maximum AUC value**
        - **find the best hyper paramter using k-fold cross validation(use gridsearch cv or randomsearch cv)/simple cross validation data(you can write your own for loops refer sample solution)**
        ** **
        - **Representation of results**
            - **You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure**

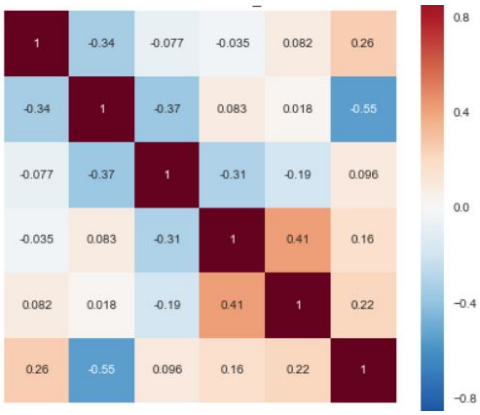


with X-axis as min_sample_split, Y-axis as max_depth, and Z-axis as AUC Score , we have given the

notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

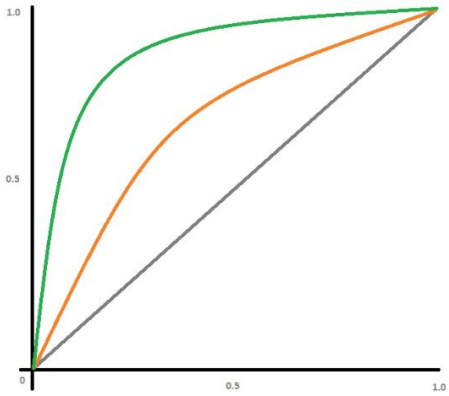
or

- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



[seaborn heat maps] with rows as n_estimators, columns as max_depth, and values inside the cell representing AUC Score

- You choose either of the plotting techniques out of 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.



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

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

- Once after you plot the confusion matrix with the test data, get all the `false positive data points`
  - Plot the WordCloud(https://www.geeksforgeeks.org/generating-word-cloud-python/) with the words of essay text of these `false positive data points`
  - Plot the box plot with the `price` of these `false positive data points`
  - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

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]), 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>

Hint for calculating Sentiment scores

1. Decision Tree

Task 1

1.1 Loading Data

In [125]:

```
import pandas
data = pandas.read_csv(path+'preprocessed_data.csv',nrows=50000)
```

In [126]:

```
data.head(1)
```

Out[126]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ca	mrs	grades_prek_2	53	1	math_sc

In [127]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

import re
from tqdm import tqdm
```

1.1.0 Adding Sentiment analysis features such as NEG, POS, NEU and COMPOUND polarity scores

In [128]:

```
import nltk
nltk.download('vader_lexicon')
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()
NEG = []
NEU = []
POS = []
COMP = []
essays = data['essay'].values
for senetence in essays:
  ss = sid.polarity_scores(senetence)
  NEG.append(ss['neg'])
```

```
  POS.append(ss['pos'])
  NEU.append(ss['neu'])
  COMP.append(ss['compound'])

df2 = pd.DataFrame({'NEG':NEG,
                    'POS':POS,
                    'NEU':NEU,
                    'COMPOUND':COMP})
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

In [129]:

```
df2.head(2)
```

Out[129]:

	NEG	POS	NEU	COMPOUND
0	0.013	0.205	0.783	0.9867
1	0.072	0.248	0.680	0.9897

In [130]:

```
data = pd.concat([data, df2], axis=1)
data.head(2)
```

Out[130]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ca	mrs	grades_prek_2	53	1	math_sc
1	ut	ms	grades_3_5	4	1	special

1.1.1 Processing Project Essay.

In [131]:

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

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

In [132]:

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

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

In [133]:

```
# Combining all the above stundents
from tqdm import tqdm
def preprocess_text(text_data):
    preprocessed_text = []
    # tqdm is for printing the status bar
    for sentance in tqdm(text_data):
        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
        # https://gist.github.com/sebleier/554280
        sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
        preprocessed_text.append(sent.lower().strip())
    return preprocessed_text
```

In [134]:

```
data.essay.iloc[:1]
```

Out[134]:

```
0    i fortunate enough use fairy tale stem kits cl...
Name: essay, dtype: object
```

As there are some stop words present in the text of essay of already preprocessed_data. For example word ` i ' is present in the first essay sentence. So, I am processing the essay text again inorder to remove the stop words if there are any by chance and also because unnecessary stop words increase the dimensionality of the bow/tfidf representation.

In [135]:

```
data['essay'] = preprocess_text(data['essay'].values)
```

```
100%|██████████| 50000/50000 [00:19<00:00, 2504.70it/s]
```

In [136]:

```
data.essay.iloc[:1]
```

Out[136]:

```
0    fortunate enough use fairy tale stem kits clas...
Name: essay, dtype: object
```

In [137]:

```
data.head(1)
```

Out[137]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ca	mrs	grades_prek_2	53	1	math_sc

1.1.2 Loading data after processing essay

In [138]:

```
Y=data['project_is_approved']
X=data.drop('project_is_approved',axis=1)
```

In [139]:

```
X.head(1)
```

Out[139]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	clean_subcate
0	ca	mrs	grades_prek_2	53	math_science	appliedsci health_lifes

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

In [140]:

```
from sklearn.model_selection import train_test_split

X_tr,X_te,Y_tr,Y_te = train_test_split(X,Y,test_size=0.33, stratify=Y, random_state=10)
```

In [141]:

```
print(X_tr.shape,Y_tr.shape,X_te.shape,Y_te.shape,end=" ")
```

```
(33500, 12) (33500,) (16500, 12) (16500,)
```

In [142]:

```
X_train,X_cv,Y_train,Y_cv = train_test_split(X_tr,Y_tr,test_size=0.33, stratify=Y_tr, random_state
=10)
```

In [143]:

```
print(X_train.shape,Y_train.shape,X_cv.shape,Y_cv.shape,end=" ")
```

```
(22445, 12) (22445,) (11055, 12) (11055,)
```

1.3 Make Data Model Ready: encoding project essay

1.3.1 TFIDF Representation of essay.

In [144]:

```
features_inorder_tfidf = []
```

In [145]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,4))
vectorizer.fit(X_train['essay'].values)

essay_tr_tfidf = vectorizer.transform(X_train['essay'].values)
essay_cv_tfidf = vectorizer.transform(X_cv['essay'].values)
essay_te_tfidf = vectorizer.transform(X_te['essay'].values)
```

In [146]:

```
print(essay_tr_tfidf.shape,essay_cv_tfidf.shape,essay_te_tfidf.shape,end=" ")
```

```
(22445, 65226) (11055, 65226) (16500, 65226)
```

In [147]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
#print(features_inorder)
```

```
65226
```

1.3.2 TFIDF-W2V Representation of essay.

In [148]:

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

In [149]:

```
# average Word2Vec
# compute average word2vec for each review.
def tfidf_w2v_transform(preprocessed_essays):
  tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
  for sentence in tqdm(preprocessed_essays): # 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 tf
idf 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.append(vector)

  return tfidf_w2v_vectors
```

Train data

In [150]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4))
tfidf_model.fit(X_train['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [151]:

```
essay_tr_tfidf_w2v = np.array(tfidf_w2v_transform(X_train['essay'].values))
essay_cv_tfidf_w2v = np.array(tfidf_w2v_transform(X_cv['essay'].values))
essay_te_tfidf_w2v = np.array(tfidf_w2v_transform(X_te['essay'].values))
#print(preprocessed_essays[:3])
```

```
100%|██████████| 22445/22445 [00:43<00:00, 514.05it/s]
100%|██████████| 11055/11055 [00:21<00:00, 512.14it/s]
100%|██████████| 16500/16500 [00:32<00:00, 506.35it/s]
```

In [152]:

```
print(essay_tr_tfidf_w2v.shape,essay_cv_tfidf_w2v.shape,essay_te_tfidf_w2v.shape,end=" ")
```

```
(22445, 300) (11055, 300) (16500, 300)
```

1.4 Make Data Model Ready: encoding numerical, categorical features

1.3.3 Encoding Categorical features

In [153]:

```
data.columns
```

Out[153]:

```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'NEG',
       'POS', 'NEU', 'COMPOUND'],
      dtype='object')
```

School State

In [154]:

```
from sklearn.feature_extraction.text import CountVectorizer

vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values)

state_tr = vectorizer.transform(X_train['school_state'].values)
state_cv = vectorizer.transform(X_cv['school_state'].values)
state_te = vectorizer.transform(X_te['school_state'].values)
```

In [155]:

```
print(state_tr.shape,state_cv.shape,state_te.shape,end=" ")
```

```
(22445, 51) (11055, 51) (16500, 51)
```

In [156]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
#print(features_inorder)
```

```
65277
```

Teacher prefix

In [157]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)

tchr_prefix_tr = vectorizer.transform(X_train['teacher_prefix'].values)
tchr_prefix_cv = vectorizer.transform(X_cv['teacher_prefix'].values)
tchr_prefix_te = vectorizer.transform(X_te['teacher_prefix'].values)
```

In [158]:

```
print(tchr_prefix_tr.shape,tchr_prefix_cv.shape,tchr_prefix_te.shape,end=" ")
```

```
(22445, 5) (11055, 5) (16500, 5)
```

In [159]:

```
vectorizer.get_feature_names()
```

Out[159]:

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
```

In [160]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
```

```
65282
```

Project grade_category

In [161]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values)

grade_tr = vectorizer.transform(X_train['project_grade_category'].values)
grade_cv = vectorizer.transform(X_cv['project_grade_category'].values)
grade_te = vectorizer.transform(X_te['project_grade_category'].values)
```

In [162]:

```
print(grade_tr.shape,grade_cv.shape,grade_te.shape,end=" ")
```

```
(22445, 4) (11055, 4) (16500, 4)
```

In [163]:

```
vectorizer.get_feature_names()
```

Out[163]:

```
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
```

In [164]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
```

```
65286
```

Subject categories

In [165]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values)

subject_tr = vectorizer.transform(X_train['clean_categories'].values)
subject_cv = vectorizer.transform(X_cv['clean_categories'].values)
subject_te = vectorizer.transform(X_te['clean_categories'].values)
```

In [166]:

```
print(subject_tr.shape,subject_cv.shape,subject_te.shape,end=" ")
```

```
(22445, 9) (11055, 9) (16500, 9)
```

In [167]:

```
vectorizer.get_feature_names()
```

Out[167]:

```
['appliedlearning',
 'care_hunger',
 'health_sports',
 'history_civics',
 'literacy_language',
 'math_science',
 'music_arts',
 'specialneeds',
 'warmth']
```

In [168]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
```

```
65295
```

Subject sub categories

In [169]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values)

subj_subct_tr = vectorizer.transform(X_train['clean_subcategories'].values)
subj_subct_cv = vectorizer.transform(X_cv['clean_subcategories'].values)
subj_subct_te = vectorizer.transform(X_te['clean_subcategories'].values)
```

In [170]:

```
print(subj_subct_tr.shape,subj_subct_cv.shape,subj_subct_te.shape,end=" ")
```

```
(22445, 30) (11055, 30) (16500, 30)
```

In [171]:

```
vectorizer.get_feature_names()
```

Out[171]:

```
['appliedsciences',
 'care_hunger',
 'charactereducation',
 'civics_government',
 'college_careerprep',
 'communityservice',
 'earlydevelopment',
 'economics',
 'environmentalscience',
 'esl',
 'extracurricular',
 'financialliteracy',
 'foreignlanguages',
 'gym_fitness',
 'health_lifescience',
 'health_wellness',
 'history_geography',
 'literacy',
 'literature_writing',
 'mathematics',
 'music',
 'nutritioneducation',
 'other',
 'parentinvolvement',
 'performingarts',
 'socialsciences',
 'specialneeds',
 'teamsports',
 'visualarts',
 'warmth']
```

In [172]:

```
features_inorder_tfidf.extend(list(vectorizer.get_feature_names()))
print(len(features_inorder_tfidf))
```

```
65325
```

From the above codes of subject categories and subject sub categories, we can observe that care_hunger is present in both of the categories. Thus feature indices 10062 and 100611 represent same feature name care_hunger.

1.3.4 Encoding Numerical features

teacher_number_of_previously_posted_projects

In [173]:

```
#For z-score normalization the values will be both negative and positive. MultinomialNB does not w
ork with negative values.
#So we use Min-Max normalization.
#from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()
scaler.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))

tchr_prj_tr =
scaler.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
tchr_prj_cv = scaler.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape
(-1, 1))
tchr_prj_te = scaler.transform(X_te['teacher_number_of_previously_posted_projects'].values.reshape
(-1, 1))
```

In [174]:

```
print(list(tchr_prj_tr[:5]),'\n',list(tchr_prj_cv[:5]),'\n',list(tchr_prj_te[:5]))
```

```
[array([0.00280899]), array([0.]), array([0.04494382]), array([0.08146067]), array([0.01123596])]
 [array([0.]), array([0.]), array([0.01404494]), array([0.00561798]), array([0.00280899])]
 [array([0.00842697]), array([0.00561798]), array([0.01966292]), array([0.03651685]),
array([0.00280899])]
```

In [175]:

```
#from sklearn.preprocessing import MinMaxScaler

#scaler = MinMaxScaler()
#scaler.fit(data['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
#data['teacher_number_of_previously_posted_projects']=scaler.transform(data['teacher_number_of_prev
ly_posted_projects'].values.reshape(-1, 1))
```

In [176]:

```
features_inorder_tfidf.extend(['teacher_number_of_previously_posted_projects'])
print(len(features_inorder_tfidf))
#print(features_inorder)
```

```
65326
```

price

In [177]:

```
# Min-Max Normalization

scaler = MinMaxScaler()
scaler.fit(X_train['price'].values.reshape(-1, 1))

price_tr = scaler.transform(X_train['price'].values.reshape(-1, 1) )
price_cv = scaler.transform(X_cv['price'].values.reshape(-1, 1) )
price_te = scaler.transform(X_te['price'].values.reshape(-1, 1) )
```

In [178]:

```
print(list(price_tr[:5]),'\n',list(price_cv[:5]),'\n',list(price_te[:5]))
```

```
[array([0.02487778]), array([0.04781618]), array([0.00340865]), array([0.01502989]),
array([0.00585512])]
 [array([0.00060712]), array([0.00107621]), array([0.03421257]), array([0.00407678]),
array([0.02369055])]
 [array([0.07126968]), array([0.00790852]), array([0.02513283]), array([0.02131009]),
array([0.03150205])]
```

In [179]:

```
# Min-Max Normalization Use only one Normalization but not both.

#scaler = MinMaxScaler()
#scaler.fit(data['price'].values.reshape(-1, 1))
#data['price']=scaler.transform(data['price'].values.reshape(-1, 1))
```

In [180]:

```
features_inorder_tfidf.extend(['price','NEG','POS','NEU','COMPOUND'])
print(len(features_inorder_tfidf))
#print(features_inorder)
```

```
65331
```

1.4 Stacking all features to form set1 and set2 features.

In [181]:

```
data.columns
```

Out[181]:

```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'NEG',
       'POS', 'NEU', 'COMPOUND'],
      dtype='object')
```

1.4.1. Set1(TFIDF) features

In [182]:

```
from scipy.sparse import hstack

X_tr_tfidf = hstack((essay_tr_tfidf, state_tr, tchr_prefix_tr, grade_tr, subject_tr, subj_subct_tr
, tchr_prj_tr, price_tr,  np.array(X_train['NEG']).reshape(-1,1), np.array(X_train['POS']).reshape(
-1,1), np.array(X_train['NEU']).reshape(-1,1), np.array(X_train['COMPOUND']).reshape(-1,1))).tocsr(
)
X_cv_tfidf = hstack((essay_cv_tfidf, state_cv, tchr_prefix_cv, grade_cv, subject_cv, subj_subct_cv
, tchr_prj_cv, price_cv,  np.array(X_cv['NEG']).reshape(-1,1), np.array(X_cv['POS']).reshape(-1,1),
np.array(X_cv['NEU']).reshape(-1,1), np.array(X_cv['COMPOUND']).reshape(-1,1))).tocsr()
X_te_tfidf = hstack((essay_te_tfidf, state_te, tchr_prefix_te, grade_te, subject_te, subj_subct_te
, tchr_prj_te, price_te,  np.array(X_te['NEG']).reshape(-1,1), np.array(X_te['POS']).reshape(-1,1),
np.array(X_te['NEU']).reshape(-1,1), np.array(X_te['COMPOUND']).reshape(-1,1))).tocsr()

print("Final Data matrix")
print(X_tr_tfidf.shape, Y_train.shape)
print(X_cv_tfidf.shape, Y_cv.shape)
print(X_te_tfidf.shape, Y_te.shape)
print("="*100)
```

```
Final Data matrix
(22445, 65331) (22445,)
(11055, 65331) (11055,)
(16500, 65331) (16500,)
====================================================================================================
```

In [183]:

```
print(len(features_inorder_tfidf))

#print(features_inorder)
```

```
65331
```

1. As the Gridserch module available in sklearn implements the inbuilt cross validation, it's better to merge train and cv data.

In [184]:

```
from scipy.sparse import vstack

X_train_tfidf=vstack((X_tr_tfidf,X_cv_tfidf)).tocsr()
Y_train_tfidf=np.concatenate((Y_train,Y_cv))
```

In [185]:

```
print("Final Data matrix")
print(X_train_tfidf.shape, Y_train_tfidf.shape)
print(X_te_tfidf.shape, Y_te.shape)
print("="*100)
```

```
Final Data matrix
(33500, 65331) (33500,)
(16500, 65331) (16500,)
==========================================================================================
```

1.4.2 Set2(TFIDF-W2V) features

In [186]:

```
from scipy.sparse import hstack

X_tr_tfidf_w2v = hstack((essay_tr_tfidf_w2v, state_tr, tchr_prefix_tr, grade_tr, subject_tr, subj_s
ubct_tr , tchr_prj_tr, price_tr,  np.array(X_train['NEG']).reshape(-1,1), np.array(X_train['POS']).
reshape(-1,1), np.array(X_train['NEU']).reshape(-1,1), np.array(X_train['COMPOUND']).reshape(-1,1))
).tocsr()
X_cv_tfidf_w2v = hstack((essay_cv_tfidf_w2v, state_cv, tchr_prefix_cv, grade_cv, subject_cv, subj_s
ubct_cv , tchr_prj_cv, price_cv,  np.array(X_cv['NEG']).reshape(-1,1), np.array(X_cv['POS']).reshap
e(-1,1), np.array(X_cv['NEU']).reshape(-1,1), np.array(X_cv['COMPOUND']).reshape(-1,1))).tocsr()
X_te_tfidf_w2v = hstack((essay_te_tfidf_w2v, state_te, tchr_prefix_te, grade_te, subject_te, subj_s
ubct_te , tchr_prj_te, price_te,  np.array(X_te['NEG']).reshape(-1,1), np.array(X_te['POS']).reshap
e(-1,1), np.array(X_te['NEU']).reshape(-1,1), np.array(X_te['COMPOUND']).reshape(-1,1))).tocsr()

print("Final Data matrix")
print(X_tr_tfidf_w2v.shape, Y_train.shape)
print(X_cv_tfidf_w2v.shape, Y_cv.shape)
print(X_te_tfidf_w2v.shape, Y_te.shape)
print("="*100)
```

```
Final Data matrix
(22445, 405) (22445,)
(11055, 405) (11055,)
(16500, 405) (16500,)
==========================================================================================
```

1. As the Gridserch module available in sklearn implements the inbuilt cross validation, it's better to merge train and cv data.

In [187]:

```
from scipy.sparse import vstack

X_train_tfidf_w2v=vstack((X_tr_tfidf_w2v,X_cv_tfidf_w2v)).tocsr()
Y_train_tfidf_w2v=np.concatenate((Y_train,Y_cv))
```

In [188]:

```
print("Final Data matrix")
print(X_train_tfidf_w2v.shape, Y_train_tfidf_w2v.shape)
print(X_te_tfidf_w2v.shape, Y_te.shape)
print("="*100)
```

```
Final Data matrix
(33500, 405) (33500,)
(16500, 405) (16500,)
==========================================================================================
```

2. Hyper parameter Tuning

2.0 functions for plotly plotting

In [216]:

```
import plotly.offline as offline
```

```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
import numpy as np
```

In [217]:

```
#https://stackoverflow.com/questions/47230817/plotly-notebook-mode-with-google-colaboratory/47230966
def enable_plotly_in_cell():
  import IPython
  from plotly.offline import init_notebook_mode
  display(IPython.core.display.HTML('''<script src="/static/components/requirejs/require.js"></script>'''))
  init_notebook_mode(connected=False)
```

2.1 Set1 (TF-IDF) Features

In [219]:

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV

depth = [1,5,10,50]
min_samples = [5, 10, 100, 500]
hyper_param = {'max_depth' : depth, 'min_samples_split' : min_samples }

clf = DecisionTreeClassifier()
classifier = GridSearchCV(clf, hyper_param, cv=5,return_train_score=True, scoring='roc_auc', n_jobs=-1)
classifier.fit(X_train_tfidf, Y_train_tfidf)

results = pd.DataFrame.from_dict(classifier.cv_results_)
```

In [220]:

```
results = results.sort_values(['rank_test_score'])
results.head(2)
```

Out[220]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	12.972162	0.640699	0.025814	0.005383	10	500	{'max_depth': 10, 'min_samples_split': 500}	
10	14.331892	0.812178	0.023070	0.000930	10	100	{'max_depth': 10, 'min_samples_split': 100}	

In [221]:

```
train_auc= results['mean_train_score']
cv_auc = results['mean_test_score']
depth =  results['param_max_depth']
min_samples = results['param_min_samples_split']
# we need not generate mesh grid explicitly as depth and min_samples combined together form 2D points for which auc is available.
#print(depth)
#print(min_samples)
```

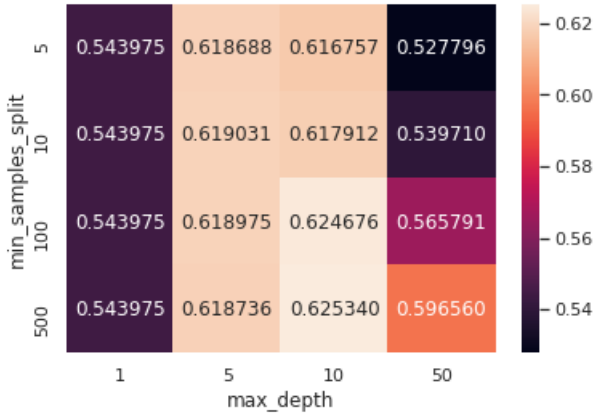
In [222]:

```
enable_plotly_in_cell()

trace1 = go.Scatter3d(x=min_samples,y=depth,z=train_auc, name = 'train')
trace2 = go.Scatter3d(x=min_samples,y=depth,z=cv_auc, name = 'Cross validation')
data_to_plot = [trace1, trace2]

layout = go.Layout(scene = dict(
```

```
        xaxis = dict(title='min_samples'),
        yaxis = dict(title='max_depth'),
        zaxis = dict(title='AUC'),))

fig = go.Figure(data_to_plot, layout=layout)
fig.show()
```

In [223]:

```
import seaborn as sns
cv_auc_values = pd.DataFrame({'max_depth':depth,
                              'min_samples_split': min_samples,
                              'auc': cv_auc})
cv_auc_values = cv_auc_values.pivot("min_samples_split","max_depth", "auc")
sns.heatmap(cv_auc_values, annot=True, fmt="f")
plt.show()
```



In [224]:

```
results = results.sort_values(['rank_test_score'])
best_depth = int(results[results['rank_test_score'] == 1].param_max_depth)
best_min_samples = int(results[results['rank_test_score'] == 1].param_min_samples_split)
results.head(2)
```

Out[224]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	12.972162	0.640699	0.025814	0.005383	10	500	{'max_depth': 10, 'min_samples_split': 500}	
10	14.331892	0.812178	0.023070	0.000930	10	100	{'max_depth': 10, 'min_samples_split': 100}	

In [225]:

```
print('DT having depth {} and min_samples_split {} gives the best cross-validation auc value'.form
at(best_depth,best_min_samples))
```

```
DT having depth 10 and min_samples_split 500 gives the best cross-validation auc value
```

From the above plot and table, we can observe that best hyper parameters are max_depth = 10 and min_Samples_split = 500 and we take these values for testing.

2.1.1 Testing

In [226]:

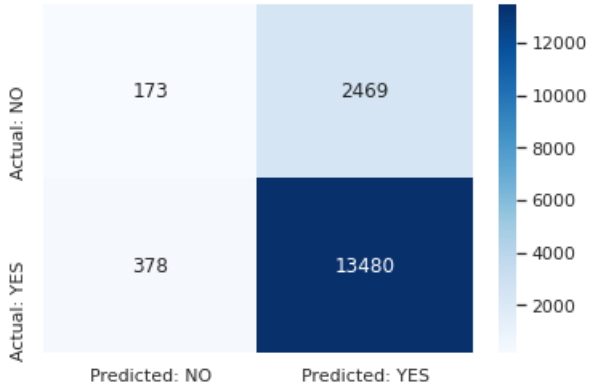
```
from sklearn.metrics import roc_curve,roc_auc_score,confusion_matrix

clf = DecisionTreeClassifier(max_depth = best_depth, min_samples_split= best_min_samples)
clf.fit(X_train_tfidf,Y_train_tfidf)

y_prob_tr = clf.predict_proba(X_train_tfidf)[:,1]
fpr_tr, tpr_tr, thresholds_tr = roc_curve(Y_train_tfidf,y_prob_tr)
plt.plot(fpr_tr, tpr_tr)

y_prob_te = clf.predict_proba(X_te_tfidf)[:,1]
fpr_te, tpr_te, thresholds_te = roc_curve(Y_te,y_prob_te)
plt.plot(fpr_te, tpr_te)

AUC_tr_tfidf = roc_auc_score(Y_train_tfidf, y_prob_tr)
AUC_te_tfidf = roc_auc_score(Y_te, y_prob_te)

plt.grid()
plt.legend( ('Train ROC & Train AUC -- '+str(np.round(AUC_tr_tfidf, decimals=4)), 'Test ROC & Test
AUC -- '+str(np.round(AUC_te_tfidf, decimals=4)) ) )
plt.xlabel('fpr values')
plt.ylabel('Tpr values')
plt.title('Roc Curves for Train and Test data.')
plt.show()
```

In [227]:

```
y_pred_tfidf=clf.predict(X_te_tfidf)
cnf_mtrx_tfidf = confusion_matrix(Y_te, y_pred_tfidf)
```

```
print('Confusion matrix for the Test data.')
#print(cnf_mtrx_tfidf)
x=pd.DataFrame(cnf_mtrx_tfidf, columns = ["Predicted: NO","Predicted: YES"], index = ["Actual: NO",
"Actual: YES"] )
sns.heatmap(x, annot=True,fmt="d", cmap='Blues')
plt.show()
```

```
Confusion matrix for the Test data.
```



In [228]:

```
sam = pd.DataFrame({'act' : Y_te.values,
                    'pred': y_pred_tfidf},index = Y_te.index)
sam.head()
fp_indices = sam[sam['act']==0][sam['pred']==1].index.values
#fp_indices = fp_indices.reshape(-1,1)
print((fp_indices.shape))
```

```
(2469,)
```

In [229]:

```
fp_data = X.iloc[fp_indices]  # X is the main date before splitting X into train and test data.
fp_data.head(2)
```

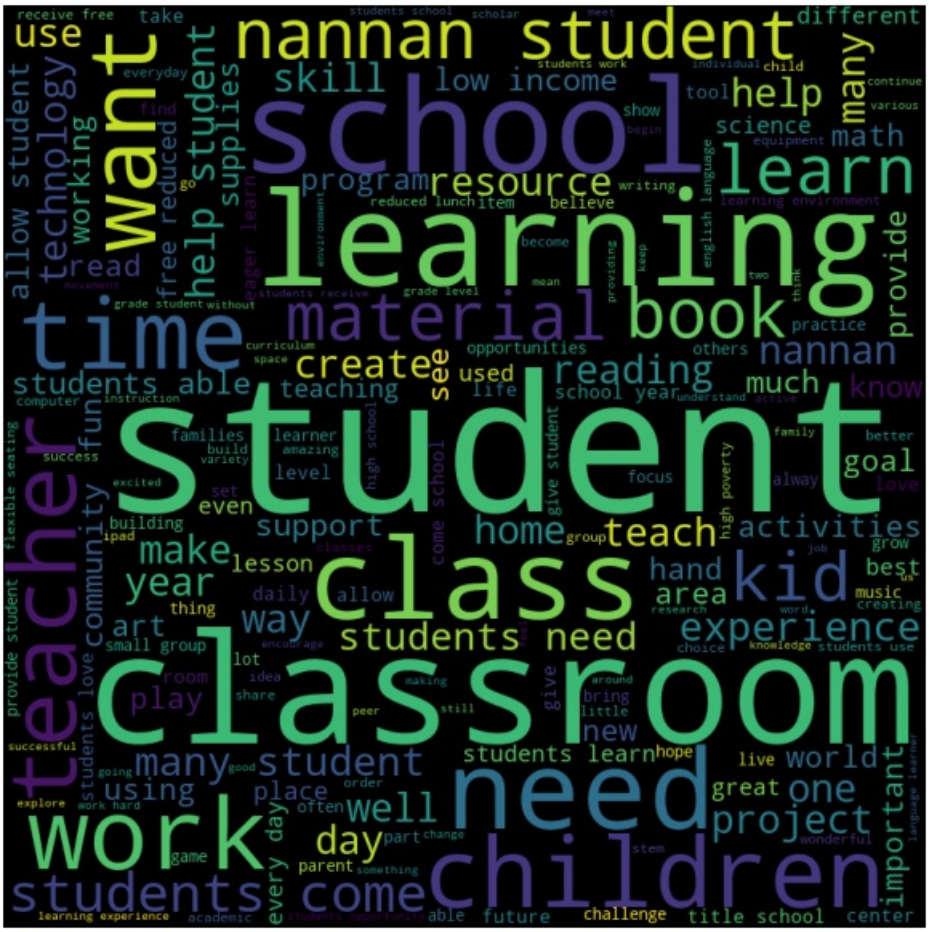
Out[229]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	clean_sul
12977	tx	mrs	grades_6_8	2	literacy_language	literat
35211	sc	mrs	grades_3_5	1	literacy_language music_arts	literat

In [230]:

```
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt

# Reads 'Youtube04-Eminem.csv' file
df = fp_data.essay.copy()

comment_words = ''
stopwords = set(STOPWORDS)
#print(df)
# iterate through the csv file
for val in df:

 # split the value
 tokens = val.split()
```

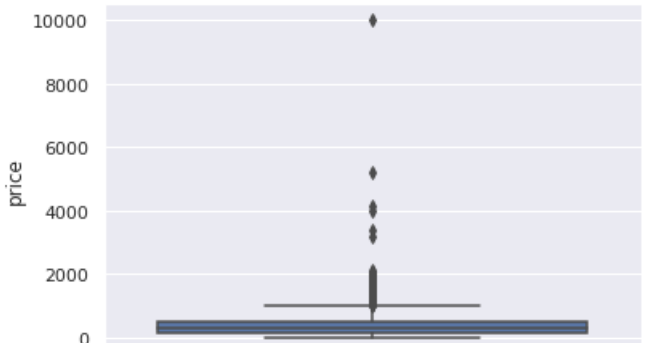
```
 comment_words += " ".join(tokens)+" "

cloud = WordCloud(width = 800, height = 800,
    background_color ='black',
    stopwords = stopwords,
    min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(cloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



These are the words present in false positive data points of test data. Words of actual disapproved projects but our DT model classifies them as approved projects. Thus we can interpret it as dont get betrayed by looking at these words. Because these words are of actually disapproved projects.

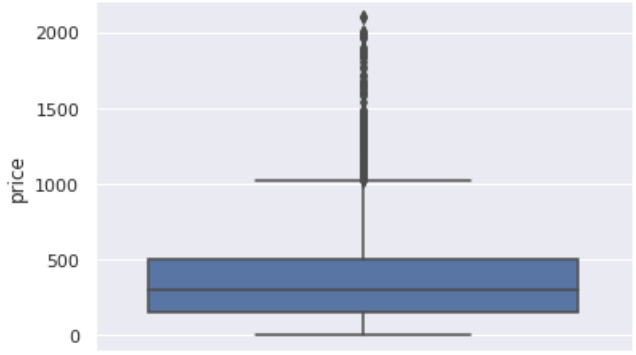
In [231]:

```
pric = fp_data.price.copy()
sns.boxplot(y=pric)
plt.show()
```



In [233]:

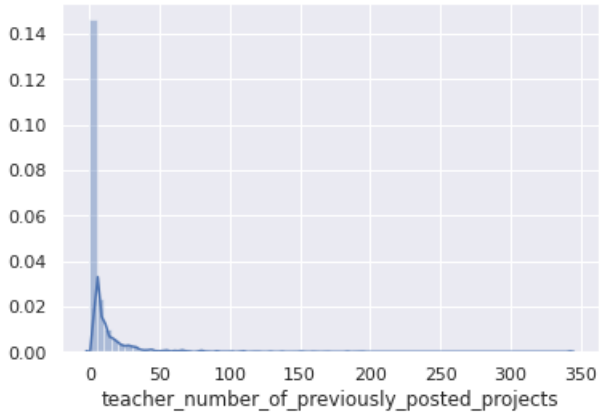
```
pric = fp_data[fp_data['price']<3000].price.copy()
sns.boxplot(y=pric)
plt.show()
```



By removing some of the data points having more price, we can observe that 50th percentile of the false positive points is approximately 250 units. We can observe that most of the false positve data points have price < 1000 units.

In [234]:

```
prev_tchr_prj = fp_data.teacher_number_of_previously_posted_projects.copy()
sns.set()

sns.distplot(prev_tchr_prj,bins=np.arange(0,300,5))
plt.show()
```



For these False positive points, the number of previously posted projects by a teacher less than 5 are very high.

2.2 Set2(TF-IDF Weighted W2V) Features

In [235]:

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV

depth = [1,5,10,50]
min_samples = [5, 10, 100, 500]
hyper_param = {'max_depth' : depth, 'min_samples_split' : min_samples }

clf = DecisionTreeClassifier()
classifier = GridSearchCV(clf, hyper_param, cv=5,return_train_score=True, scoring='roc_auc', n_jobs
=-1)
classifier.fit(X_train_tfidf_w2v, Y_train_tfidf_w2v)

results = pd.DataFrame.from_dict(classifier.cv_results_)
```

In [236]:

```
results = results.sort_values(['rank_test_score'])
results.head(2)
```

Out[236]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	20.373235	0.449969	0.024808	0.001097	10	500	{'max_depth': 10, 'min_samples_split': 500}	
7	10.224600	0.151608	0.023984	0.000648	5	500	{'max_depth': 5, 'min_samples_split': 500}	

In [237]:

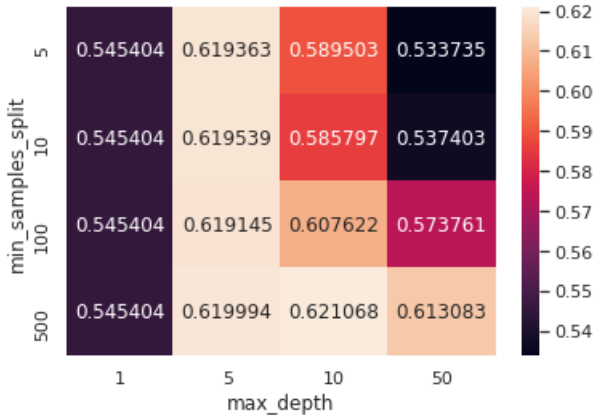
```
train_auc= results['mean_train_score']
cv_auc = results['mean_test_score']
depth =  results['param_max_depth']
min_samples = results['param_min_samples_split']
# we need not generate mesh grid explicitly as depth and min_samples combined together form 2D poi
nts for which auc is available.
#print(depth)
#print(min_samples)
```

In [238]:

```
enable_plotly_in_cell()

trace1 = go.Scatter3d(x=min_samples,y=depth,z=train_auc, name = 'train')
trace2 = go.Scatter3d(x=min_samples,y=depth,z=cv_auc, name = 'Cross validation')
data_to_plot = [trace1, trace2]

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

fig = go.Figure(data_to_plot, layout=layout)
fig.show()
```

In [239]:

```
import seaborn as sns
cv_auc_values = pd.DataFrame({'max_depth':depth,
                              'min_samples_split': min_samples,
                              'auc': cv_auc})
cv_auc_values = cv_auc_values.pivot("min_samples_split","max_depth", "auc")
sns.heatmap(cv_auc_values, annot=True, fmt="f")
plt.show()
```



In [272]:

```
results = results.sort_values(['rank_test_score'])
best_depth_tfidf_w2v = int(results[results['rank_test_score'] == 1].param_max_depth)
best_min_samples_tfidf_w2v = int(results[results['rank_test_score'] == 1].param_min_samples_split)
results.head(2)
```

Out[272]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	3.921620	0.141900	0.009953	0.000100	10	500	{'max_depth': 10, 'min_samples_split': 500}	
10	4.328289	0.169212	0.010075	0.000131	10	100	{'max_depth': 10, 'min_samples_split': 100}	

In [273]:

```
print('DT having depth {} and min_samples_split {} gives the best cross-validation auc value'.form
at(best_depth_tfidf_w2v,best_min_samples_tfidf_w2v))
```

```
DT having depth 10 and min_samples_split 500 gives the best cross-validation auc value
```

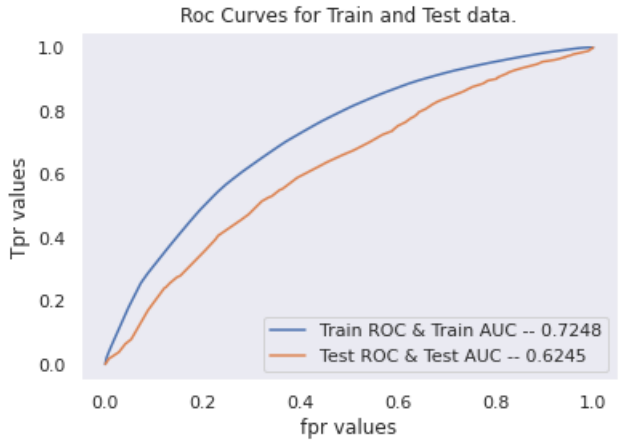
From the above plot and table, we can observe that best hyper parameters are max_depth = 10 and min_Samples_split = 500 and we take these values for testing.

2.1.1 Testing

In [274]:

```
from sklearn.metrics import roc_curve,roc_auc_score,confusion_matrix

clf = DecisionTreeClassifier(max_depth = best_depth_tfidf_w2v, min_samples_split=
best_min_samples_tfidf_w2v)
clf.fit(X_train_tfidf_w2v,Y_train_tfidf_w2v)

y_prob_tr = clf.predict_proba(X_train_tfidf_w2v)[:,1]
fpr_tr, tpr_tr, thresholds_tr = roc_curve(Y_train_tfidf_w2v, y_prob_tr)
```

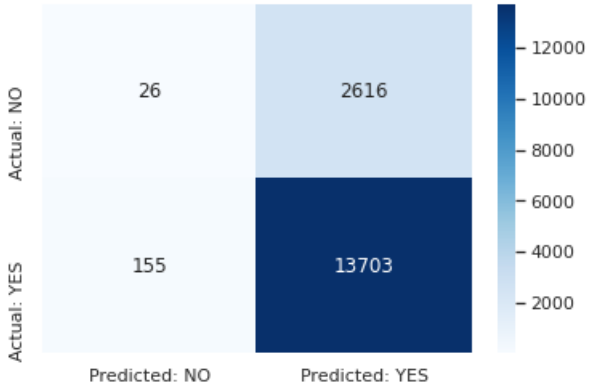
```
fpr_tr, tpr_tr, thresholds_tr = roc_curve(Y_train_tfidf_w2v,y_prob_tr)
plt.plot(fpr_tr, tpr_tr)

y_prob_te = clf.predict_proba(X_te_tfidf_w2v)[:,1]
fpr_te, tpr_te, thresholds_te = roc_curve(Y_te,y_prob_te)
plt.plot(fpr_te, tpr_te)

AUC_tr_tfidf_w2v = roc_auc_score(Y_train_tfidf_w2v, y_prob_tr)
AUC_te_tfidf_w2v = roc_auc_score(Y_te, y_prob_te)

plt.grid()
plt.legend( ('Train ROC & Train AUC -- '+str(np.round(AUC_tr_tfidf_w2v, decimals=4)), 'Test ROC & T
est AUC -- '+str(np.round(AUC_te_tfidf_w2v, decimals=4)) ) )
plt.xlabel('fpr values')
plt.ylabel('Tpr values')
plt.title('Roc Curves for Train and Test data.')
plt.show()
```



In [275]:

```
y_pred_tfidf_w2v=clf.predict(X_te_tfidf_w2v)
cnf_mtrx_tfidf_w2v = confusion_matrix(Y_te, y_pred_tfidf_w2v)

print('Confusion matrix for the Test data.')
#print(cnf_mtrx_tfidf)
x=pd.DataFrame(cnf_mtrx_tfidf_w2v, columns = ["Predicted: NO","Predicted: YES"], index = ["Actual:
NO","Actual: YES"] )
sns.heatmap(x, annot=True,fmt="d", cmap='Blues')
plt.show()
```

Confusion matrix for the Test data.



In [276]:

```
sam = pd.DataFrame({'act' : Y_te.values,
                    'pred': y_pred_tfidf_w2v},index = Y_te.index)
sam.head()
fp_indices = sam[sam['act']==0][sam['pred']==1].index.values
#fp_indices = fp_indices.reshape(-1,1)
print((fp_indices.shape))
```

```
(2616,)
```

In [277]:

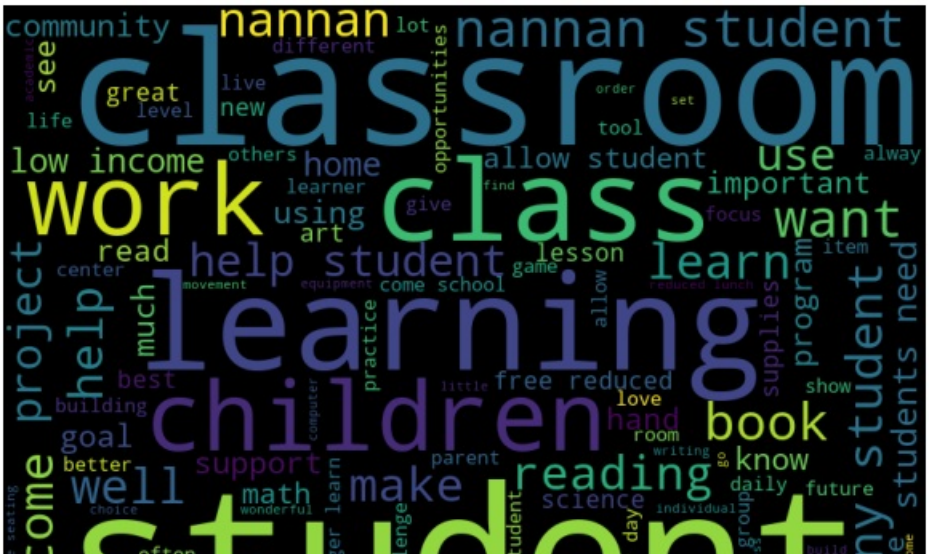
```
fp_data = X.iloc[fp_indices]
fp_data.head(2)
```

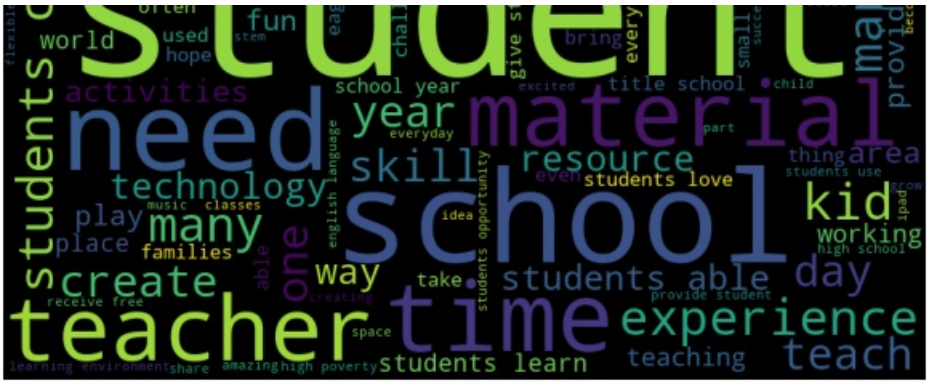
Out[277]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	clean_sul
12977	tx	mrs	grades_6_8	2	literacy_language	literat
35211	sc	mrs	grades_3_5	1	literacy_language music_arts	literat

In [278]:

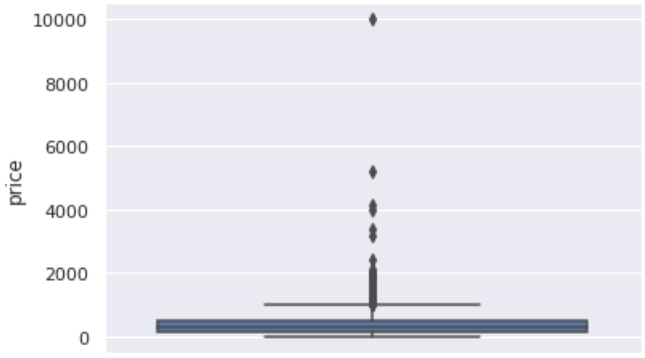
```
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt

# Reads 'Youtube04-Eminem.csv' file
df = fp_data.essay.copy()

comment_words = ''
stopwords = set(STOPWORDS)
#print(df)
# iterate through the csv file
for val in df:

 # split the value
 tokens = val.split()

 comment_words += " ".join(tokens)+" "

cloud = WordCloud(width = 800, height = 800,
    background_color ='black',
    stopwords = stopwords,
    min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(cloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```





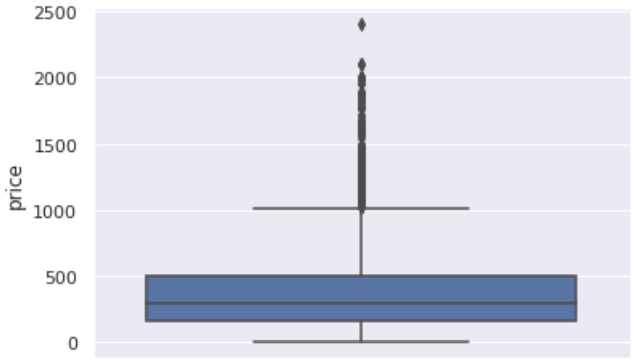
In [279]:

```
pric = fp_data.price.copy()
sns.boxplot(y=pric)
plt.show()
```



In [280]:

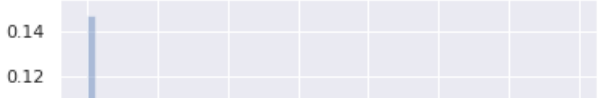
```
pric = fp_data[fp_data['price']<3000].price.copy()
sns.boxplot(y=pric)
plt.show()
```

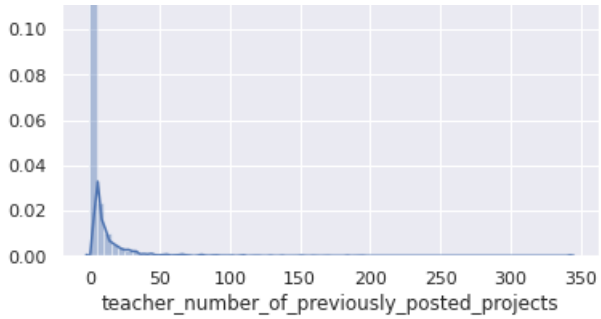


By removing some of the data points having more price, we can observe that 50th percentile of the false positive points is approximately 250 units. We can observe that most of the false positve data points have price < 1000 units.

In [281]:

```
prev_tchr_prj = fp_data.teacher_number_of_previously_posted_projects.copy()
sns.set()

sns.distplot(prev_tchr_prj,bins=np.arange(0,300,5))
plt.show()
```





For these False positive points, the number of previously posted projects by a teacher less than 5 are very high.

Task 2

In [282]:

```
from sklearn.tree import DecisionTreeClassifier
clf = DecisionTreeClassifier()
clf.fit(X_train_tfidf, Y_train_tfidf)

ftr_impt = clf.feature_importances_
print(len(ftr_impt))
print(ftr_impt)
non_0_ftr = list(filter(lambda x: ftr_impt[x]>0, range(len(ftr_impt)) ))
X_tr_imp_ftr = X_train_tfidf[:,non_0_ftr]
X_te_imp_ftr = X_te_tfidf[:,non_0_ftr]
print(X_tr_imp_ftr.shape,X_te_imp_ftr.shape)
```

```
65331
[0.         0.         0.         ... 0.00369367 0.00493949 0.0026047 ]
(33500, 2193) (16500, 2193)
```

Hyper parameter tuning for non zero feature importance features using Decision Tree classifier.

In [283]:

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV

depth = [1,5,10,50]
min_samples = [5, 10, 100, 500]
hyper_param = {'max_depth' : depth, 'min_samples_split' : min_samples }

clf = DecisionTreeClassifier()
classifier = GridSearchCV(clf, hyper_param, cv=5,return_train_score=True, scoring='roc_auc', n_jobs
=-1)
classifier.fit(X_tr_imp_ftr, Y_train_tfidf)

results = pd.DataFrame.from_dict(classifier.cv_results_)
```

In [284]:

```
results = results.sort_values(['rank_test_score'])
results.head(2)
```

Out[284]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	3.855608	0.160090	0.010044	0.000439	10	500	{'max_depth': 10, 'min_samples_split': 500}	
10	4.323032	0.189716	0.013542	0.003641	10	100	{'max_depth': 10, 'min_samples_split': 100}	

In [285]:

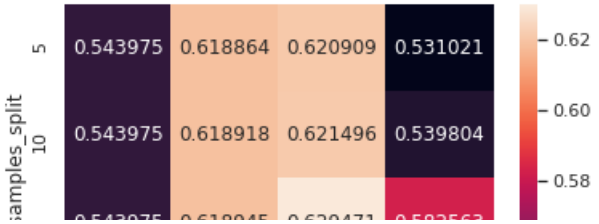
```
train_auc= results['mean_train_score']
cv_auc = results['mean_test_score']
depth =  results['param_max_depth']
min_samples = results['param_min_samples_split']
```

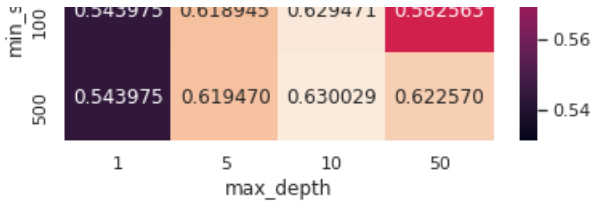
In [286]:

```
enable_plotly_in_cell()

trace1 = go.Scatter3d(x=min_samples,y=depth,z=train_auc, name = 'train')
trace2 = go.Scatter3d(x=min_samples,y=depth,z=cv_auc, name = 'Cross validation')
data_to_plot = [trace1, trace2]

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

fig = go.Figure(data_to_plot, layout=layout)
fig.show()
```

In [287]:

```
import seaborn as sns
cv_auc_values = pd.DataFrame({'max_depth':depth,
                              'min_samples_split': min_samples,
                              'auc': cv_auc})
cv_auc_values = cv_auc_values.pivot("min_samples_split","max_depth", "auc")
sns.heatmap(cv_auc_values, annot=True, fmt="f")
plt.show()
```





In [288]:

```
results = results.sort_values(['rank_test_score'])
best_depth = int(results[results['rank_test_score'] == 1].param_max_depth)
best_min_samples = int(results[results['rank_test_score'] == 1].param_min_samples_split)
results.head(2)
```

Out[288]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_min_samples_split	params	s
11	3.855608	0.160090	0.010044	0.000439	10	500	{'max_depth': 10, 'min_samples_split': 500}	
10	4.323032	0.189716	0.013542	0.003641	10	100	{'max_depth': 10, 'min_samples_split': 100}	

In [289]:

```
print('DT having depth {} and min_samples_split {} gives the best cross-validation auc value'.form
at(best_depth,best_min_samples))
```

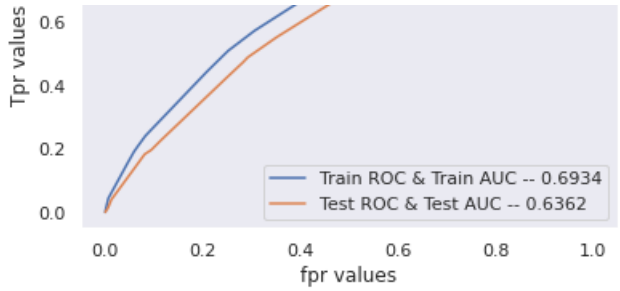
```
DT having depth 10 and min_samples_split 500 gives the best cross-validation auc value
```

From the above plot and table, we can observe that best hyper parameters are max_depth = 10 and min_Samples_split = 500 and we take these values for testing.

Testing

In [290]:

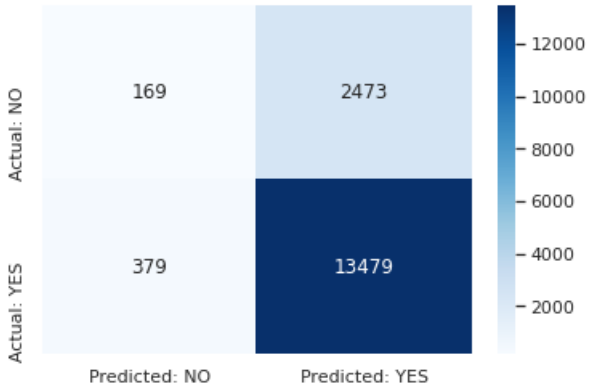
```
from sklearn.metrics import roc_curve,roc_auc_score,confusion_matrix

clf = DecisionTreeClassifier(max_depth = best_depth, min_samples_split= best_min_samples)
clf.fit(X_tr_imp_ftr,Y_train_tfidf)

y_prob_tr = clf.predict_proba(X_tr_imp_ftr)[:,1]
fpr_tr, tpr_tr, thresholds_tr = roc_curve(Y_train_tfidf,y_prob_tr)
plt.plot(fpr_tr, tpr_tr)

y_prob_te = clf.predict_proba(X_te_imp_ftr)[:,1]
fpr_te, tpr_te, thresholds_te = roc_curve(Y_te,y_prob_te)
plt.plot(fpr_te, tpr_te)

AUC_tr_imp_ftr = roc_auc_score(Y_train_tfidf, y_prob_tr)
AUC_te_imp_ftr = roc_auc_score(Y_te, y_prob_te)

plt.grid()
plt.legend( ('Train ROC & Train AUC -- '+str(np.round(AUC_tr_tfidf, decimals=4)), 'Test ROC & Test
AUC -- '+str(np.round(AUC_te_tfidf, decimals=4)) ) )
plt.xlabel('fpr values')
plt.ylabel('Tpr values')
plt.title('Roc Curves for Train and Test data.')
plt.show()
```



In [291]:

```
y_pred_imp_ftr = clf.predict(X_te_imp_ftr)
cnf_mtrx_imp_ftr = confusion_matrix(Y_te, y_pred_imp_ftr)

print('Confusion matrix for the Test data.')
#print(cnf_mtrx_tfidf)
x=pd.DataFrame(cnf_mtrx_imp_ftr, columns = ["Predicted: NO","Predicted: YES"], index = ["Actual: NO
","Actual: YES"] )
sns.heatmap(x, annot=True,fmt="d", cmap='Blues')
plt.show()
```

```
Confusion matrix for the Test data.
```



In [292]:

```
sam = pd.DataFrame({'act' : Y_te.values,
                    'pred': y_pred_imp_ftr},index = Y_te.index)
sam.head()
fp_indices = sam[sam['act']==0][sam['pred']==1].index.values
#fp_indices = fp_indices.reshape(-1,1)
print((fp_indices.shape))
```

```
(2473,)
```

In [293]:

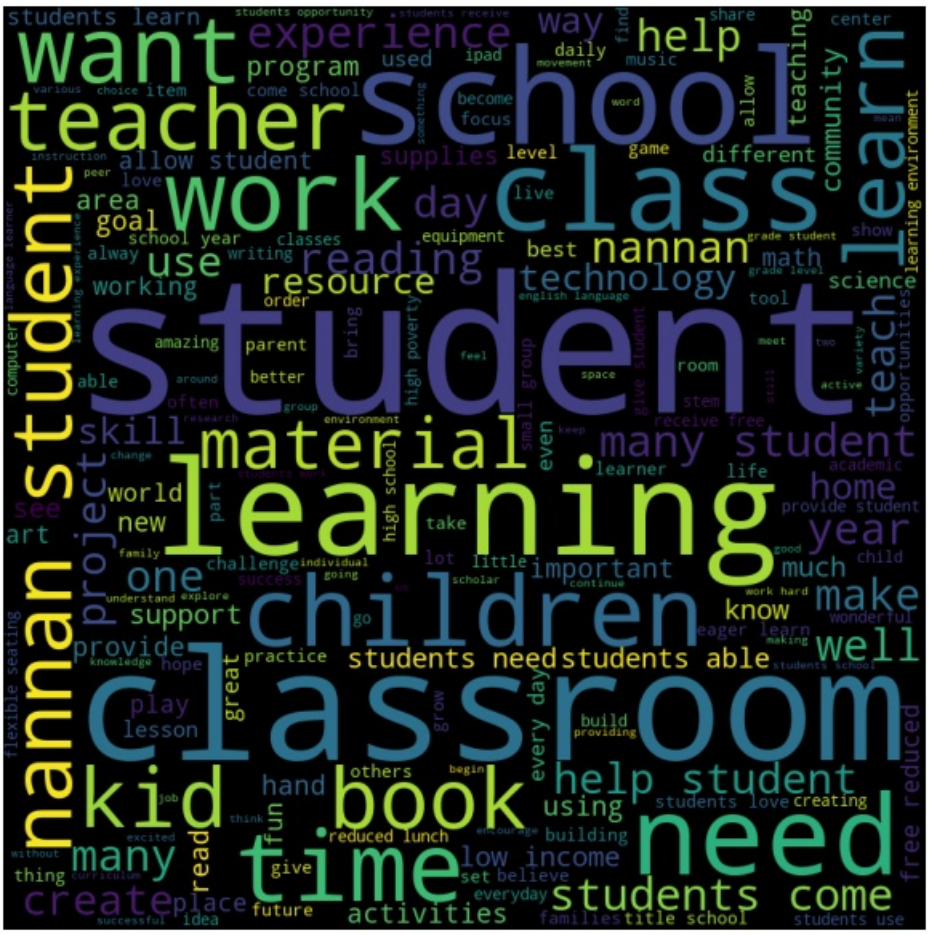
```
fp_data = X.iloc[fp_indices]
fp_data.head(2)
```

Out[293]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	clean_sul
12977	tx	mrs	grades_6_8	2	literacy_language	literat
35211	sc	mrs	grades_3_5	1	literacy_language music_arts	literat

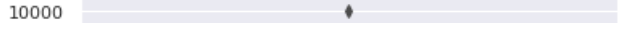
In [294]:

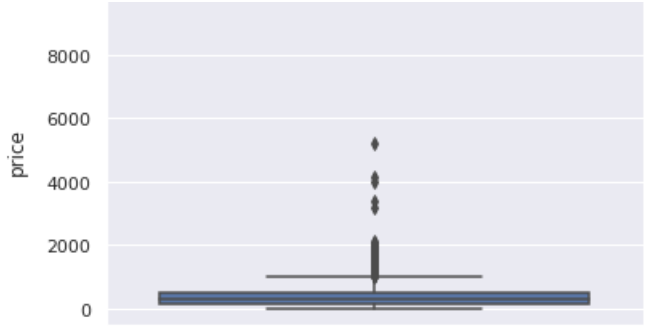
```
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt

# Reads 'Youtube04-Eminem.csv' file
df = fp_data.essay.copy()

comment_words = ''
stopwords = set(STOPWORDS)
#print(df)
# iterate through the csv file
for val in df:

 # split the value
 tokens = val.split()

 comment_words += " ".join(tokens)+" "

cloud = WordCloud(width = 800, height = 800,
    background_color ='black',
    stopwords = stopwords,
    min_font_size = 10).generate(comment_words)

# plot the WordCloud image
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(cloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [295]:

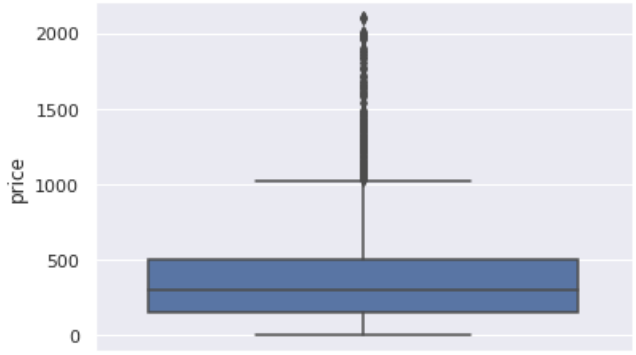
```
pric = fp_data.price.copy()
sns.boxplot(y=pric)
plt.show()
```





In [296]:

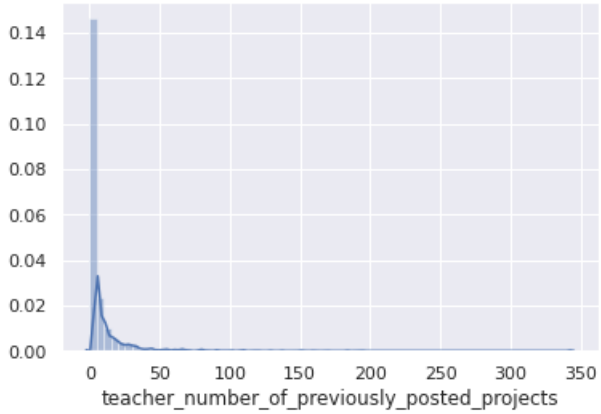
```
pric = fp_data[fp_data['price']<3000].price.copy()
sns.boxplot(y=pric)
plt.show()
```



By removing some of the data points having more price, we can observe that 50th percentile of the false positive points is approximately 250 units.

In [297]:

```
prev_tchr_prj = fp_data.teacher_number_of_previously_posted_projects.copy()
sns.set()

sns.distplot(prev_tchr_prj,bins=np.arange(0,300,5))
plt.show()
```



For these False positive points, the number of previously posted projects by a teacher less than 5 are very high.

Observations from Task1 and Task2:

1. **Results on task1 and task2 are almost similar.**
2. **Results on DT classifier by taking all features is almost same as results on the same DT classfier taking only the important features(features having non zero feature importance.)**
3. **AUC values are same for both Task1 and Task2.**

3. Summary

In [301]:

```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer","Model", "Hyper parameters (depth and min_samples split)", "Train
AUC", "Test AUC"]

for i in range(1):
    x.add_row(['TFIDF', "Decision Tree", (best_depth,best_min_samples) , np.round(AUC_tr_tfidf,4),
np.round(AUC_te_tfidf,4) ])
    x.add_row(["TFIDF-W2V", "Decision Tree" , (best_depth_tfidf_w2v,best_min_samples_tfidf_w2v) , n
p.round(AUC_tr_tfidf_w2v,4) , np.round(AUC_te_tfidf_w2v,4) ])
print(x)
```

```
+------------+---------------+-------------------------------------------------+-----------+--------
| Vectorizer |     Model     | Hyper parameters (depth and min_samples split) | Train AUC | Test AU
C |
+------------+---------------+-------------------------------------------------+-----------+--------
|   TFIDF    | Decision Tree |                   (10, 500)                     |   0.6934  |  0.6362
|
| TFIDF-W2V  | Decision Tree |                   (10, 500)                     |   0.7248  |  0.6245
|
+------------+---------------+-------------------------------------------------+-----------+--------
```