In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer
from sklearn.preprocessing import Normalizer
from sklearn.model_selection import train_test_split, KFold

from sklearn.metrics import confusion_matrix, roc_curve, auc, roc_auc_score, accuracy_score
from scipy.sparse import hstack

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

import pickle
import tqdm

import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()

from wordcloud import WordCloud, STOPWORDS

import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
data = pd.read_csv('preprocessed_data.csv', nrows=50000)
```

In [3]:
```
data.shape
```

Out[3]:
```
(50000, 9)
```

Spliting X and Y

In [4]:
```
y = data.project_is_approved
X = data.drop(["project_is_approved"], axis=1)
```

Spliting Train, Test and Cross Validation datasets

In [5]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size= 0.33, stratify=y)
#X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

Defing one hot encoding functions

In [6]:
```
def convert_text_into_TFIDF(feature):
    '''This function transforms a feature into TFIDF vector'''

    vectorizer = TfidfVectorizer(min_df = 10, ngram_range=(1,4), max_features=5000)
    vectorizer.fit(X_train[feature].values)

    X_train_ohe = vectorizer.transform(X_train[feature].values)
    X_test_ohe = vectorizer.transform(X_test[feature].values)
    #X_cv_ohe = vectorizer.transform(X_cv[feature].values)

    return vectorizer, X_train_ohe, X_test_ohe #,X_cv_ohe
```

In [7]:
```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words = set(model.keys())

def calculate_TFIDF_Weighted_W2V(feature_value, dictionary, tfidf_words):


    tfidf_w2v_vectors = []

    for sentence in feature_value:
        vector = np.zeros(300)
        tf_idf_weight = 0

        for word in sentence.split():
            if(word in tfidf_words) and (word in glove_words):
                vec = model[word]

                tf_idf = dictionary[word] * (sentence.count(word)/len(sentence.split()))
                vector += (vec * tf_idf)
                tf_idf_weight += tf_idf

        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        tfidf_w2v_vectors.append(vector)

    return tfidf_w2v_vectors

def convert_Text_Into_TFIDF_Weighted_W2V(feature):
```

```
    tfidf_model = TfidfVectorizer()
    tfidf_model.fit(X_train[feature].values)

    dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
    tfidf_words = set(tfidf_model.get_feature_names())

    X_train_tfidf_w2v = calculate_TFIDF_Weighted_W2V(X_train[feature].values, dictionary, tfidf_word
s)
    #X_cv_tfidf_w2v = calculate_TFIDF_Weighted_W2V(X_cv[feature].values)
    X_test_tfidf_w2v = calculate_TFIDF_Weighted_W2V(X_test[feature].values, dictionary, tfidf_words)

    return tfidf_model, X_train_tfidf_w2v, X_test_tfidf_w2v #, X_cv_tfidf_w2v
```

In [8]:
```
def convert_categorical_Into_BOW(feature):

    vectorizer = CountVectorizer(binary=True)
    vectorizer.fit(X_train[feature].values)

    X_train_ohe = vectorizer.transform(X_train[feature].values)
    #X_cv_ohe = vectorizer.transform(X_cv[feature].values)
    X_test_ohe = vectorizer.transform(X_test[feature].values)

    return vectorizer, X_train_ohe, X_test_ohe #, X_cv_ohe
```

In [9]:
```
def encode_numerical_features(feature):

    normalizer = Normalizer()
    normalizer.fit(X_train[feature].values.reshape(1,-1))

    X_train_ohe = normalizer.transform(X_train[feature].values.reshape(1,-1))
    #X_cv_ohe = normalizer.transform(X_cv[feature].values.reshape(1,-1))
    X_test_ohe = normalizer.transform(X_test[feature].values.reshape(1,-1))

    return normalizer, X_train_ohe.reshape(-1,1), X_test_ohe.reshape(-1,1)#, X_cv_ohe.reshape(-1,1)
```

In [10]:
```
'''
#Categorical
X_train['school_state']
X_train['teacher_prefix']
X_train['project_grade_category']
X_train['clean_categories']
X_train['clean_subcategories']

#numerical
X_train['teacher_number_of_previously_posted_projects']
```

```
X_train['price']

#essay
X_train['essay']'''
```

Out[10]:
```
"\n#Categorical\nX_train['school_state']\nX_train['teacher_prefix']\nX_train['project_grade_cate
gory']\nX_train['clean_categories']\nX_train['clean_subcategories']\n\n#numerical\nX_train['teac
her_number_of_previously_posted_projects']\nX_train['price']\n\n#essay\nX_train['essay']"
```

Applying One hot encoding on categorical features

In [11]:
```
#Permoring One hot encoding for School State
vectorizer_state, X_train_state, X_test_state = convert_categorical_Into_BOW('school_state')
lst_state_features = vectorizer_state.get_feature_names()

#Permoring One hot encoding for tech_prefix
vectorizer_tchr_prfx, X_train_tchr_prfx, X_test_tchr_prfx = convert_categorical_Into_BOW('teacher_pr
efix')
lst_tchr_prfx_features = vectorizer_tchr_prfx.get_feature_names()

#Permoring One hot encoding for grade_category
vectorizer_grade, X_train_grade, X_test_grade = convert_categorical_Into_BOW('project_grade_categor
y')
lst_grade_features = vectorizer_grade.get_feature_names()

#Permoring One hot encoding for categories
vectorizer_categories, X_train_categories, X_test_categories = convert_categorical_Into_BOW('clean_c
ategories')
lst_categories_features = vectorizer_categories.get_feature_names()

#Permoring One hot encoding for subcategories
vectorizer_subcategories, X_train_subcategories, X_test_subcategories \
                                = convert_categorical_Into_BOW('clean_subcategories')
lst_subcategories_features = vectorizer_subcategories.get_feature_names()
```

In [12]:
```
X_train_categories.shape
```

Out[12]:
```
(33500, 7)
```

Applying Normalizing on numerical features

In [13]:
```
#Permoring normalization on teacher_number_of_previously_posted_projects
normalizer_prev_projects, X_train_prev_projects, X_test_prev_projects \
                        = encode_numerical_features('teacher_number_of_previously_posted_projects')
```

```
#Permoring normalization on price
normalizer_price, X_train_price, X_test_price = encode_numerical_features('price')
```

Applying One hot encoding on textual features (TFIDF)

In [14]:
```
#Performing TFIDF feature vectoriztion on essay
tfdif_vectorizer_essay, X_train_essay_tfidf, X_test_essay_tfidf = convert_text_into_TFIDF('essay')
```

Applying One hot encoding on textual features (TFIDF Word2Vec)

In [15]:
```
#Performing TFIDF word2vec feature vectoriztion on essay
w2v_vectorizer_essay, X_train_essay_w2v, X_test_essay_w2v = convert_Text_Into_TFIDF_Weighted_W2V('es
say')
```

Concatenating all features

In [16]:
```
#Concatinating feature set 1(TFIDF)
X_tr_set1 = hstack((X_train_state, X_train_tchr_prfx, X_train_grade, X_train_categories, X_train_sub
categories,
                    X_train_prev_projects, X_train_price, X_train_essay_tfidf)).tocsr()

#X_cv_set1 = hstack((X_cv_state, X_cv_tchr_prfx, X_cv_grade, X_cv_categories, X_cv_subcategories,
#                    X_cv_prev_projects, X_cv_price, X_cv_essay_tfidf)).tocsr()

X_te_set1 = hstack((X_test_state, X_test_tchr_prfx, X_test_grade, X_test_categories, X_test_subcateg
ories,
                    X_test_prev_projects, X_test_price, X_test_essay_tfidf)).tocsr()
```

In [17]:
```
#Concatinating feature set 1(TFIDF Word2Vec)
X_tr_set2 = hstack((X_train_state, X_train_tchr_prfx, X_train_grade, X_train_categories, X_train_sub
categories,
                    X_train_prev_projects, X_train_price, X_train_essay_w2v)).tocsr()

#X_cv_set2 = hstack((X_cv_state, X_cv_tchr_prfx, X_cv_grade, X_cv_categories, X_cv_subcategories,
#                    X_cv_prev_projects, X_cv_price, X_cv_essay_tfidf)).tocsr()

X_te_set2 = hstack((X_test_state, X_test_tchr_prfx, X_test_grade, X_test_categories, X_test_subcateg
ories,
                    X_test_prev_projects, X_test_price, X_test_essay_w2v)).tocsr()
```

In [18]:
```
class CV_Results:
    def __init__(self, depth, split, acc_score):
        self.depth = depth
        self.split = split
        self.acc_score = acc_score
```

In [19]:
```
def getTrain_and_Cv_scores(grid_search):

    lst_train_scores = []
    lst_cv_scores = []


    idx_score = 0
    for i, depth in enumerate(depth_range):
        for j, min_split in enumerate(min_split_sample_range):

            train_scores = []
            cv_scores = []

            for k in range(n_folds):
                k_fold_train_score = grid_search.cv_results_['split' + str(k) +'_train_score'][idx_s
core]
                k_fold_cv_score = grid_search.cv_results_['split' + str(k) +'_test_score'][idx_score
]


                train_scores.append(k_fold_train_score)
                cv_scores.append(k_fold_cv_score)

            idx_score += 1

            #print(np.mean(np.array(train_scores)))
            #print(np.mean(np.array(cv_scores)))
            train_result = CV_Results(depth, min_split, np.mean(np.array(train_scores)))
            cv_result = CV_Results(depth, min_split, np.mean(np.array(cv_scores)))

            lst_train_scores.append(train_result)
            lst_cv_scores.append(cv_result)

    return lst_train_scores, lst_cv_scores
```

In [20]:
```
def print_train_cv_score(lst_train_scores, lst_cv_scores):
    print('\n---------Train scores----------')
    for scores in lst_train_scores:
        print(f'Depth :{scores.depth} Split :{scores.split} Auc score:{scores.acc_score}')
```

```
    print('\n---------CV scores----------')
    for scores in lst_cv_scores:
        print(f'Depth :{scores.depth} Split :{scores.split} Auc score:{scores.acc_score}')
```

In [21]:
```
def plot_HeatMap(lst_train_scores, lst_cv_scores):

    lst_train_cv_scores = [lst_train_scores, lst_cv_scores]

    fig = plt.figure(figsize = (15,5))

    plot_counter = 1
    for data in lst_train_cv_scores:

        split = []
        depth = []
        auc_scores = []

        for x in data:
            split.append(x.split)
            depth.append(x.depth)
            auc_scores.append(x.acc_score)


        #https://stackoverflow.com/questions/45470882/x-y-z-array-data-to-heatmap/45660022
        df = pd.DataFrame.from_dict(np.array([split,depth,auc_scores]).T)
        df.columns = ['Split','Depth','AUC Scores']
        df['AUC Scores'] = pd.to_numeric(df['AUC Scores'])

        pivotted= df.pivot('Split','Depth','AUC Scores')

        sns.heatmap(pivotted, ax= fig.add_subplot(1, 2, plot_counter), annot=True, cmap='coolwarm')

        if plot_counter == 1:
            plt.title('Train AUC Scores for each Hyperparameter')
        else:
            plt.title('CV AUC Scores for each Hyperparameter')

        plot_counter +=1
```

In [22]:
```
def plot_AUC(train_fpr, train_tpr, test_fpr, test_tpr, train_auc, test_auc, title):
    '''This function plot AUC curve for both train and test FPR and TPR'''

    plt.plot(train_fpr, train_tpr, label= f"Train AUC = {train_auc}" )
    plt.plot(test_fpr, test_tpr, label = f"Test AUC = {test_auc}")
    plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
```

```
    plt.legend()
    plt.xlabel("False Positive Rate")
    plt.ylabel("True Positive Rate")
    plt.title(title)

    plt.grid()
    plt.show()
```

In [23]:
```
def create_wordcloud_using_fp_essay(X_test_fp_essay):

    comment_words = ' '
    stopwords = set(STOPWORDS)

    # iterate through the csv file
    for val in X_test_fp_essay:

        # typecaste each val to string
        val = str(val)

        # split the value
        tokens = val.split()

        # Converts each token into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            comment_words = comment_words + words + ' '


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

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

    plt.show()
```

In [24]:
```
def plot_Box_plot(X_te_fp_price):
    sns.boxplot(data= X_te_fp_price)
    plt.xlabel("Price")
```

```
    plt.ylabel("Percentiles")
    plt.title("Price vs Likelihood of more datapoints")
    plt.show()
```

In [25]:
```
def plot_PDF(X_test_fp_tchr_prfx):
    plt.close()
    sns.distplot(X_test_fp_tchr_prfx, bins=5)
    #counts, bin_edges = sns.distplot(X_test_fp_tchr_prfx, bins=5)

    #pdf = counts/sum(counts)

    #plt.plot(bin_edges[1:], pdf)

    plt.xlabel("Bins")
    plt.ylabel("Likelihood of price")
    plt.title("PDF plot")
    plt.grid()
    plt.show();
```

Train model with Train set 1

In [26]:
```
depth_range = [1, 5, 10, 50]
min_split_sample_range = [5, 10, 100, 500]


param = {'max_depth': depth_range, 'min_samples_split': min_split_sample_range}
n_folds = 3

clf = DecisionTreeClassifier(class_weight='balanced')

#Finding best alpha using GridSearchCV method
clf_set1 = GridSearchCV(estimator = clf, param_grid= param, cv=n_folds, scoring='roc_auc')
clf_set1.fit(X_tr_set1, y_train)

clf_set1.best_params_
```

Out[26]:
```
{'max_depth': 10, 'min_samples_split': 500}
```

Getting Train and CV Scores for set 1

In [27]:
```
lst_train_scores_set1, lst_cv_scores_set1 = getTrain_and_Cv_scores(clf_set1)
```

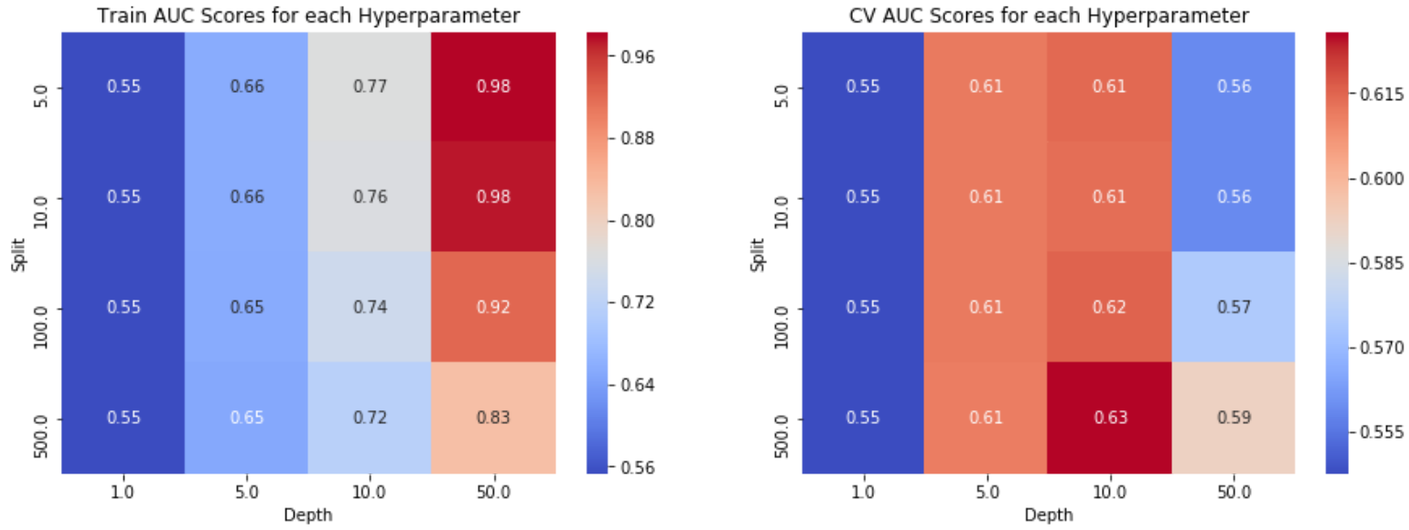
Printing Train and CV Scores for set 1

In [28]:
```
print_train_cv_score(lst_train_scores_set1, lst_cv_scores_set1)
```

```
---------Train scores----------
Depth :1 Split :5 Auc score:0.5531029626427145
Depth :1 Split :10 Auc score:0.5531029626427145
Depth :1 Split :100 Auc score:0.5531029626427145
Depth :1 Split :500 Auc score:0.5531029626427145
Depth :5 Split :5 Auc score:0.6558121199265049
Depth :5 Split :10 Auc score:0.6557413334438197
Depth :5 Split :100 Auc score:0.6539239047131564
Depth :5 Split :500 Auc score:0.6516864870987386
Depth :10 Split :5 Auc score:0.7669841626692152
Depth :10 Split :10 Auc score:0.7643157501162748
Depth :10 Split :100 Auc score:0.7427241617617416
Depth :10 Split :500 Auc score:0.7156524352571089
Depth :50 Split :5 Auc score:0.9826461994572814
Depth :50 Split :10 Auc score:0.9758113203459429
Depth :50 Split :100 Auc score:0.9229445994328146
Depth :50 Split :500 Auc score:0.8285170162176154

---------CV scores----------
Depth :1 Split :5 Auc score:0.5475591239834557
Depth :1 Split :10 Auc score:0.5475591239834557
Depth :1 Split :100 Auc score:0.5475591239834557
Depth :1 Split :500 Auc score:0.5475591239834557
Depth :5 Split :5 Auc score:0.6117598510626188
Depth :5 Split :10 Auc score:0.6119100192653187
Depth :5 Split :100 Auc score:0.6118167332377211
Depth :5 Split :500 Auc score:0.6112064177534887
Depth :10 Split :5 Auc score:0.614462191829113
Depth :10 Split :10 Auc score:0.6138101339822722
Depth :10 Split :100 Auc score:0.6156062708963551
Depth :10 Split :500 Auc score:0.62575207621815
Depth :50 Split :5 Auc score:0.559108576062652
Depth :50 Split :10 Auc score:0.5589480306415644
Depth :50 Split :100 Auc score:0.5747588932890063
Depth :50 Split :500 Auc score:0.5922373861562734
```

Plotting 3D graph for Train and CV Scores for set 1

In [29]:
```
plot_HeatMap(lst_train_scores_set1, lst_cv_scores_set1)
```



Training model with best parameter set 1

In [30]:
```
decision_tree_clf_set1 = DecisionTreeClassifier(max_depth= clf_set1.best_params_['max_depth'],
                                                min_samples_split= clf_set1.best_params_['min_sample
s_split'],
                                                class_weight='balanced')

decision_tree_clf_set1.fit(X_tr_set1, y_train)
```

Out[30]:
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini',
            max_depth=10, max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
```

Finding AUC curve on train and test data for set 1

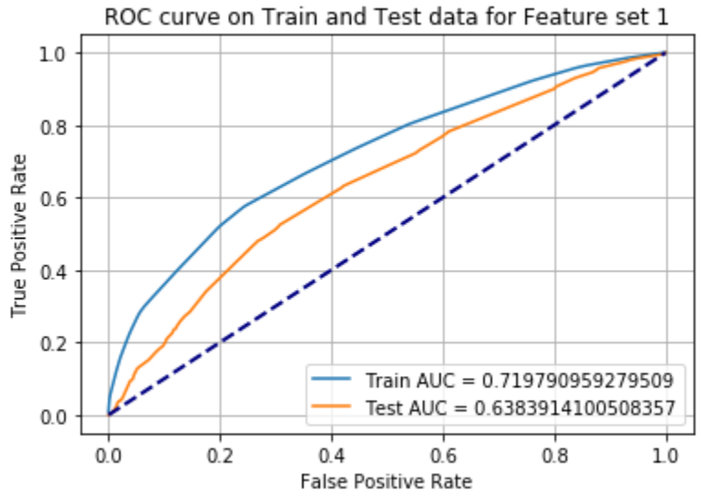
In [31]:
```
y_train_proba_set1 = decision_tree_clf_set1.predict_proba(X_tr_set1)[:,1]
y_test_proba_set1 = decision_tree_clf_set1.predict_proba(X_te_set1)[:,1]


#Finding AUC on train and test data
train_auc_set1 = roc_auc_score(y_train, y_train_proba_set1)
```

```
print('Train Auc for set 1')
print(train_auc_set1)

test_auc_set1 = roc_auc_score(y_test, y_test_proba_set1)
print('\n Test Auc for set 1')
print(test_auc_set1)
```

```
Train Auc for set 1
0.719790959279509

 Test Auc for set 1
0.6383914100508357
```

Plotting ROC curve of train and test data for set 1

In [32]:
```
#Finding FPR and TPR both on train and test
train_fpr_set1, train_tpr_set1, train_threshold_set1 = roc_curve(y_train, y_train_proba_set1)
test_fpr_set1, test_tpr_set1, test_threshold_set1 = roc_curve(y_test, y_test_proba_set1)

#Plotting AUC curve
plot_AUC(train_fpr_set1, train_tpr_set1, test_fpr_set1, test_tpr_set1, train_auc_set1, test_auc_set1
,
         'ROC curve on Train and Test data for Feature set 1')
```

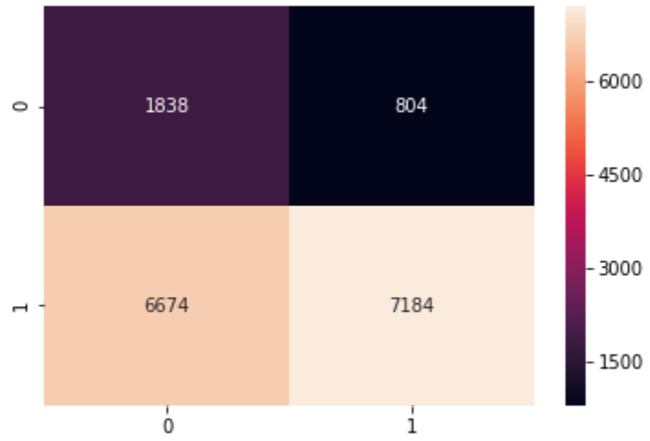


Plotting confusion matrix for set 1

In [33]:
```
#Predicting y_test
```

```
y_test_pred_set1 = decision_tree_clf_set1.predict(X_te_set1)

confusion_matrix_set1 = confusion_matrix(y_test, y_test_pred_set1)

#Seaborn Heatmap representaion of Train confusion matrix
sns.heatmap(confusion_matrix_set1, annot=True, fmt="d")
```

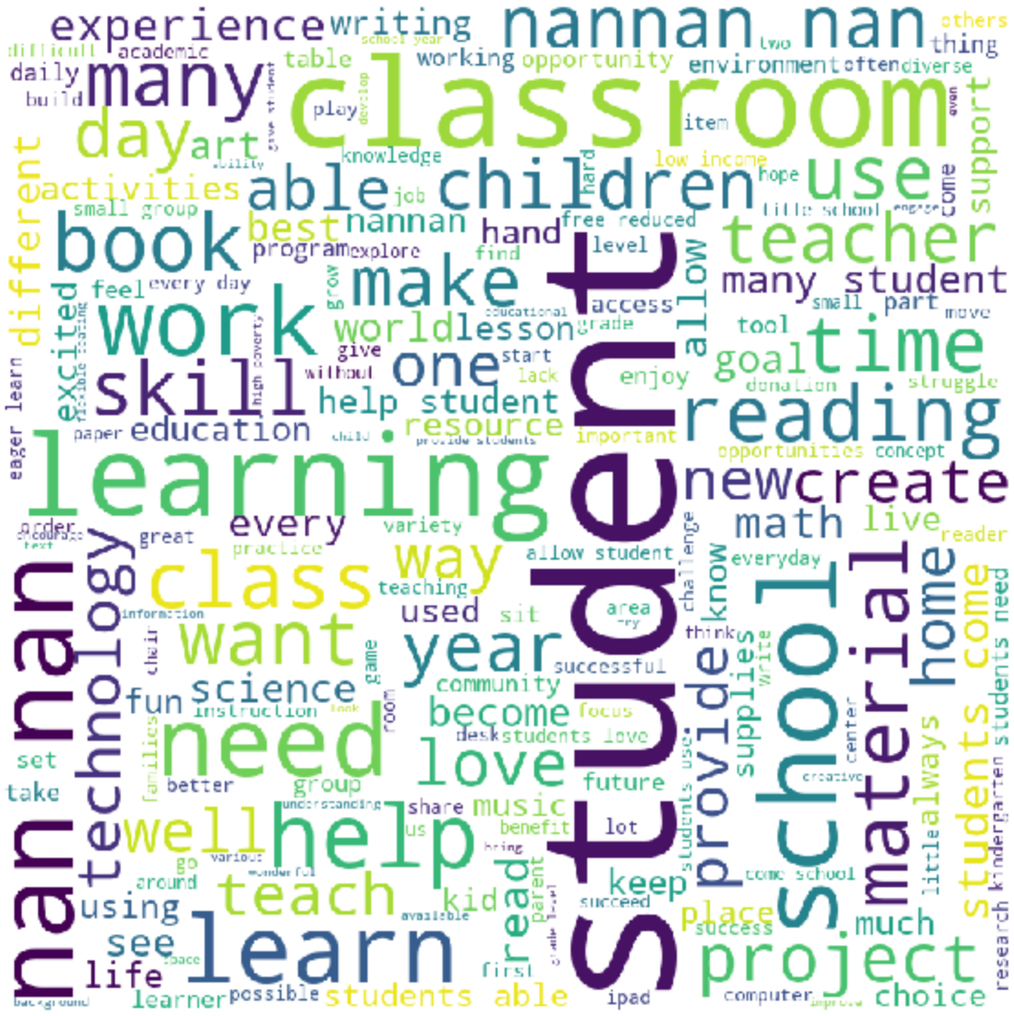
Out[33]: <matplotlib.axes._subplots.AxesSubplot at 0x1a6e01f85c0>



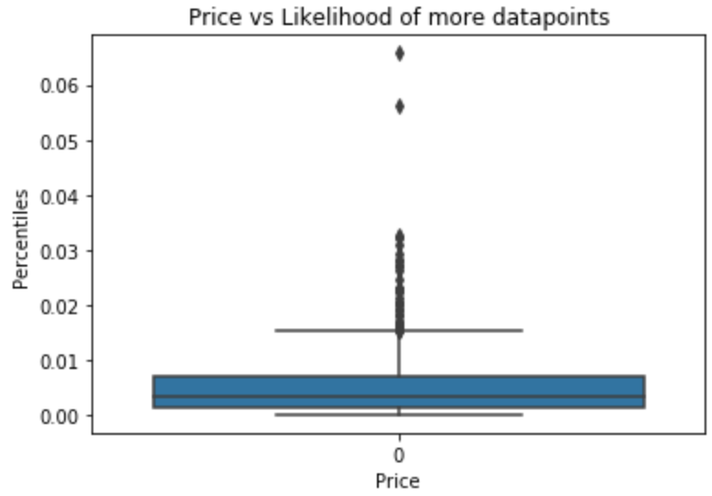
In [34]:
```
#Extracting False positive datapoints

fp_indices = []
for i in range(len(y_test)):
    if (np.array(y_test)[i] == 0) & (y_test_pred_set1[i] == 1):
        fp_indices.append(i)
```

Exploratory Data analysis for set 1

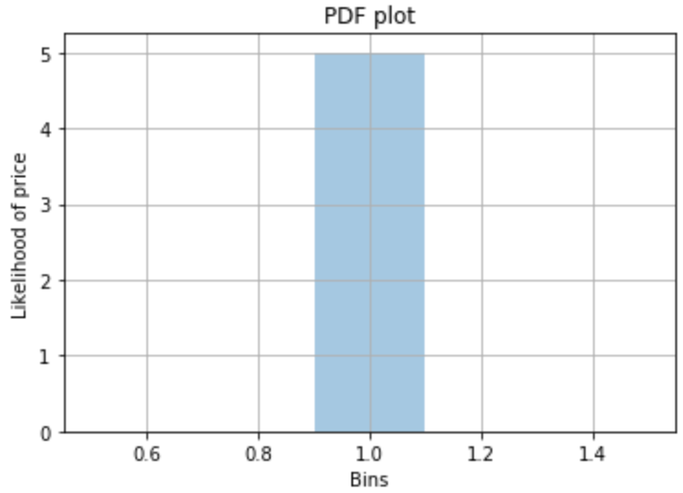
In [35]:
```
#Creating wordcloud from false positive data points of feature essay
X_test_fp_set1 = X_test['essay'][fp_indices]

create_wordcloud_using_fp_essay(X_test_fp_set1)
```



In [36]:
```
#Extracting price feature and plotting Box plot
plot_Box_plot(X_test_price[fp_indices])
```



In [37]:
```
#Extracting teacher_number_of_previously_posted_projects feature and plotting PDF
plot_PDF(X_test_tchr_prfx[fp_indices].data)
```



Train model with Train set 2

In [38]:
```
clf = DecisionTreeClassifier(class_weight='balanced')

#Finding best alpha using GridSearchCV method
```

```
clf_set2 = GridSearchCV(estimator = clf, param_grid= param, cv=n_folds, scoring='roc_auc')
clf_set2.fit(X_tr_set2, y_train)

clf_set2.best_params_
```

Out[38]: {'max_depth': 5, 'min_samples_split': 10}

Getting Train and CV Scores for set 2

In [39]:
```
lst_train_scores_set2, lst_cv_scores_set2 = getTrain_and_Cv_scores(clf_set2)
```

Printing Train and CV Scores for set 2

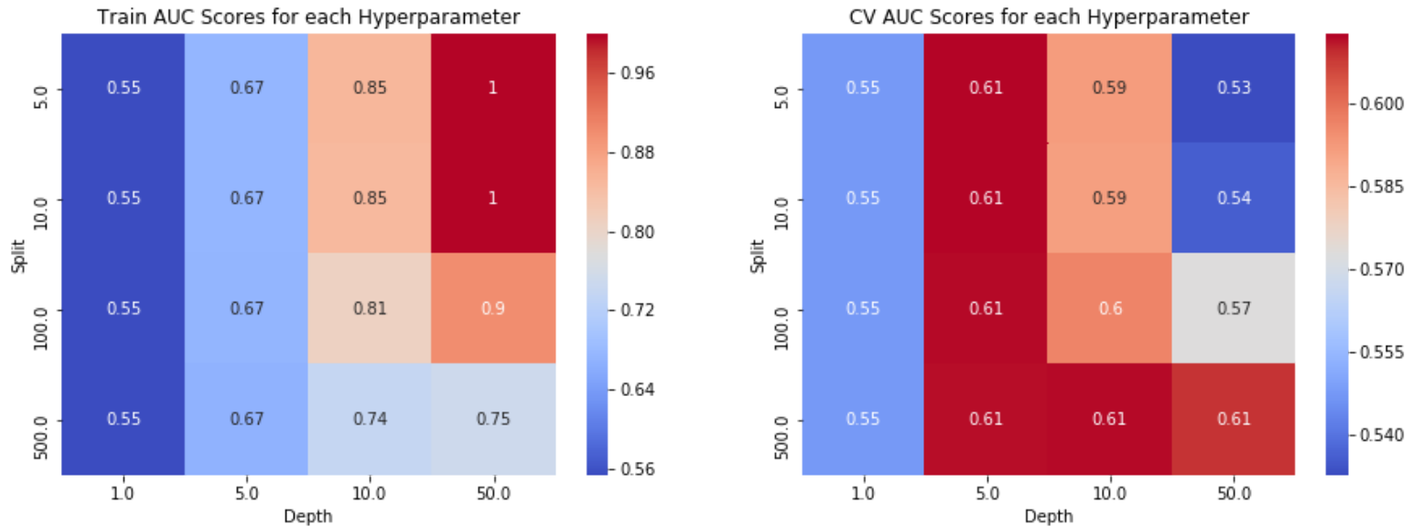
In [40]:
```
print_train_cv_score(lst_train_scores_set2, lst_cv_scores_set2)
```

```
---------Train scores----------
Depth :1 Split :5 Auc score:0.5531029626427145
Depth :1 Split :10 Auc score:0.5531029626427145
Depth :1 Split :100 Auc score:0.5531029626427145
Depth :1 Split :500 Auc score:0.5531029626427145
Depth :5 Split :5 Auc score:0.6736476624659012
Depth :5 Split :10 Auc score:0.6736476624659012
Depth :5 Split :100 Auc score:0.6728840862817832
Depth :5 Split :500 Auc score:0.6683794944914752
Depth :10 Split :5 Auc score:0.8521156988964725
Depth :10 Split :10 Auc score:0.8493069195315615
Depth :10 Split :100 Auc score:0.8088750378093063
Depth :10 Split :500 Auc score:0.7393009695236995
Depth :50 Split :5 Auc score:0.9998777215380548
Depth :50 Split :10 Auc score:0.9989708550181772
Depth :50 Split :100 Auc score:0.9018188266495145
Depth :50 Split :500 Auc score:0.7506683486799607

---------CV scores----------
Depth :1 Split :5 Auc score:0.5475591239834557
Depth :1 Split :10 Auc score:0.5475591239834557
Depth :1 Split :100 Auc score:0.5475591239834557
Depth :1 Split :500 Auc score:0.5475591239834557
Depth :5 Split :5 Auc score:0.6126230506801081
Depth :5 Split :10 Auc score:0.6127290868454778
Depth :5 Split :100 Auc score:0.6123812030851943
Depth :5 Split :500 Auc score:0.611981908066579
Depth :10 Split :5 Auc score:0.592171936331392
Depth :10 Split :10 Auc score:0.5916355703562476
```

```
Depth :10 Split :100 Auc score:0.5965426896035396
Depth :10 Split :500 Auc score:0.6122014975497215

Depth :50 Split :5 Auc score:0.5325363975178979
Depth :50 Split :10 Auc score:0.53574216915538
Depth :50 Split :100 Auc score:0.5726992437054423
Depth :50 Split :500 Auc score:0.6087875966851852
```

Plotting 3D graph for Train and CV Scores for set 2

In [41]:
```
plot_HeatMap(lst_train_scores_set2, lst_cv_scores_set2)
```



Training model with best parameter set 2

In [42]:
```
decision_tree_clf_set2 = DecisionTreeClassifier(max_depth= clf_set2.best_params_['max_depth'],
                                                min_samples_split= clf_set2.best_params_['min_sample
s_split'],
                                                class_weight='balanced')

decision_tree_clf_set2.fit(X_tr_set2, y_train)
```

Out[42]:
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=10,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
```

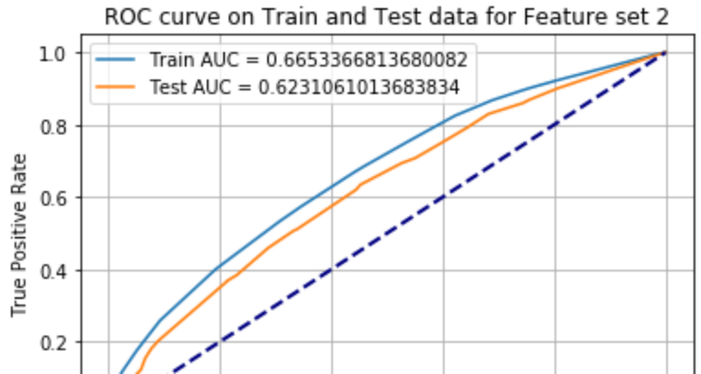
Finding AUC curve on train and test data for set 2

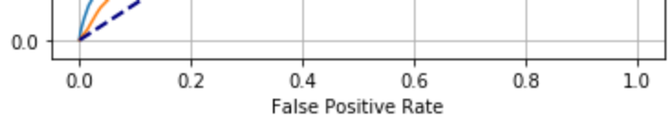
In [43]:
```
y_train_proba_set2 = decision_tree_clf_set2.predict_proba(X_tr_set2)[:,1]
y_test_proba_set2 = decision_tree_clf_set2.predict_proba(X_te_set2)[:,1]


#Finding AUC on train and test data
train_auc_set2 = roc_auc_score(y_train, y_train_proba_set2)
print('Train Auc for set 2')
print(train_auc_set2)

test_auc_set2 = roc_auc_score(y_test, y_test_proba_set2)
print('\n Test Auc for set 2')
print(test_auc_set2)
```

```
Train Auc for set 2
0.6653366813680082

 Test Auc for set 2
0.6231061013683834
```

Plotting ROC curve of train and test data for set 2

In [44]:
```
#Finding FPR and TPR both on train and test
train_fpr_set2, train_tpr_set2, train_threshold_set2 = roc_curve(y_train, y_train_proba_set2)
test_fpr_set2, test_tpr_set2, test_threshold_set2 = roc_curve(y_test, y_test_proba_set2)

#Plotting AUC curve
plot_AUC(train_fpr_set2, train_tpr_set2, test_fpr_set2, test_tpr_set2, train_auc_set2, test_auc_set2
,
         'ROC curve on Train and Test data for Feature set 2')
```

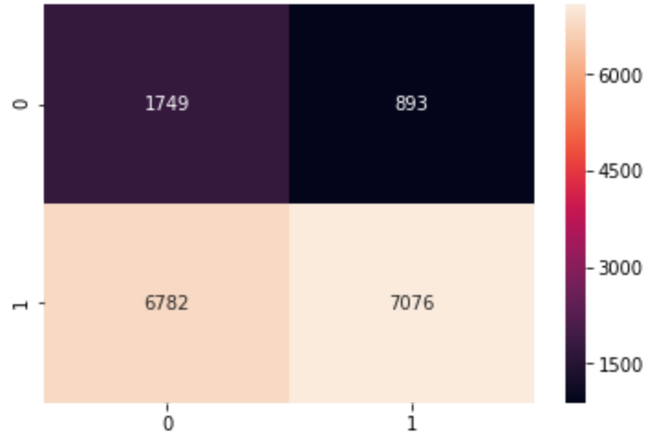




Plotting confusion matrix for set 2

In [45]:
```
#Predicting y_test
y_test_pred_set2 = decision_tree_clf_set2.predict(X_te_set2)

confusion_matrix_set2 = confusion_matrix(y_test, y_test_pred_set2)

#Seaborn Heatmap representaion of Train confusion matrix
sns.heatmap(confusion_matrix_set2, annot=True, fmt="d")
```

Out[45]: <matplotlib.axes._subplots.AxesSubplot at 0x1a6da8f5ac8>

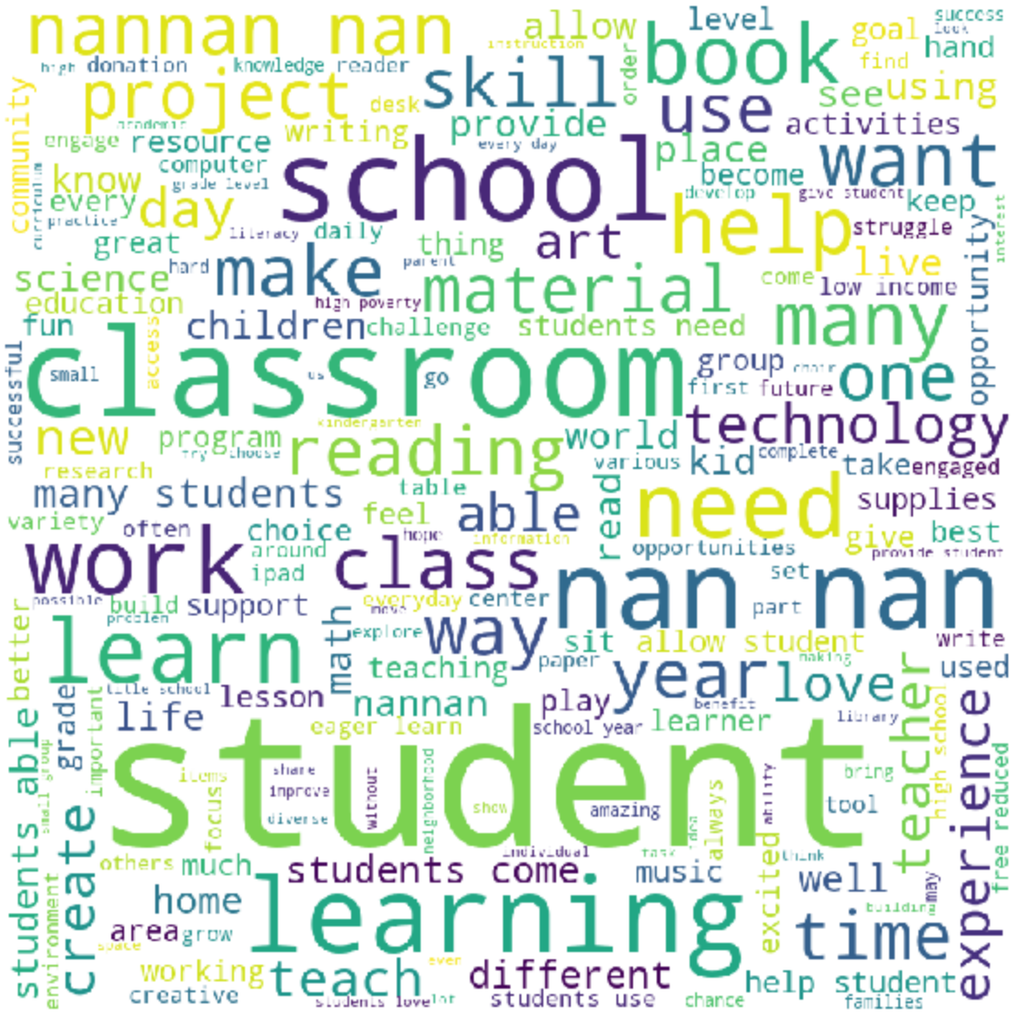


In [46]:
```
#Extracting False positive datapoints

fp_indices = []
for i in range(len(y_test)):
    if (np.array(y_test)[i] == 0) & (y_test_pred_set2[i] == 1):
        fp_indices.append(i)
```

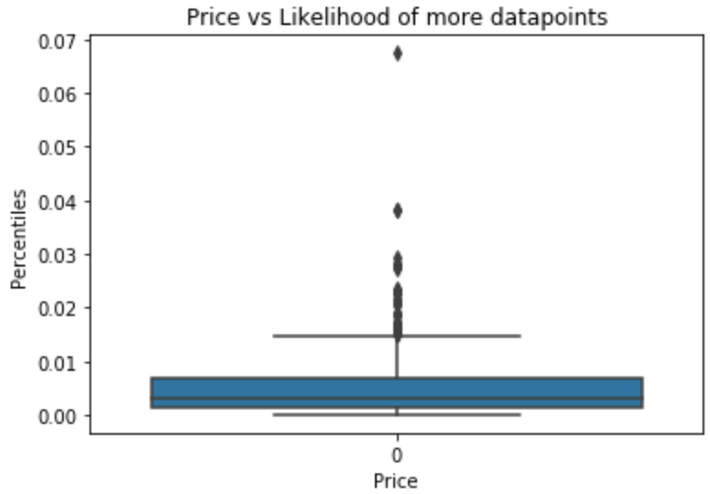
Exploratory Data analysis for set 2

In [47]:
```
#Creating wordcloud from false positive data points of feature essay
X_test_fp_set2 = X_test['essay'][fp_indices]
```

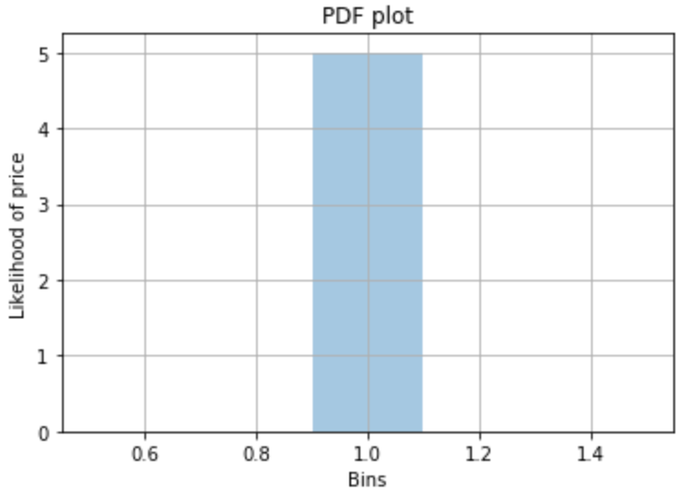
```
create_wordcloud_using_fp_essay(X_test_fp_set2)
```



In [48]:
```
#Extracting price feature and plotting Box plot
plot_Box_plot(X_test_price[fp_indices])
```



In [49]:
```
#Extracting teacher_number_of_previously_posted_projects feature and plotting PDF
plot_PDF(X_test_tchr_prfx[fp_indices].data)
```



Task 2

Training model with dataset 1 with max_depth as None to get feature_importances

In [50]:
```
task2_clf_set1 = DecisionTreeClassifier(min_samples_split= clf_set1.best_params_['min_samples_split'
])

task2_clf_set1.fit(X_tr_set1, y_train)
```

Out[50]:
```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=500,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
```

In [51]:
```
#Extracting nonZero features
nonzero_features = np.nonzero(task2_clf_set1.feature_importances_)[0]
print(nonzero_features)
```

```
[  95   96  105 ... 5089 5090 5095]
```

Training model with dataset 1 by discarding the nonzero features

In [52]:
```
from sklearn.linear_model import LogisticRegression

X_tr_nonzero_set1 = X_tr_set1[:, nonzero_features]
X_te_nonzero_set1 = X_te_set1[:, nonzero_features]

param = {'C': [0.001, 1, 100]}

clf_LR = LogisticRegression()

grid_search = GridSearchCV(clf_LR, param_grid = param)
grid_search.fit(X_tr_nonzero_set1, y_train)
```

Out[52]:
```
GridSearchCV(cv=None, error_score='raise',
       estimator=LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
          intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
          penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
          verbose=0, warm_start=False),
       fit_params=None, iid=True, n_jobs=1,
       param_grid={'C': [0.001, 1, 100]}, pre_dispatch='2*n_jobs',
       refit=True, return_train_score='warn', scoring=None, verbose=0)
```

In [53]:
```
grid_search.best_params_
```

Out[53]:
```
{'C': 1}
```

Training model with best parameter set 1

In [54]:
```
LR_clf_set1 = LogisticRegression(C= grid_search.best_params_['C'])

LR_clf_set1.fit(X_tr_nonzero_set1, y_train)
```

Out[54]:
```
LogisticRegression(C=1, class_weight=None, dual=False, fit_intercept=True,
          intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
          penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
          verbose=0, warm_start=False)
```

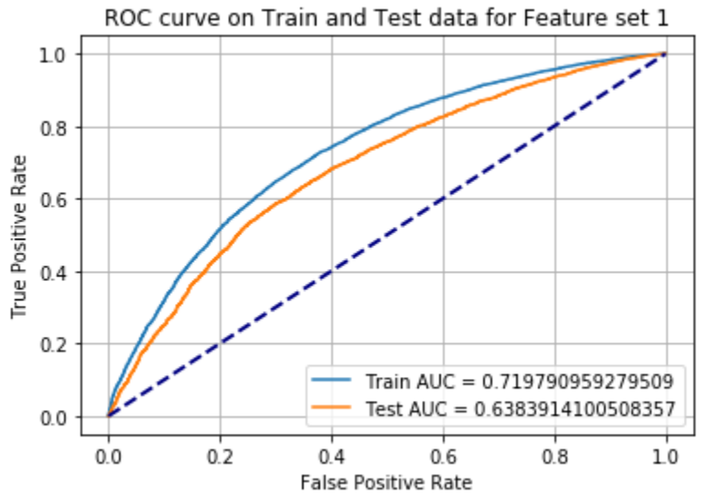
Finding AUC curve on train and test data for set 1

In [55]:
```
y_train_proba_set1 = LR_clf_set1.predict_proba(X_tr_nonzero_set1)[:,1]
y_test_proba_set1 = LR_clf_set1.predict_proba(X_te_nonzero_set1)[:,1]


#Finding AUC on train and test data
LR_train_auc_set1 = roc_auc_score(y_train, y_train_proba_set1)
print('Train Auc for set 1')
print(LR_train_auc_set1)

LR_test_auc_set1 = roc_auc_score(y_test, y_test_proba_set1)
print('\n Test Auc for set 1')
print(LR_test_auc_set1)
```

```
Train Auc for set 1
0.7325235355895412

 Test Auc for set 1
0.6869342489612114
```

Plotting ROC curve of train and test data for set 1

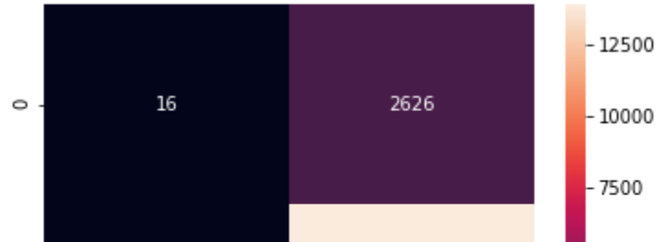
In [56]:
```
#Finding FPR and TPR both on train and test
train_fpr_set1, train_tpr_set1, train_threshold_set1 = roc_curve(y_train, y_train_proba_set1)
test_fpr_set1, test_tpr_set1, test_threshold_set1 = roc_curve(y_test, y_test_proba_set1)

#Plotting AUC curve
plot_AUC(train_fpr_set1, train_tpr_set1, test_fpr_set1, test_tpr_set1, train_auc_set1, test_auc_set1
,
         'ROC curve on Train and Test data for Feature set 1')
```



Plotting confusion matrix for set 1

In [57]:
```
#Predicting y_test
y_test_pred_set1 = LR_clf_set1.predict(X_te_nonzero_set1)

confusion_matrix_set1 = confusion_matrix(y_test, y_test_pred_set1)

#Seaborn Heatmap representaion of Train confusion matrix
sns.heatmap(confusion_matrix_set1, annot=True, fmt="d")
```

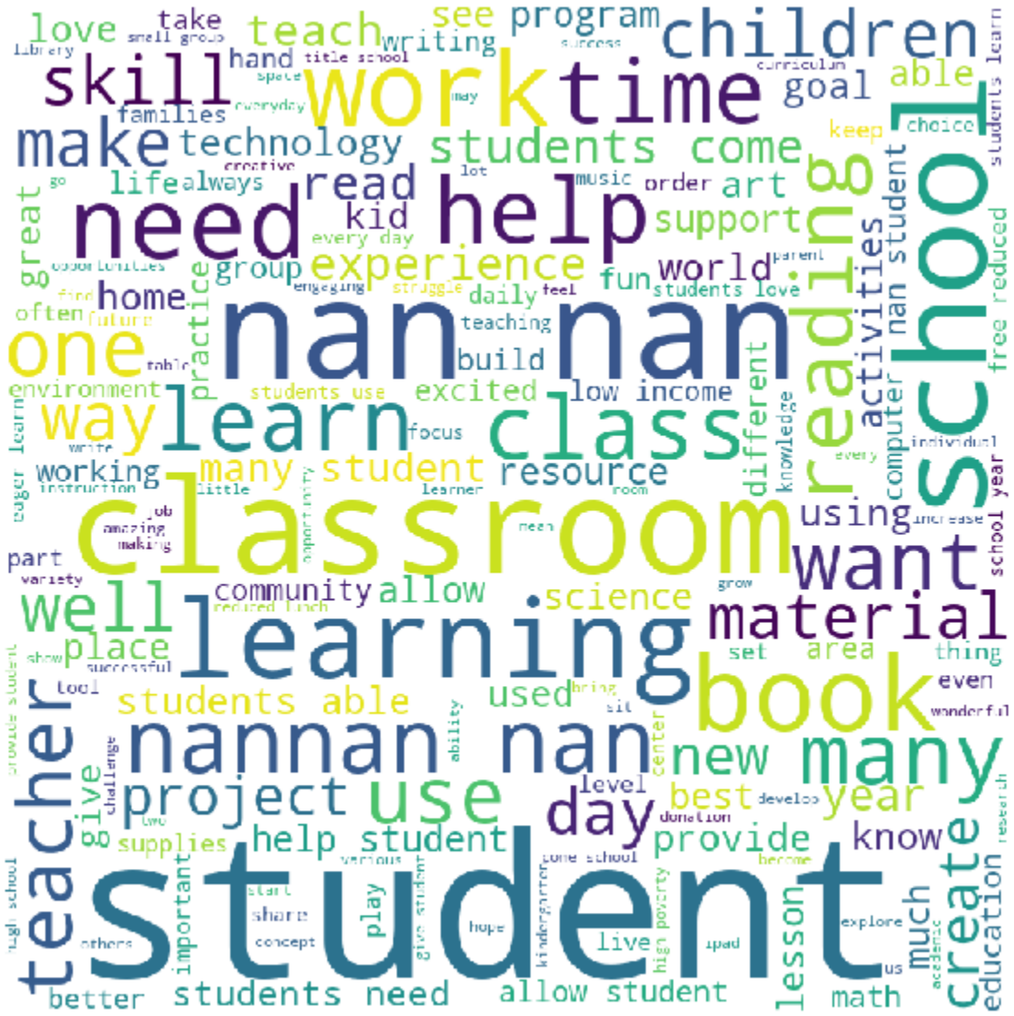
Out[57]: <matplotlib.axes._subplots.AxesSubplot at 0x1a6d902beb8>



In [58]:
```
#Extracting False positive datapoints

fp_indices = []
for i in range(len(y_test)):
    if (np.array(y_test)[i] == 0) & (y_test_pred_set1[i] == 1):
        fp_indices.append(i)
```

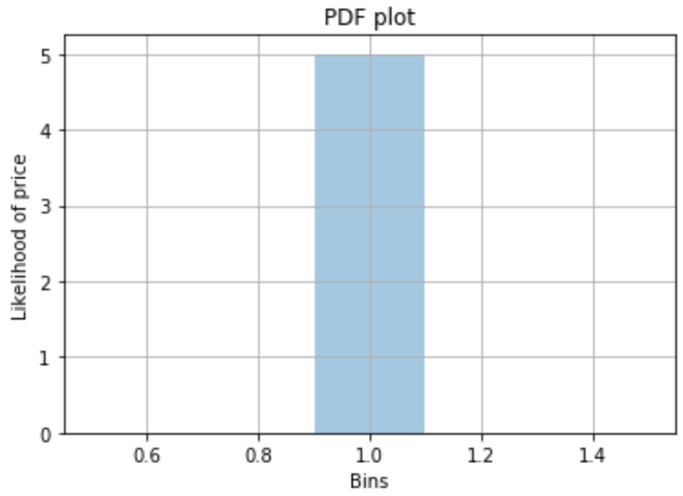
Exploratory Data analysis for set 1

In [59]:
```
#Creating wordcloud from false positive data points of feature essay
X_test_fp_set1 = X_test['essay'][fp_indices]

create_wordcloud_using_fp_essay(X_test_fp_set1)
```



In [ ]:
```
#Extracting price feature and plotting Box plot
plot_Box_plot(X_test_price[fp_indices])
```

In [60]:
```
#Extracting teacher_number_of_previously_posted_projects feature and plotting PDF
plot_PDF(X_test_tchr_prfx[fp_indices].data)
```



In [61]:
```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyper parameter", "AUC"]


x.add_row(["TFIDF", 'Decision Tree', clf_set1.best_params_, test_auc_set2])
x.add_row(["W2V", 'Decision Tree', clf_set2.best_params_, test_auc_set1])
x.add_row(["TFIDF", 'Logistic Regression', grid_search.best_params_, LR_test_auc_set1])
print(x)
```

```
+------------+---------------------+-------------------------------------------+--------------
------+
| Vectorizer |        Model        |               Hyper parameter             |        AUC
|
+------------+---------------------+-------------------------------------------+--------------
------+
|   TFIDF    |    Decision Tree    | {'max_depth': 10, 'min_samples_split': 500} | 0.62310610136
83834 |
|    W2V     |    Decision Tree    |  {'max_depth': 5, 'min_samples_split': 10}  | 0.63839141005
08357 |
|   TFIDF    | Logistic Regression |                  {'C': 1}                 | 0.68693424896
12114 |
+------------+---------------------+-------------------------------------------+--------------
------+
```