DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy`

Feature	Description
	• `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

* See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

your neighborhood, and your school are all helpful.

- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

  For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [1]:

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

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

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

from tqdm import tqdm
import os

from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

1.1 Reading Data

In [105]:

```
project_data = pd.read_csv('train_data.csv',nrows = 60000)
resource_data = pd.read_csv('resources.csv')
```

In [106]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (60000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [107]:

In [107]:

```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[107]:

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

1.2 preprocessing of `project_subject_categories`

In [108]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python:
https://stackoverflow.com/a/47301924/4084039

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

project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)

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

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

1.3 preprocessing of `project_subject_subcategories`

In [109]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python:
https://stackoverflow.com/a/47301924/4084039

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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
```

```
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [110]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[110]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Grades PreK-2

In [111]:

```
#preprocessing project_grade_categories
#project_grade contain grade with space so we remove the grades from the data set

project_grade= list(project_data['project_grade_category'].values)
# remove special characters from list of strings python:
# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/

grade_cat_list = []
for i in project_grade:
# consider we have text like this:
    for j in i.split(' '): # # split by space
        j=j.replace('Grades','')# clean grades from the row
```

```
    grade_cat_list.append(j.strip())

project_data['clean_grade'] = grade_cat_list
project_data.drop(['project_grade_category'], axis=1, inplace=True)

my_counter = Counter()
for word in project_data['clean_grade'].values:
     my_counter.update(word.split())
project_grade_category_dict= dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda
kv: kv[1]))
```

In [112]:

```
project_data.head(2)
```

Out[112]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_title	projec
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Engineering STEAM into the Primary Classroom	I have fortuna to use ...
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Mobile Learning with a Mobile Listening Center	Having 24 stuc comes diver...

1.3 Text preprocessing

In [113]:

```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [114]:

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
```

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as the STEM j
ournals, which my students really enjoyed.  I would love to implement more of the Lakeshore STEM k
its in my classroom for the next school year as they provide excellent and engaging STEM
lessons.My students come from a variety of backgrounds, including language and socioeconomic statu
s.  Many of them don't have a lot of experience in science and engineering and these kits give me
the materials to provide these exciting opportunities for my students.Each month I try to do
several science or STEM/STEAM projects.  I would use the kits and robot to help guide my science i
nstruction in engaging and meaningful ways.  I can adapt the kits to my current language arts paci
ng guide where we already teach some of the material in the kits like tall tales (Paul Bunyan) or
Johnny Appleseed.  The following units will be taught in the next school year where I will
implement these kits: magnets, motion, sink vs. float, robots.  I often get to these units and don
't know If I am teaching the right way or using the right materials.    The kits will give me
additional ideas, strategies, and lessons to prepare my students in science.It is challenging to d
evelop high quality science activities.  These kits give me the materials I need to provide my
students with science activities that will go along with the curriculum in my classroom.  Although
```

I have some things (like magnets) in my classroom, I don't know how to use them effectively. The kits will provide me with the right amount of materials and show me how to use them in an appropriate way.
==
What we learn with pleasure we never forget.\r\n-Alfred Mercier \r\nStudents learn through many different ways, my students learn from engaging hands on activities. Our kindergarten class is ful l of students with lots of energy and the eagerness to learn.I am, the Kindergarten Teacher of an EIP class. My students are brilliant and are in love with learning. They love to dance, sing, and act in order to learn. Our school is a STEAM school, so bringing arts into the classroom is a our main goal. In our classroom we are constantly incorporating the arts, which helps students retain the material they learned in a fun way!   \r\n\r\nOur classroom has become a family and a home to enter into every morning. It is a safe place to learn and share. We respect one another and strive to each other. A lot of my students come from broken homes and coming to school is there pl ace to shine! Outside of the classroom our school is just as supportive. The atmosphere of our sch ool is a place where students feel welcome and feel like they are apart of. Walking through the ha lls the students work is displayed everywhere to show them that we care and value their work! With mutual student teacher respect we have become a family as a whole!Since we are a STEAM school and focus on the arts, our technology is at a shortage. Kindles for our classroom would help the stude nts have hands on engaging learning opportunities. Having Kindles in the classroom will help me as a teacher not fight the technology of today's world, but welcome it into the classroom as a great learning resource. My students love hands on engaging activities! We would love to use our Kindles has a station, so they can have another chance for independent learning. This will give my struggl ing auditory and visual learners a chance to deepen their learning and not fall so far behind!Our classroom appreciates any donations and giving our class the chance to have up to date technology. If our donations are meet you are giving our Kindergartens the chance to have interacting, engagin g activities that are fun to learn through using the Kindles learning Apps!
==
Some beginners are pre-reader, and some can read independently the first day of school. Our goal i s for students to read a level C or higher. To achieve this goal, we teach strategies for mastery. We spend about 90 minutes per day on literacy and these books will help students be successful rea ders.Most of our students come from an urban background where poverty and survival is a way of lif e. They do not have many books at home and many of them are cared for by older siblings while thei r parents work. The exposure they get to these books will open up opportunities for future success and teach them about a world they might not get to see otherwise. I chose books to teach science, manners, relationships, and also to entertain. A love of reading and books will last a l ifetime. When you see a child light up with pride when they read for the first time or learn something cool from a book you never forget it. Those are the moments that remind you why you lov e being a teacher!These resources will be in leveled boxes, and the students will know which box t hey should use during guided reading. They are allowed to pre-select some books weekly. The goal is to master these books and choose new ones the next week. Eventually, they will move up to the next level of books, then the next, then the next. By having large variety of levels and subjects, these books will appeal to a wide variety of students. It is exciting to see children become independent readers!As I mentioned earlier, many of these students do not have access to bo oks at home. A print rich environment at school is so important for the expansion of their minds and will contribute to the future success of these children. They are our future, and I am in the business of helping to form future leaders. Your donation will help us all achieve that goal...together.
==
I am a veteran teacher. I have taught in NYC public schools for the past few years and recently mo ved to Seattle. I donated al of my materials of the past 9 years to the school I just left in the Bronx since I was moving across the country.\r\n\r\n I am starting at a new school that has limite d classroom reading resources. The school has a technology focus however, I want to provide the s tudents with tangible books. The community here is wonderful and is extremely tight knit and are v ery welcoming.These guided reading sets will provide my students with direct reading instruction i n small groups. It is important to espouse students to different themes, genres, and topics. It is my overall goal to increase reading skills and have my students fall in love with reading, as well as support my students to coming life long learners. \r\n\r\nThese guided reading sets will allow me to work directly with small groups of students to focus on decoding, fluency, and comprehension strategies. The sets are leveled based on reading abilities and provide both fiction and non ficti on reading opportunities for students. \r\n\r\nThank you!nannan

In [115]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

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

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
```

```
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [119]:

```
# 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"]
```

1.4 Preprocessing of `project_title`

In [122]:

```
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
```

```
Engineering STEAM into the Primary Classroom
==================================================
Kindles for Kids!
==================================================
We Love to Read!
==================================================
Help Readers Grow By Growing Their Library!
==================================================
```

In [125]:

```
# we cannot remove rows where teacher prefix is not available therefore we are replacing 'nan' val
ue with
# 'null'(string)
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna('null')
```

1.5 Preparing data for models

1.5 Preparing data for models

In [103]:

```
project_data.columns
```

Out[103]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'clean_grade', 'essay'],
      dtype='object')
```

we are going to consider

- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- project_grade_category : categorical data
- teacher_prefix : categorical data

- project_title : text data
- text : text data
- project_resource_summary: text data (optinal)

- quantity : numerical (optinal)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

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

In [129]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data,
project_data['project_is_approved'],stratify = project_data['project_is_approved'], test_size=0.33
)
X_train,X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [130]:

```
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, stratify= y_train,test_size = 0.3
3)
```

In [133]:

```
X_train.drop(["project_is_approved"], axis = 1, inplace = True)

X_test.drop(["project_is_approved"], axis = 1, inplace = True)

X_cv.drop(["project_is_approved"], axis = 1, inplace = True)
```

In [134]:

```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)
```

(10045, 17) (10045,)

```
(18045, 17) (18045,)
(8889, 17) (8889,)
(19800, 17) (19800,)
==========================================================================================
```

In [135]:

```
project_data.head(1)
```

Out[135]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_title	projec
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Engineering STEAM into the Primary Classroom	I have fortuna to use ...

In [136]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 18045/18045
[00:14<00:00, 1233.65it/s]
```

In [137]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 19800/19800
[00:16<00:00, 1226.68it/s]
```

In [138]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_cv = []
# tqdm is for printing the status bar
```

```
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_cv.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:07<00:00, 1242.83it/s]
```

In [139]:

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

```
100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:00<00:00, 21120.40it/s]
```

In [140]:

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

```
100%|████████████████████████████████████████████████████████████████| 18045/18045
[00:00<00:00, 26221.67it/s]
```

In [141]:

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

```
100%|████████████████████████████████████████████████████████████████| 19800/19800
[00:00<00:00, 25062.34it/s]
```

[00:00<00:00, 25062.34it/s]

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/

In [142]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_clean = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False,
binary=True)
vectorizer_clean.fit(X_train['clean_categories'].values)

X_train_cat = vectorizer_clean.transform(X_train['clean_categories'].values)
X_cv_cat = vectorizer_clean.transform(X_cv['clean_categories'].values)
X_test_cat = vectorizer_clean.transform(X_test['clean_categories'].values)



print(vectorizer_clean.get_feature_names())

print("After vectorizations")
print(X_train_cat.shape, y_train.shape)
print(X_cv_cat.shape, y_cv.shape)
print(X_test_cat.shape, y_test.shape)

feature_1 = vectorizer_clean.get_feature_names()
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
After vectorizations
(18045, 9) (18045,)
(8889, 9) (8889,)
(19800, 9) (19800,)
```

In [143]:

```
# we use count vectorizer to convert the values into one
vectorizer_clean_sub = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=Fals
e, binary=True)
vectorizer_clean_sub.fit(X_train['clean_subcategories'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_sub_ohe = vectorizer_clean_sub.transform(X_train['clean_subcategories'].values)
X_cv_clean_sub_ohe = vectorizer_clean_sub.transform(X_cv['clean_subcategories'].values)
X_test_clean_sub_ohe = vectorizer_clean_sub.transform(X_test['clean_subcategories'].values)


print(vectorizer_clean_sub.get_feature_names())

print("After vectorizations")
print(X_train_clean_sub_ohe.shape, y_train.shape)
print(X_cv_clean_sub_ohe.shape, y_cv.shape)
print(X_test_clean_sub_ohe.shape, y_test.shape)

feature_2 = vectorizer_clean_sub.get_feature_names()
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'History_Geography', 'Music', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
After vectorizations
(18045, 30) (18045,)
(8889, 30) (8889,)
(19800, 30) (19800,)
```

In [144]:

```
# school_state convert categorical to vectors
# now time to cont the each words
from collections import Counter
my_counter = Counter()
for word in project_data['school_state'].values:
    my_counter.update(word.split())# count the words



school_state_dict = dict(my_counter)# store in dicionary
sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1]))

from sklearn.feature_extraction.text import CountVectorizer
vectorizer_state = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercase=Fal
se, binary=True)
vectorizer_state.fit(X_train['school_state'].values)



# firstly convert fit the train data into the vector then it learn the vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer_state.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer_state.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer_state.transform(X_test['school_state'].values)
print(vectorizer_state.get_feature_names())


print("After vectorizations")
print(X_train_school_state .shape, y_train.shape)
print(X_cv_school_state .shape, y_cv.shape)
print(X_test_school_state .shape, y_test.shape)


feature_3 = vectorizer_state.get_feature_names()
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'NE', 'SD', 'DE', 'AK', 'WV', 'HI', 'ME', 'DC', 'NM', 'KS', 'I
A', 'ID', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'NV', 'MD', 'CT', 'TN', 'AL', 'UT', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'LA', 'WA', 'MA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'TX', 'NY
', 'CA']
After vectorizations
(18045, 51) (18045,)
(8889, 51) (8889,)
(19800, 51) (19800,)
```

In [145]:

```
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
project_data['clean_grade']=project_data['clean_grade'].fillna("")# fill the null values with
space


# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_grade = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()),lowe
rcase=False, binary=True)
vectorizer_grade.fit(X_train['clean_grade'].values)


# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade_category = vectorizer_grade.transform(X_train['clean_grade'].values)
X_cv_project_grade_category = vectorizer_grade.transform(X_cv['clean_grade'].values)
X_test_project_grade_category = vectorizer_grade.transform(X_test['clean_grade'].values)
print(vectorizer_grade.get_feature_names())



print("After vectorizations")
print(X_train_project_grade_category .shape, y_train.shape)
print(X_cv_project_grade_category .shape, y_cv.shape)
print(X_test_project_grade_category .shape, y_test.shape)


feature_4 = vectorizer_grade.get_feature_names()
```

```
['9-12', '6-8', '3-5', 'PreK-2']
After vectorizations
(18045, 4) (18045,)
(8889, 4) (8889,)
(19800, 4) (19800,)
```

In [146]:

```
my_counter = Counter()
for teacher_prefix in project_data['teacher_prefix'].values:
    teacher_prefix = str(teacher_prefix)
    my_counter.update(teacher_prefix.split())



teacher_prefix_cat_dict = dict(my_counter)
sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.items(), key=lambda kv: kv[1])
)
```

In [147]:

```
vectorizer_teacher = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lower
case=False, binary=True)
vectorizer_teacher.fit(X_train['teacher_prefix'].values.astype("U"))

teacher_prefix_train = vectorizer_teacher.transform(X_train['teacher_prefix'].values.astype("U"))
teacher_prefix_test = vectorizer_teacher.transform(X_test['teacher_prefix'].values.astype("U"))
teacher_prefix_cv = vectorizer_teacher.transform(X_cv['teacher_prefix'].values.astype("U"))
```

In [148]:

```
print(vectorizer_teacher.get_feature_names())

print(teacher_prefix_train.shape,y_train.shape)
print(teacher_prefix_test.shape,y_test.shape)
print(teacher_prefix_cv.shape,y_cv.shape)


feature_5 = vectorizer_teacher.get_feature_names()
```

```
['null', 'Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
(18045, 6) (18045,)
(19800, 6) (19800,)
(8889, 6) (8889,)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [149]:

```
X_train_essay=preprocessed_essays_train
X_cv_essay=preprocessed_essays_cv
X_test_essay=preprocessed_essays_test
```

In [150]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_b = CountVectorizer(min_df=10)
vectorizer_b.fit(X_train_essay)
```

Out[150]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=None, min_df=10,
                ngram_range=(1, 1), preprocessor=None, stop_words=None,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
```

```
                tokenizer=None, vocabulary=None)
```

In [151]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_b.transform(X_train_essay)
X_cv_essay_bow = vectorizer_b.transform(X_cv_essay)
X_test_essay_bow = vectorizer_b.transform(X_test_essay)
```

In [152]:

```
print(X_train_essay_bow.shape ,y_train.shape)
print(X_cv_essay_bow.shape ,y_train.shape)
print(X_test_essay_bow.shape ,y_train.shape)
```

```
(18045, 8015) (18045,)
(8889, 8015) (18045,)
(19800, 8015) (18045,)
```

In [153]:

```
X_train_title=preprocessed_titles_train
X_cv_title=preprocessed_titles_cv
X_test_title=preprocessed_titles_test
```

In [154]:

```
vectorizer_title_bow = CountVectorizer(min_df=10)
vectorizer_title_bow.fit(X_train_title)
```

Out[154]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=None, min_df=10,
                ngram_range=(1, 1), preprocessor=None, stop_words=None,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, vocabulary=None)
```

In [155]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_bow_title = vectorizer_title_bow.transform(X_train_title)
X_cv_bow_title= vectorizer_title_bow.transform(X_cv_title)
X_test_bow_title = vectorizer_title_bow.transform(X_test_title)
```

In [156]:

```
print(X_train_bow_title.shape ,y_train.shape)
print(X_cv_bow_title.shape ,y_cv.shape)
print(X_test_bow_title.shape ,y_test.shape)
```

```
(18045, 986) (18045,)
(8889, 986) (8889,)
(19800, 986) (19800,)
```

1.5.2.2 TFIDF vectorizer

In [157]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf = TfidfVectorizer(min_df=10)
vectorizer_tfidf.fit(X_train_essay)
```

Out[157]:

```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.float64'>, encoding='utf-8',
```

```
                dtype=<class 'numpy.float64'>, encoding='utf-8',
                input='content', lowercase=True, max_df=1.0, max_features=None,
                min_df=10, ngram_range=(1, 1), norm='l2', preprocessor=None,
                smooth_idf=True, stop_words=None, strip_accents=None,
                sublinear_tf=False, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, use_idf=True, vocabulary=None)
```

In [158]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_tfidf.transform(X_train_essay)
X_cv_essay_tfidf = vectorizer_tfidf.transform(X_cv_essay)
X_test_essay_tfidf = vectorizer_tfidf.transform(X_test_essay)
```

In [159]:

```
print(X_train_essay_tfidf.shape,y_train.shape)
print(X_cv_essay_tfidf.shape,y_cv.shape)
print(X_test_essay_tfidf.shape,y_test.shape)
```

```
(18045, 8015) (18045,)
(8889, 8015) (8889,)
(19800, 8015) (19800,)
```

In [160]:

```
vectorizer_tfidf_clean_titles = TfidfVectorizer(min_df=10)
vectorizer_tfidf_clean_titles.fit(X_train_title)
```

Out[160]:

```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.float64'>, encoding='utf-8',
                input='content', lowercase=True, max_df=1.0, max_features=None,
                min_df=10, ngram_range=(1, 1), norm='l2', preprocessor=None,
                smooth_idf=True, stop_words=None, strip_accents=None,
                sublinear_tf=False, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, use_idf=True, vocabulary=None)
```

In [161]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer_tfidf_clean_titles.transform(X_train_title)
X_cv_title_tfidf = vectorizer_tfidf_clean_titles.transform(X_cv_title)
X_test_title_tfidf = vectorizer_tfidf_clean_titles.transform(X_test_title)
```

In [162]:

```
print(X_train_title_tfidf.shape,y_train.shape)
print(X_cv_title_tfidf.shape,y_cv.shape)
print(X_test_title_tfidf.shape,y_test.shape)
```

```
(18045, 986) (18045,)
(8889, 986) (8889,)
(19800, 986) (19800,)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [163]:

```
'''
# 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-sa
ve-and-load-variables-in-python/

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


'''
```

Out[163]:

```
'\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]\r
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'
```

In [164]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors (1)', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [165]:

```
#for essay
# average Word2Vec
# compute average word2vec for each review.
def func(wordlist):

  train_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
  for sentence in tqdm(wordlist): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length # we are taking the 300dimensions
very large
    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
    train_avg_w2v_vectors.append(vector)

  print(len(train_avg_w2v_vectors))
  print(len(train_avg_w2v_vectors[0]))
  return train_avg_w2v_vectors
```

In [166]:

```
train_avg_w2v_vectors=func(preprocessed_essays_train)
test_avg_w2v_vectors=func(preprocessed_essays_test)
cv_avg_w2v_vectors=func(preprocessed_essays_cv)


#for titles

train_avg_w2v_vectors_title=func(preprocessed_titles_train)
test_avg_w2v_vectors_title=func(preprocessed_titles_test)
cv_avg_w2v_vectors_title=func(preprocessed_titles_cv)
```

```
100%|████████████████████████████████████████████████████████████████| 18045/18045
[00:06<00:00, 2641.83it/s]

18045
300

100%|████████████████████████████████████████████████████████████████| 19800/19800
[00:08<00:00, 2462.42it/s]

19800
300

100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:03<00:00, 2498.99it/s]

8889
300

100%|████████████████████████████████████████████████████████████████| 18045/18045
[00:00<00:00, 52874.66it/s]

18045
300

100%|████████████████████████████████████████████████████████████████| 19800/19800
[00:00<00:00, 49347.48it/s]

19800
300

100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:00<00:00, 42441.94it/s]
```

```
8889
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [167]:

```
# 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 [168]:

```
# average Word2Vec
# compute average word2vec for each review.
def tf_idf(word_list):
    train_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
list
    for sentence in tqdm(word_list): # 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():#.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in tfidf_words):
                #vec = model.wv[word]
                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()))
                vector += (vec * tf_idf) # calculating tfidf weighted w2v
                tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        train_title_tfidf_w2v_vectors.append(vector)
    print(len(train_title_tfidf_w2v_vectors))
    print(len(train_title_tfidf_w2v_vectors[0]))
    return train_title_tfidf_w2v_vectors
```

In [169]:

```
#train_title_tfidf_w2v_vector
train_tfidf_w2v_vectors=tf_idf(preprocessed_essays_train)
test_tfidf_w2v_vectors=tf_idf(preprocessed_essays_test)
cv_tfidf_w2v_vectors=tf_idf(preprocessed_essays_cv)


#train_title_tfidf_w2v_vector
train_title_tfidf_w2v_vectors=tf_idf(preprocessed_titles_train)
test_title_tfidf_w2v_vectors=tf_idf(preprocessed_titles_test)
cv_title_tfidf_w2v_vectors=tf_idf(preprocessed_titles_cv)
```

```
100%|██████████| 18045/18045 [00:48<00:00, 373.46it/s]

18045
300

100%|██████████| 19800/19800 [00:52<00:00, 377.91it/s]

19800
300

100%|██████████| 8889/8889 [00:23<00:00, 376.55it/s]
```

```
8889
300
```

```
100%|████████████████████████████████████████████████████████████████| 18045/18045
[00:00<00:00, 19780.31it/s]
```

```
18045
300
```

```
100%|████████████████████████████████████████████████████████████████| 19800/19800
[00:01<00:00, 19405.13it/s]
```

```
19800
300
```

```
100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:00<00:00, 20059.36it/s]
```

```
8889
300
```

1.5.3 Vectorizing Numerical features

In [170]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in
-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
df = pd.merge(project_data, price_data, on='id', how='left')
print(price_data.head(2))
```

```
        id   price  quantity
0  p000001  459.56         7
1  p000002  515.89        21
```

In [171]:

```
# join two dataframes in python:
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [172]:

```
#standardization
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn:
https://scikitlearn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn import preprocessing


price_scalar = StandardScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard
deviationof this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above mean and variance.
train_price = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
test_price = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
cv_price = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))


print(train_price.shape,y_train.shape)
print(test_price.shape,y_train.shape)
print(cv_price.shape,y_cv.shape)
```

```
(18045, 1) (18045,)
```

```
(19800, 1) (18045,)
(8889, 1) (8889,)
```

In [173]:

```
# previous_year_projects
price_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # fi
nding the mean and standard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_T =price_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.res
hape(-1,1))
test_T
=price_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1
))
cv_T = price_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(
-1, 1))
```

In [174]:

```
print(train_T.shape,y_train.shape)
print(test_T.shape,y_train.shape)
print(cv_T.shape,y_cv.shape)
```

```
(18045, 1) (18045,)
(19800, 1) (18045,)
(8889, 1) (8889,)
```

In [175]:

```
price_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and
standarddeviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_quantity = price_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
cv_quantity = price_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
test_quantity = price_scalar.transform(X_test['quantity'].values.reshape(-1, 1))


print(train_quantity .shape,y_train.shape)
print(test_quantity .shape,y_train.shape)
print(cv_quantity .shape,y_cv.shape)
```

```
(18045, 1) (18045,)
(19800, 1) (18045,)
(8889, 1) (8889,)
```

1.5.4 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)

In [176]:

```
from scipy.sparse import hstack

X_tr =
hstack((X_train_essay_bow,X_train_bow_title,X_train_cat,X_train_clean_sub_ohe,X_train_school_state
,X_train_project_grade_category,teacher_prefix_train,train_price,train_T,train_quantity)).tocsr()
X_te =
hstack((X_test_essay_bow,X_test_bow_title,X_test_cat,X_test_clean_sub_ohe,X_test_school_state,X_tes
t_project_grade_category,teacher_prefix_test,test_price,test_T,test_quantity)).tocsr()
X_cr =
hstack((X_cv_essay_bow,X_cv_bow_title,X_cv_cat,X_cv_clean_sub_ohe,X_cv_school_state,X_cv_project_gr
ade_category,teacher_prefix_cv,cv_price,cv_T,cv_quantity )).tocsr()
```

In [177]:

```
print(X_tr.shape,y_train.shape)
print(X_te.shape,y_test.shape)
print(X_cr.shape,y_cv.shape)
```

```
(18045, 9104) (18045,)
(19800, 9104) (19800,)
(8889, 9104) (8889,)
```

In [178]:

```
#Feature aggregation
f=vectorizer_b.get_feature_names()
g=vectorizer_title_bow.get_feature_names()
h=vectorizer_tfidf.get_feature_names()
i=vectorizer_tfidf_clean_titles.get_feature_names()

feature_agg_bow = feature_1 + feature_2 + feature_3 + feature_4 + feature_5 + f + g
feature_agg_tfidf = feature_1 + feature_2 + feature_3+ feature_4 + feature_5 +h  + i
# p is price, q is quantity, t is teacher previous year projects
feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_previous_projects')
feature_agg_tfidf.append('teacher_previous_projects')
```

In [179]:

```
len(feature_agg_bow)
```

Out[179]:

```
9104
```

In [180]:

```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(max_depth = 3)
clf = dtree.fit(X_tr, y_train)
```

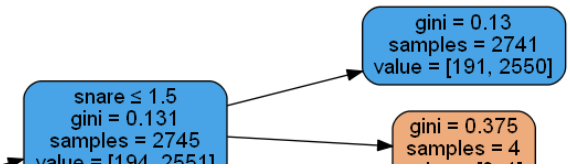
In [181]:

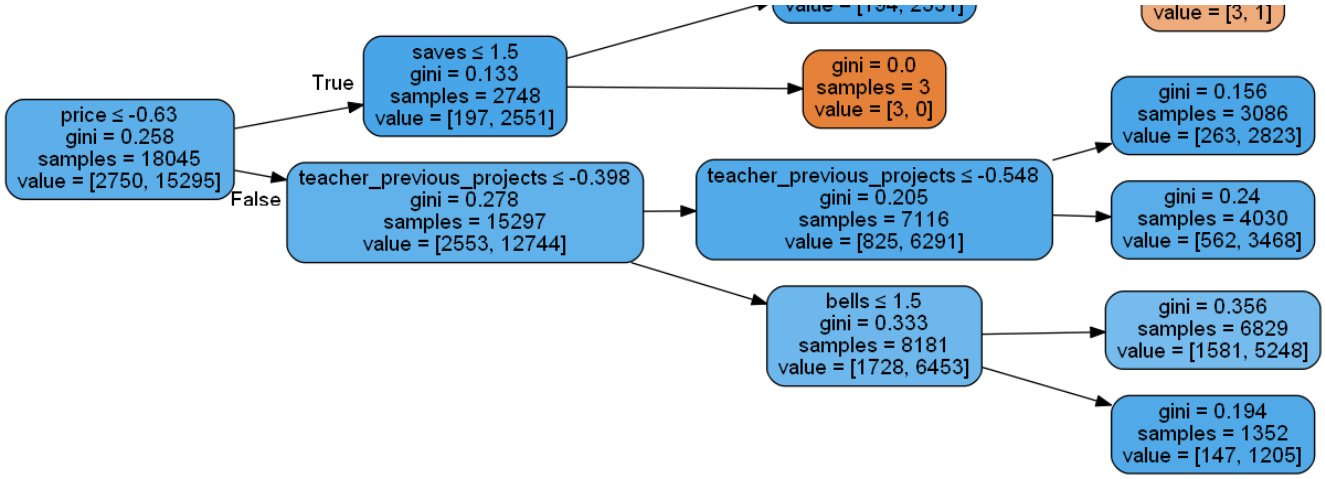
```
import os
os.environ["PATH"] += os.pathsep + 'C:/Program Files (x86)/Graphviz2.38/bin/'
```

In [182]:

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

from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clf, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature
_names=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[182]:





In [183]:

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

dtree_1 = DecisionTreeClassifier(class_weight = 'balanced')

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

In [184]:

```
clf_1 = GridSearchCV(dtree_1,parameters,cv =3,scoring = 'roc_auc',return_train_score = True)
clf_1 = clf_1.fit(X_tr,y_train)
```

In [185]:

```
train_auc= clf_1.cv_results_['mean_train_score']
train_auc_std= clf_1.cv_results_['std_train_score']
cv_auc = clf_1.cv_results_['mean_test_score']
cv_auc_std= clf_1.cv_results_['std_test_score']
```

In [186]:

```
train_auc
```

Out[186]:

```
array([0.54238082, 0.54238082, 0.54238082, 0.54238082, 0.6912459 ,
       0.69078995, 0.68961469, 0.68717859, 0.81239082, 0.80869455,
       0.78414795, 0.75277074, 0.97976095, 0.97296976, 0.92032987,
       0.82338308, 0.99474074, 0.99141298, 0.95431151, 0.8364804 ,
       0.99992211, 0.99855139, 0.96707695, 0.84909437, 0.99471016,
       0.99047303, 0.95321789, 0.83674906])
```

In [187]:

```
cv_auc
```

Out[187]:

```
array([0.53841546, 0.53841546, 0.53841546, 0.53841546, 0.6509972 ,
       0.65086577, 0.65073832, 0.65089121, 0.6537564 , 0.65242466,
       0.65867181, 0.66347248, 0.57854054, 0.57813962, 0.60293928,
       0.62733084, 0.56405607, 0.56922576, 0.58376689, 0.61538402,
       0.5600304 , 0.56337943, 0.58042951, 0.6040288 , 0.56551475,
       0.56897311, 0.58696864, 0.61589964])
```

In [188]:

```
print(clf_1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf_1.score(X_tr,y_train))
```

```
print(clf_1.score(X_te,y_test))
```

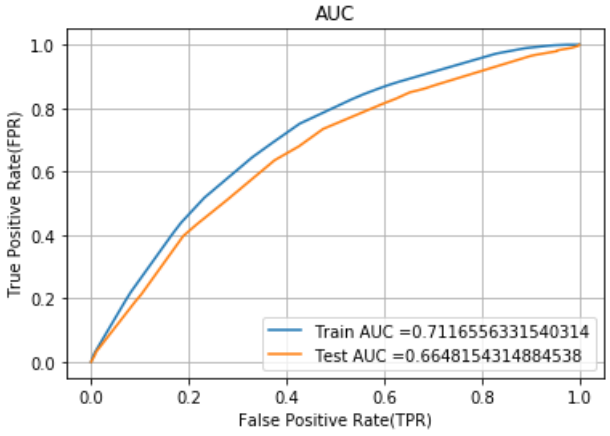
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7417242473773366
0.6668211542724742
```

In [189]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [190]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = DecisionTreeClassifier(max_depth = 10, min_samples_split = 500)

model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, X_te)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [191]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global prediction
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    prediction= predictions
    return predictions
```

In [192]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24880661157024794 for threshold 0.8
[[ 1280  1470]
 [ 2624 12671]]
```

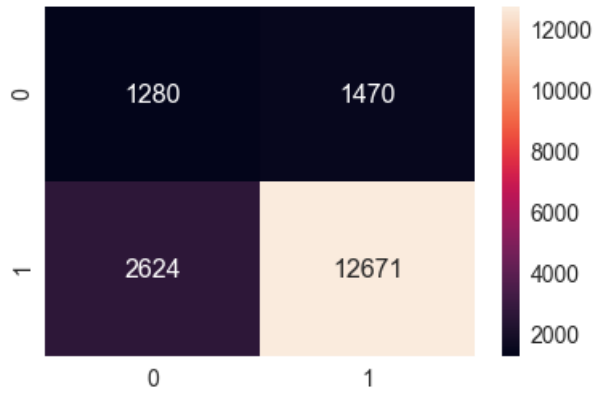
In [193]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24880661157024794 for threshold 0.8
```

Out[193]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a60fb13eb8>
```



In [194]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24938243303597898 for threshold 0.857
[[ 1584  1434]
```

```
 [ 4457 12325]]
```

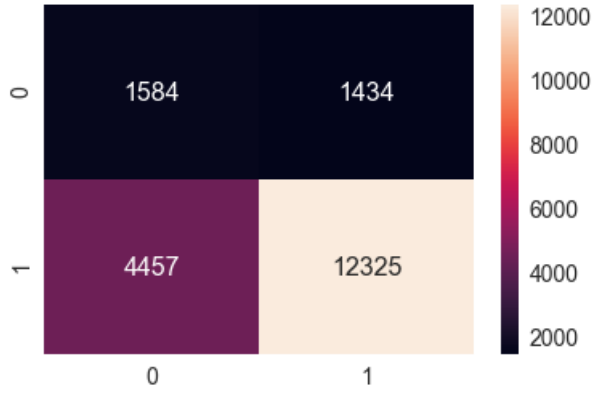
In [195]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24938243303597898 for threshold 0.857
```

Out[195]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a60db9a940>
```



In [199]:

```
fpi = []
for i in range(len(y_test)):
    if (y_test.values[i] == 0 ) & (prediction[i] == 1):
        fpi.append(i)
fp_essay1 = []
for i in fpi:
    fp_essay1.append(X_test['essay'].values[i])
```

In [200]:

```
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
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,m
in_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

In [203]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
    X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

Out[203]:

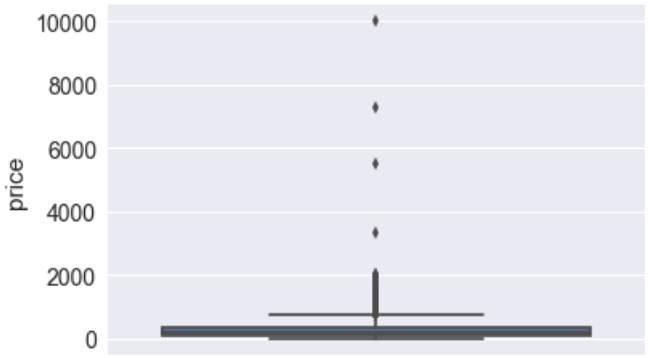
```
1434
```

In [204]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

Out[204]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a618070588>
```

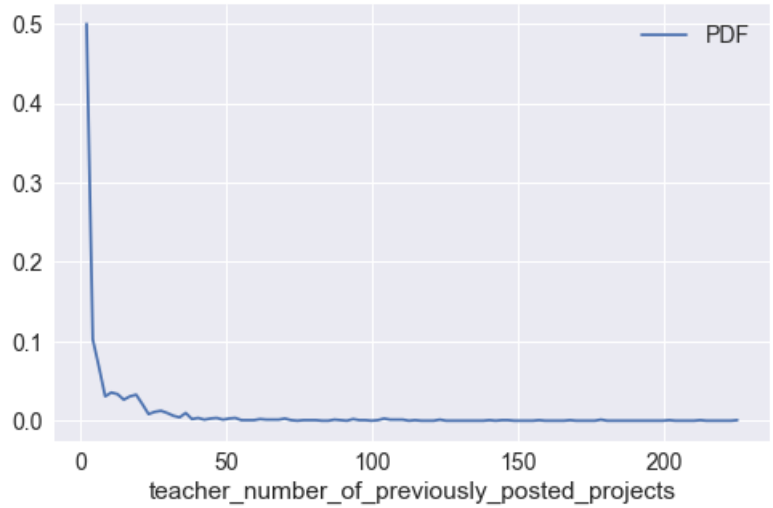


In [205]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
pdfP, = plt.plot(bin_edges[1:], pdf)
plt.legend([pdfP], ["PDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show
```

Out[205]:

```
<function matplotlib.pyplot.show(*args, **kw)>
```



In [215]:

```
c=DecisionTreeClassifier (class_weight =
'balanced',criterion="entropy",max_depth=10,min_samples_split=500)
c.fit(X_tr, y_train)
```

Out[215]:

```
DecisionTreeClassifier(class_weight='balanced', criterion='entropy',
                       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')
```

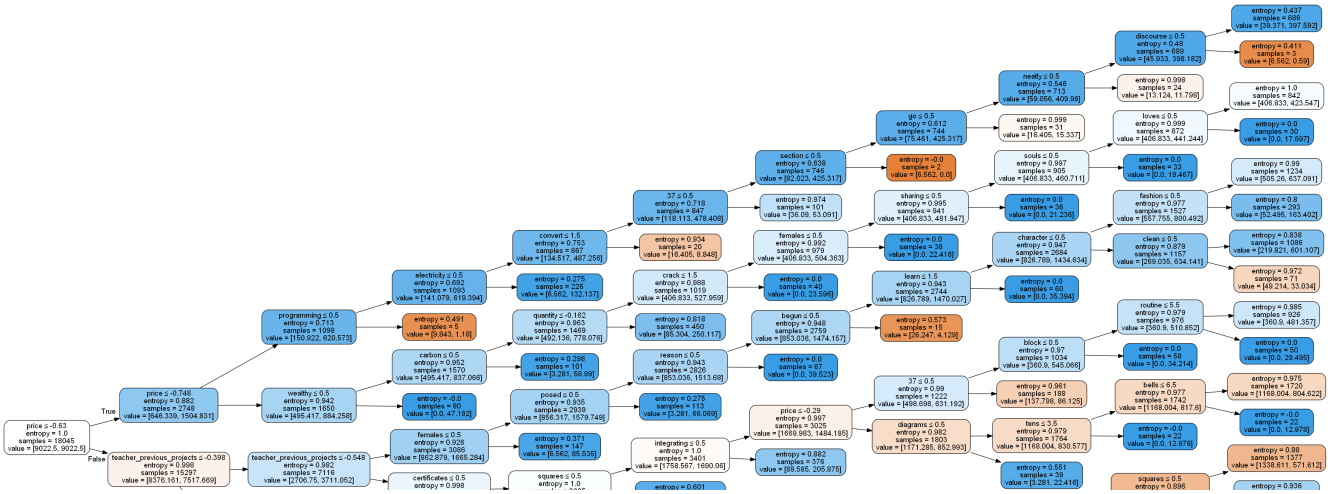
In [ ]:

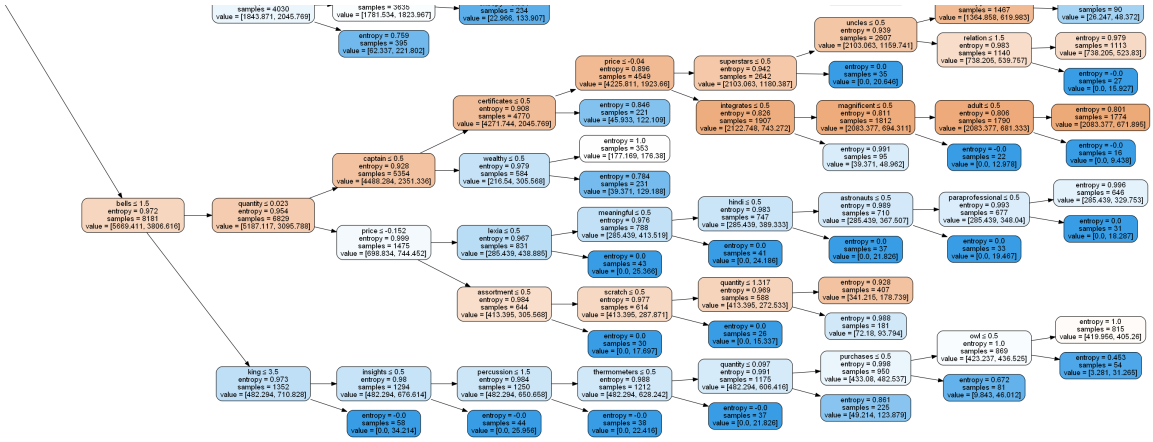
```
#Graphviz visualization of Decision Tree on bow
```

In [216]:

```
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(c, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature_n
ames=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[216]:





categorical, numerical features + project_title(tfidf) + preprocessed_eassay (tfidf)

In [217]:

```
from scipy.sparse import hstack

X_tr_tfidf =
hstack((X_train_essay_tfidf,X_train_title_tfidf,X_train_cat,X_train_clean_sub_ohe,X_train_school_st
ate,X_train_project_grade_category,teacher_prefix_train,train_price,train_T,train_quantity)).tocsr
()
X_te_tfidf =
hstack((X_test_essay_tfidf,X_test_title_tfidf,X_test_cat,X_test_clean_sub_ohe,X_test_school_state,
X_test_project_grade_category,teacher_prefix_test,test_price,test_T,test_quantity)).tocsr()
X_cr_tfidf =
hstack((X_cv_essay_tfidf,X_cv_title_tfidf,X_cv_cat,X_cv_clean_sub_ohe,X_cv_school_state,X_cv_projec
t_grade_category,teacher_prefix_cv,cv_price,cv_T,cv_quantity )).tocsr()
```

In [218]:

```
print(X_tr_tfidf.shape,y_train.shape)
print(X_te_tfidf.shape,y_test.shape)
print(X_cr_tfidf.shape,y_cv.shape)
```

```
(18045, 9104) (18045,)
(19800, 9104) (19800,)
(8889, 9104) (8889,)
```

In [220]:

```
#Feature aggregation
f=vectorizer_b.get_feature_names()
g=vectorizer_title_bow.get_feature_names()
h=vectorizer_tfidf.get_feature_names()
i=vectorizer_tfidf_clean_titles.get_feature_names()

feature_agg_bow = feature_1 + feature_2 + feature_3 + feature_4 + feature_5 + f + g
feature_agg_tfidf = feature_1 + feature_2 + feature_3+ feature_4 + feature_5 +h  + i
# p is price, q is quantity, t is teacher previous year projects
feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_previous_projects')
feature_agg_tfidf.append('teacher_previous_projects')
```

In [221]:

```
len(feature_agg_tfidf)
```

Out[221]:

```
9104
```

In [222]:

```
from sklearn.tree import DecisionTreeClassifier
dtree_1 = DecisionTreeClassifier(max_depth = 3)
clf_1 = dtree_1.fit(X_tr_tfidf, y_train)
```

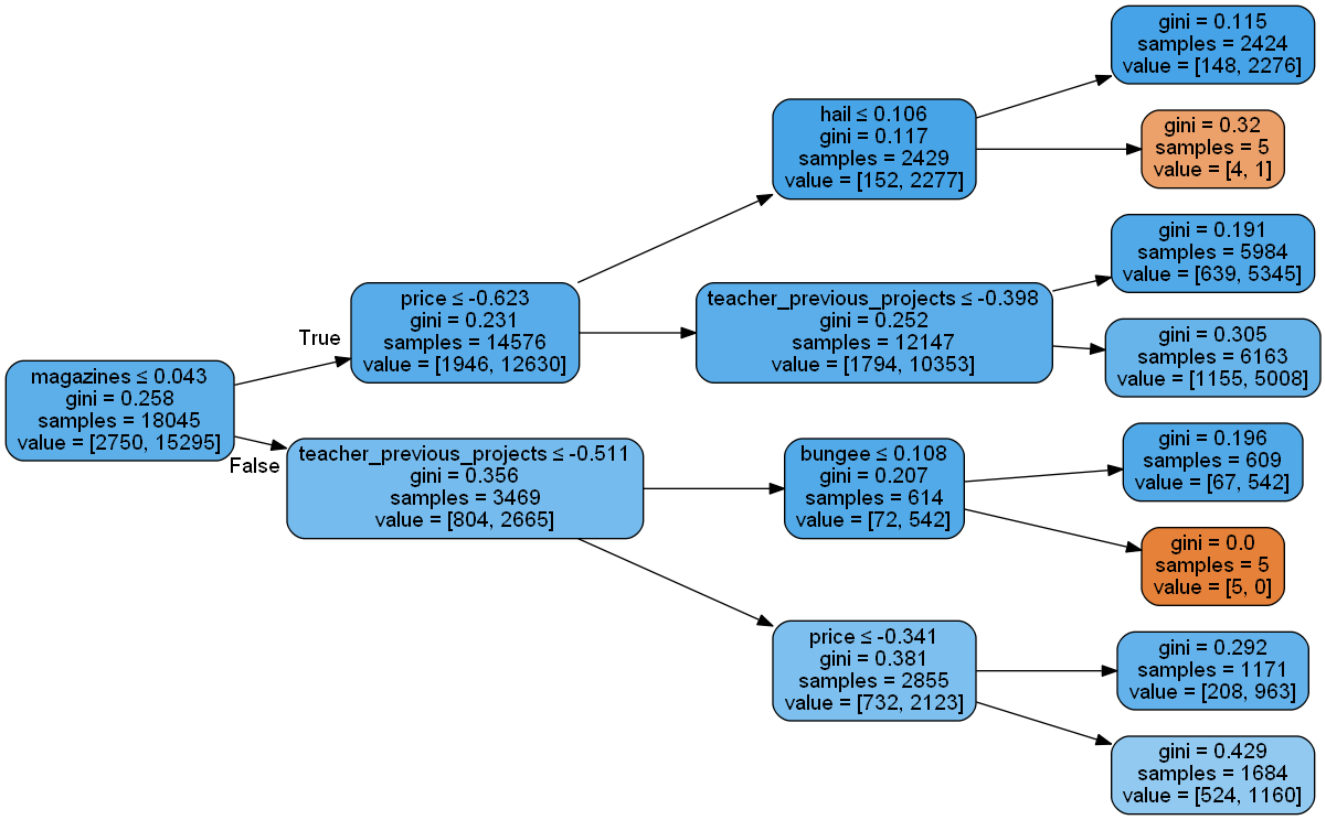
In [223]:

```
import os
os.environ["PATH"] += os.pathsep + 'C:/Program Files (x86)/Graphviz2.38/bin/'
```

In [224]:

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

from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clf_1, out_file=dot_data, filled=True, rounded=True, special_characters=True, featu
re_names=feature_agg_tfidf,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[224]:



In [225]:

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

dtree_1 = DecisionTreeClassifier(class_weight = 'balanced')

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

In [226]:

```
clf_1 = GridSearchCV(dtree_1,parameters,cv =3,scoring = 'roc_auc',return_train_score = True)
```

```
clf_1 = clf_1.fit(X_tr_tfidf,y_train)
```

In [227]:

```
train_auc= clf_1.cv_results_['mean_train_score']
train_auc_std= clf_1.cv_results_['std_train_score']
cv_auc = clf_1.cv_results_['mean_test_score']
cv_auc_std= clf_1.cv_results_['std_test_score']
```

In [228]:

```
train_auc
```

Out[228]:

```
array([0.54238082, 0.54238082, 0.54238082, 0.54238082, 0.69666375,
       0.69618142, 0.69396289, 0.69071193, 0.8315037 , 0.8274575 ,
       0.79650604, 0.76039005, 0.98790303, 0.9820551 , 0.93634231,
       0.84555441, 0.99881377, 0.99692725, 0.9644001 , 0.84929569,
       0.99995751, 0.99896711, 0.96874517, 0.85087329, 0.99913297,
       0.99686389, 0.96397744, 0.84977749])
```

In [229]:

```
cv_auc
```

Out[229]:

```
array([0.53841546, 0.53841546, 0.53841546, 0.53841546, 0.64404999,
       0.64443403, 0.6450178 , 0.64532848, 0.64060917, 0.63843462,
       0.64345301, 0.65835847, 0.57499485, 0.57152592, 0.58907947,
       0.62108148, 0.55716315, 0.55658338, 0.57200854, 0.61900298,
       0.55359132, 0.55412299, 0.56345411, 0.61794358, 0.55358135,
       0.5537851 , 0.56952609, 0.61957313])
```

In [230]:

```
print(clf_1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf_1.score(X_tr_tfidf,y_train))
print(clf_1.score(X_te_tfidf,y_test))
```

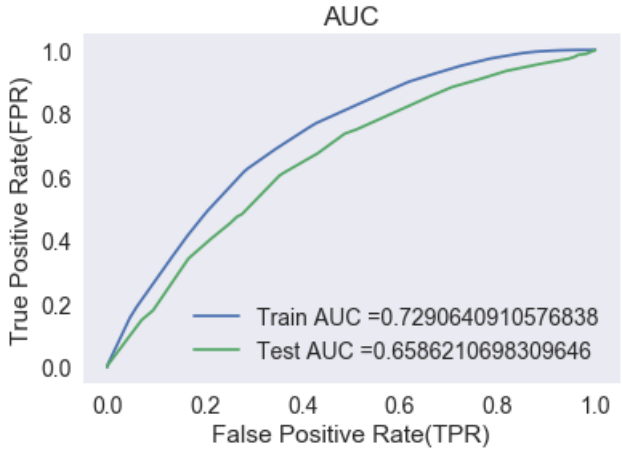
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7652798597283723
0.6554545329619234
```

In [231]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [232]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = DecisionTreeClassifier(max_depth = 10, min_samples_split = 500)

model.fit(X_tr_tfidf, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr_tfidf)
y_test_pred = batch_predict(model, X_te_tfidf)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [233]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global prediction
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    prediction= predictions
    return predictions
```

In [234]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

==========

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24481600000000003 for threshold 0.838
[[ 1573  1177]
 [ 3533 11762]]
```

In [235]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24481600000000003 for threshold 0.838
```

Out[235]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a62e6ee668>
```

In [236]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24987308312703851 for threshold 0.838
[[ 1475  1543]
 [ 4205 12577]]
```

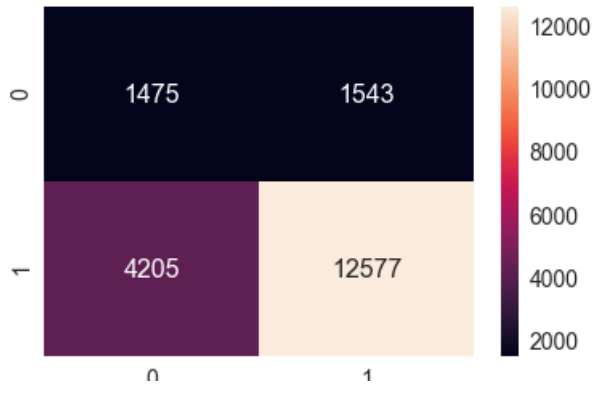
In [237]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24987308312703851 for threshold 0.838
```

Out[237]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a62d23c240>
```



In [245]:

```
fpi = []
for i in range(len(y_test)):
    if (y_test.values[i] == 0 ) & (prediction[i] == 1):
        fpi.append(i)
fp_essay1 = []
for i in fpi:
    fp_essay1.append(X_test['essay'].values[i])
```

In [246]:

```
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
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,m
in_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

In [247]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)

  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

Out[247]:

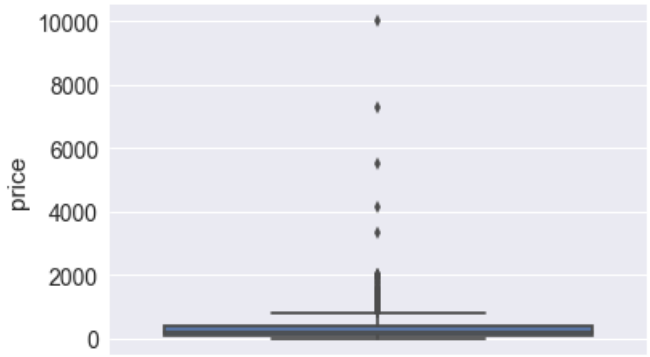
```
1543
```

In [248]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

Out[248]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a61e561cf8>
```

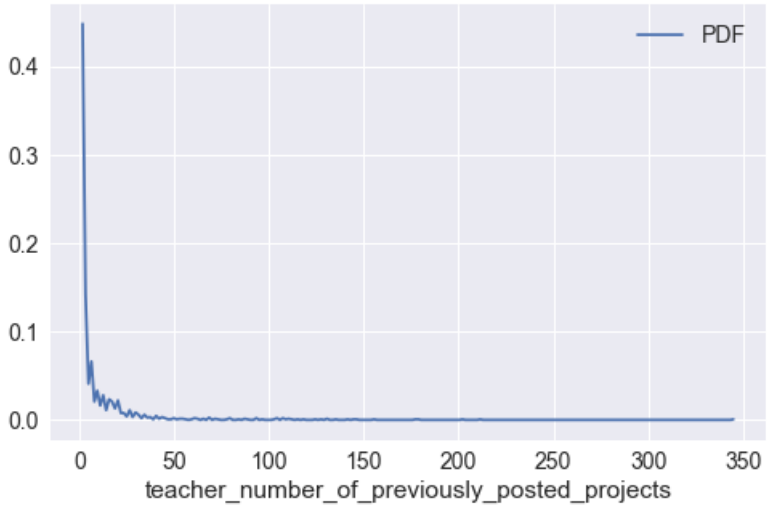


In [249]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)

plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
pdfP, = plt.plot(bin_edges[1:], pdf)
plt.legend([pdfP], ["PDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show
```

Out[249]:

```
<function matplotlib.pyplot.show(*args, **kw)>
```



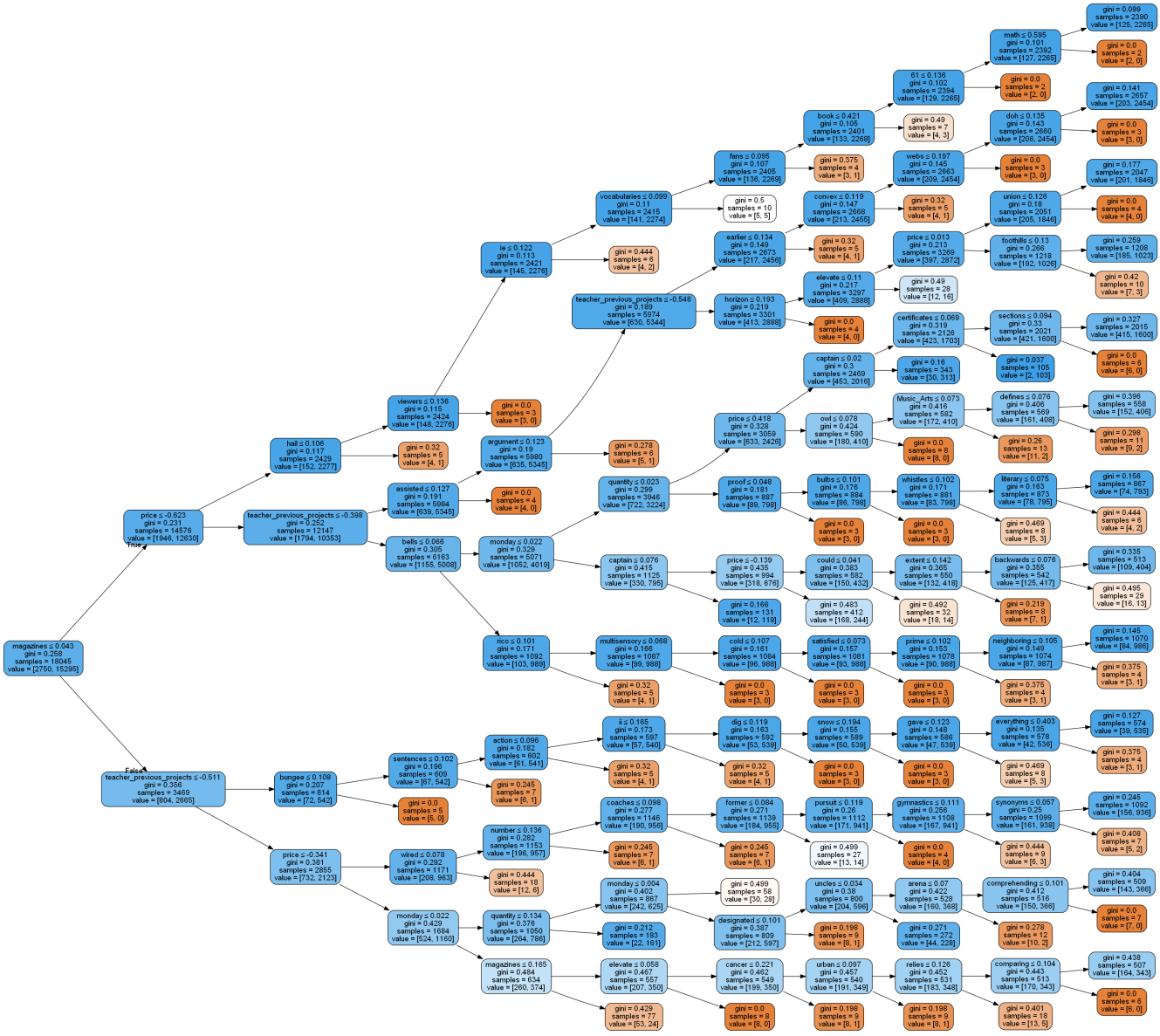
Graphviz visualization of Decision Tree on TFIDF,

In [250]:

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

```
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(model, out_file=dot_data, filled=True, rounded=True, special_characters=True, featu
re_names=feature_agg_tfidf,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[250]:



categorical, numerical features + project_title(avgw2v) + preprocessed_eassay (avgw2v)

In [251]:

```
from scipy.sparse import hstack

X_tr_w2v = hstack((train_avg_w2v_vectors,train_avg_w2v_vectors_title
,X_train_cat,X_train_clean_sub_ohe,X_train_school_state,X_train_project_grade_category,teacher_pref
ix_train,train_price,train_T,train_quantity)).tocsr()
X_te_w2v = hstack((test_avg_w2v_vectors,test_avg_w2v_vectors_title,X_test_cat,X_test_clean_sub_ohe
,X_test_school_state,X_test_project_grade_category,teacher_prefix_test,test_price,test_T,test_quant
ity)).tocsr()
X_cr_w2v =
hstack((cv_avg_w2v_vectors,cv_avg_w2v_vectors_title,X_cv_cat,X_cv_clean_sub_ohe,X_cv_school_state,
X_cv_project_grade_category,teacher_prefix_cv,cv_price,cv_T,cv_quantity )).tocsr()
```

In [252]:

```
print(X_tr_w2v.shape,y_train.shape)
print(X_te_w2v.shape,y_test.shape)
print(X_cr_w2v.shape,y_cv.shape)
```

```
(18045, 703) (18045,)
(19800, 703) (19800,)
(8889, 703) (8889,)
```

In [253]:

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

dtree_1 = DecisionTreeClassifier(class_weight = 'balanced')

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100],'min_samples_split':[5, 10,25,50 ,100,
500]}
```

In [254]:

```
clf_1 = GridSearchCV(dtree_1,parameters,cv =3,scoring = 'roc_auc',return_train_score = True)
clf_1 = clf_1.fit(X_tr_w2v,y_train)
```

In [255]:

```
train_auc= clf_1.cv_results_['mean_train_score']
train_auc_std= clf_1.cv_results_['std_train_score']
cv_auc = clf_1.cv_results_['mean_test_score']
cv_auc_std= clf_1.cv_results_['std_test_score']
```

In [256]:

```
train_auc
```

Out[256]:

```
array([0.54238082, 0.54238082, 0.54238082, 0.54238082, 0.54238082,
       0.54238082, 0.708934  , 0.70890139, 0.7076662 , 0.70555119,
       0.70417751, 0.69920751, 0.90056372, 0.89766371, 0.88405227,
       0.86524532, 0.84188546, 0.76119622, 0.99942231, 0.99859123,
       0.99044392, 0.97022733, 0.92440102, 0.77242169, 0.99997667,
       0.99954424, 0.99246208, 0.97412069, 0.92992868, 0.77234256,
       0.99997848, 0.99957559, 0.9927032 , 0.97405935, 0.92928808,
       0.7709239 , 0.99998202, 0.99957229, 0.99309466, 0.97427118,
       0.92929055, 0.77134032])
```

In [257]:

```
cv_auc
```

Out[257]:

```
array([0.53841546, 0.53841546, 0.53841546, 0.53841546, 0.53841546,
       0.53841546, 0.62669407, 0.62633913, 0.62637219, 0.62719785,
       0.6271088 , 0.62776234, 0.57325709, 0.57247223, 0.57412163,
       0.58397164, 0.5930578 , 0.61573643, 0.53226586, 0.53131817,
       0.5346599 , 0.55133898, 0.56427962, 0.6089345 , 0.5297918 ,
       0.53206127, 0.53120995, 0.54878809, 0.55479509, 0.6077172 ,
       0.53152411, 0.53172778, 0.53154098, 0.545086  , 0.55514055,
       0.61049044, 0.52816855, 0.52823414, 0.53324389, 0.54741246,
       0.55577658, 0.61021167])
```

In [258]:

```
print(clf_1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf_1.score(X_tr_w2v,y_train))
```

```
print(clf_1.score(X_te_w2v,y_test))
```

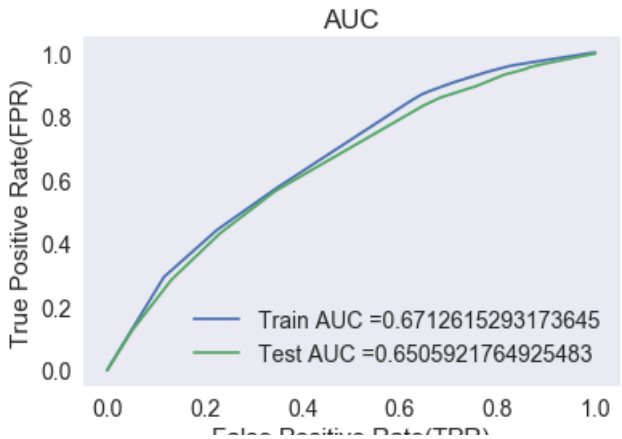
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6906166721150703
0.6511496310343555
```

In [259]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [291]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = DecisionTreeClassifier(max_depth = 5, min_samples_split = 500)

model.fit(X_tr_w2v, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr_w2v)
y_test_pred = batch_predict(model, X_te_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



False Positive Rate(TPR)

In [292]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global prediction
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    prediction= predictions
    return predictions
```

In [293]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2363747438016529 for threshold 0.848
[[ 1054  1696]
 [ 2390 12905]]
```

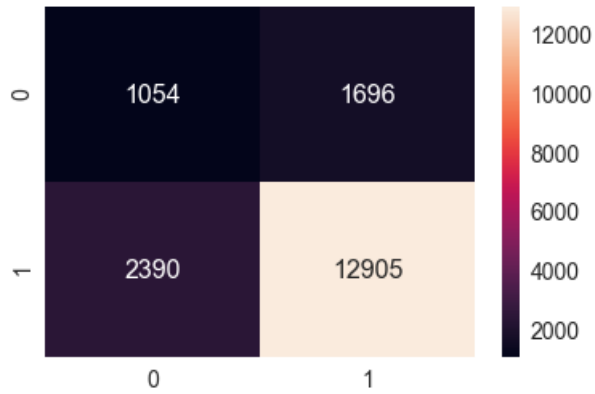
In [294]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.2363747438016529 for threshold 0.848
```

Out[294]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a61eb38978>
```



In [295]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.22786629021980334 for threshold 0.848
```

```
[[ 1060  1958]
 [ 2776 14006]]
```

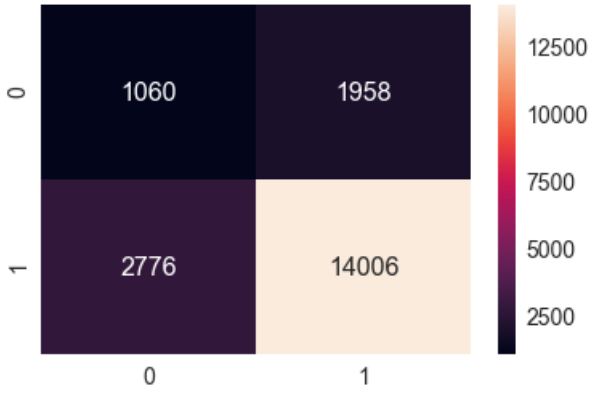
In [296]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.22786629021980334 for threshold 0.848
```

Out[296]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a62f4288d0>
```

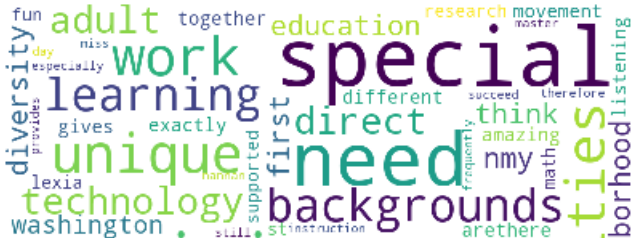


In [297]:

```
fpi = []
for i in range(len(y_test)):
    if (y_test.values[i] == 0 ) & (prediction[i] == 1):
        fpi.append(i)
fp_essay1 = []
for i in fpi:
    fp_essay1.append(X_test['essay'].values[i])
```

In [298]:

```
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
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,m
in_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



In [299]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)

  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

Out[299]:

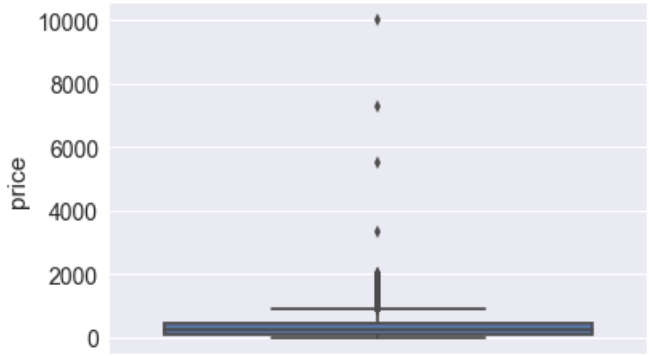
```
1958
```

In [300]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

Out[300]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a609f4a0f0>
```

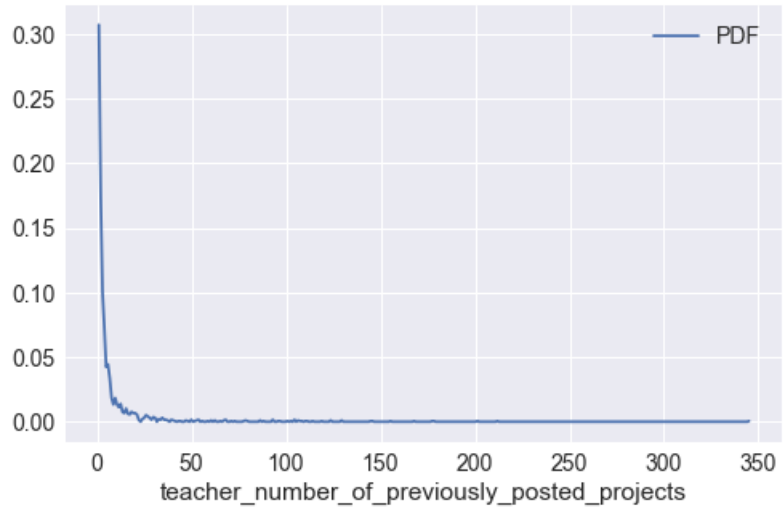


In [301]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
pdfP, = plt.plot(bin_edges[1:], pdf)
plt.legend([pdfP], ["PDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show
```

Out[301]:

```
<function matplotlib.pyplot.show(*args, **kw)>
```



categorical, numerical features + project_title(tfidfw2v) + preprocessed_eassay (tfidfw2v)

In [281]:

```
from scipy.sparse import hstack

X_tr_tfidf_w2v =
hstack((train_tfidf_w2v_vectors,train_title_tfidf_w2v_vectors,X_train_cat,X_train_clean_sub_ohe,X_
train_school_state,X_train_project_grade_category,teacher_prefix_train,train_price,train_T,train_qu
antity)).tocsr()
X_te_tfidf_w2v =
hstack((test_tfidf_w2v_vectors,test_title_tfidf_w2v_vectors,X_test_cat,X_test_clean_sub_ohe,X_test
_school_state,X_test_project_grade_category,teacher_prefix_test,test_price,test_T,test_quantity)).
tocsr()
X_cr_tfidf_w2v =
hstack((cv_tfidf_w2v_vectors,cv_title_tfidf_w2v_vectors,X_cv_cat,X_cv_clean_sub_ohe,X_cv_school_sta
te,X_cv_project_grade_category,teacher_prefix_cv,cv_price,cv_T,cv_quantity )).tocsr()
```

In [282]:

```
print(X_tr_tfidf_w2v.shape,y_train.shape)
print(X_te_tfidf_w2v.shape,y_test.shape)
print(X_cr_tfidf_w2v.shape,y_cv.shape)
```

```
(18045, 703) (18045,)
(19800, 703) (19800,)
(8889, 703) (8889,)
```

In [283]:

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

dtree_1 = DecisionTreeClassifier()

parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 100],'min_samples_split':[5, 10,25,50,75, 100,
500]}
```

In [284]:

```
clf_1 = GridSearchCV(dtree_1,parameters,cv =3,scoring = 'roc_auc',return_train_score = True)
clf_1 = clf_1.fit(X_tr_tfidf_w2v,y_train)
```

In [285]:

```
train_auc= clf_1.cv_results_['mean_train_score']
```

```
train_auc= clf_1.cv_results_['mean_train_score']
train_auc_std= clf_1.cv_results_['std_train_score']
cv_auc = clf_1.cv_results_['mean_test_score']
cv_auc_std= clf_1.cv_results_['std_test_score']
```

In [286]:

```
train_auc
```

Out[286]:

```
array([0.56292379, 0.56292379, 0.56292379, 0.56292379, 0.56292379,
       0.56292379, 0.56292379, 0.6943707 , 0.69417947, 0.69384581,
       0.69384581, 0.69362095, 0.69335795, 0.69163035, 0.82841211,
       0.82560028, 0.81494857, 0.80454927, 0.79499687, 0.78734389,
       0.74305078, 0.99934027, 0.99629327, 0.98205164, 0.96236654,
       0.94987596, 0.93570252, 0.82781397, 0.9993856 , 0.99613719,
       0.98264999, 0.96296557, 0.94835875, 0.93764882, 0.82712886,
       0.99943685, 0.99616422, 0.98204486, 0.96362612, 0.94810534,
       0.93557098, 0.82386668, 0.99941323, 0.99628128, 0.98238864,
       0.96279059, 0.94962418, 0.93667505, 0.82305803])
```

In [287]:

```
cv_auc
```

Out[287]:

```
array([0.55399008, 0.55399008, 0.55399008, 0.55399008, 0.55399008,
       0.55399008, 0.55399008, 0.62975775, 0.62950587, 0.62959902,
       0.62966322, 0.62959318, 0.62953531, 0.6300379 , 0.58468826,
       0.58799352, 0.59546342, 0.60179026, 0.60400734, 0.60996643,
       0.62485328, 0.52697357, 0.53724123, 0.54783463, 0.56063984,
       0.56316222, 0.56930013, 0.60366982, 0.53728793, 0.5370846 ,
       0.54659849, 0.55815559, 0.56752626, 0.56971124, 0.60731704,
       0.53544552, 0.53538144, 0.55169043, 0.56122973, 0.56777787,
       0.57682755, 0.60505248, 0.53616144, 0.5420731 , 0.54483868,
       0.55781683, 0.56395908, 0.57251037, 0.60365786])
```

In [288]:

```
print(clf_1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf_1.score(X_tr_tfidf_w2v,y_train))
print(clf_1.score(X_te_tfidf_w2v,y_test))
```

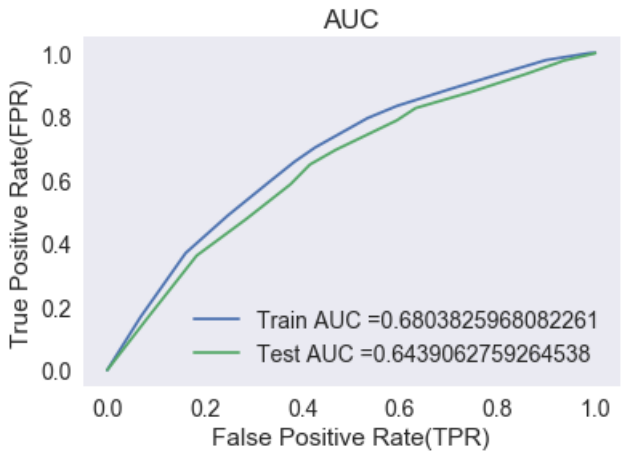
```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6803825968082261
0.6436017233902429
```

In [289]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [302]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = DecisionTreeClassifier(max_depth = 5, min_samples_split = 500)

model.fit(X_tr_tfidf_w2v, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr_tfidf_w2v)
y_test_pred = batch_predict(model, X_te_tfidf_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [303]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global prediction
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    prediction= predictions
    return predictions
```

In [304]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24890499173553718 for threshold 0.827
[[ 1284  1466]
 [ 3148 12147]]
```

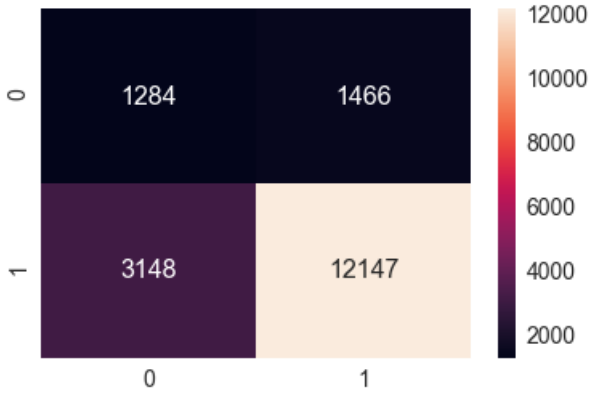
In [305]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24890499173553718 for threshold 0.827
```

Out[305]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a61e80cdd8>
```



In [306]:

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24896698887742685 for threshold 0.855
[[ 1606  1412]
 [ 5135 11647]]
```

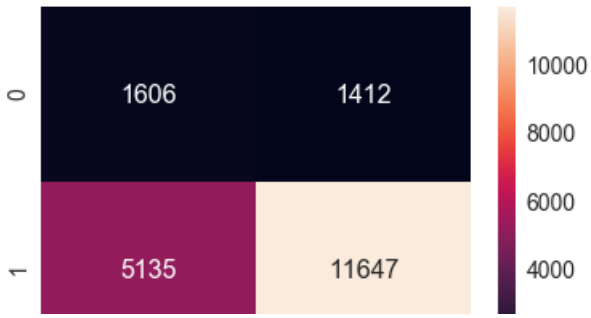
In [307]:

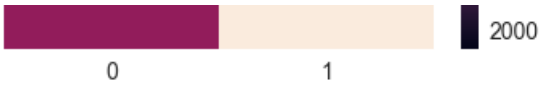
```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.24896698887742685 for threshold 0.855
```

Out[307]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a62d530d68>
```





In [308]:

```
fpi = []
for i in range(len(y_test)):
    if (y_test.values[i] == 0 ) & (prediction[i] == 1):
        fpi.append(i)
fp_essay1 = []
for i in fpi:
    fp_essay1.append(X_test['essay'].values[i])
```

In [309]:

```
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
    val = str(val)
    tokens = val.split()
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,m
in_font_size = 10).generate(comment_words)

plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

In [310]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
    X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

```
len(X_test_falsePos1)
```

Out[310]:

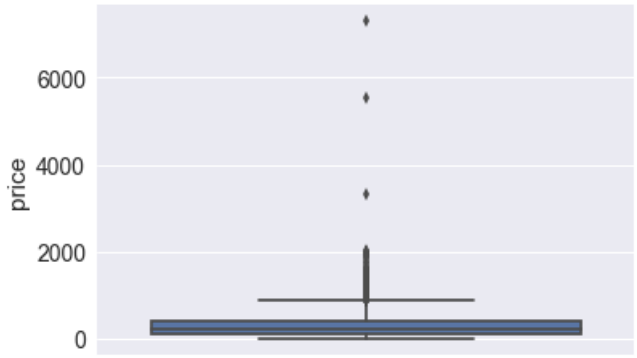
```
1412
```

In [311]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

Out[311]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2a609dd6588>
```

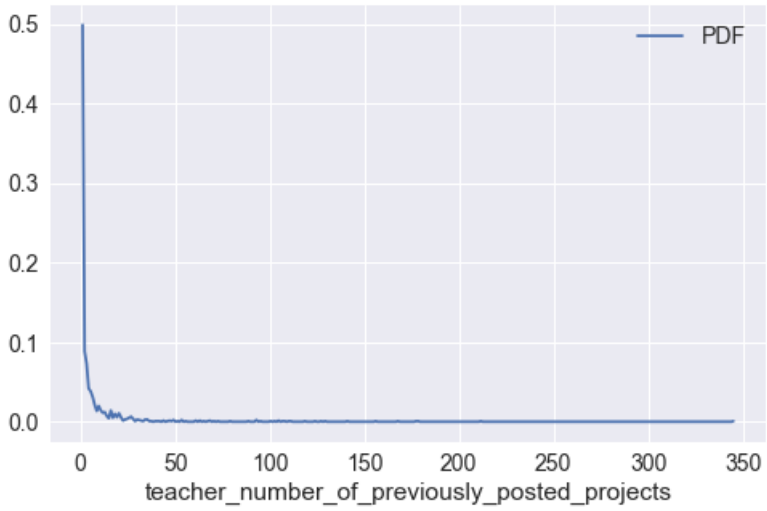


In [312]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
pdfP, = plt.plot(bin_edges[1:], pdf)
plt.legend([pdfP], ["PDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show
```

Out[312]:

```
<function matplotlib.pyplot.show(*args, **kw)>
```



3. Conclusion

In [313]:

```
# http://zetcode.com/python/prettytable/
```

```
from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameters(max depth,min samples split)", "Train AUC"
, "Test AUC"]

x.add_row(["BOW", "Decision Trees","(10, 100)", 0.711, 0.664])
x.add_row(["TFIDF", "Decision Trees", "(10, 500)", 0.729, 0.658])
x.add_row(["AVG W2V", "Decision Trees", "(5, 500)", 0.671, 0.650])
x.add_row(["TFIDF W2V", "Decision Trees", "(5, 50)", 0.680, 0.643])


print(x)
```

```
+------------+----------------+-----------------------------------------------+-----------+---------
| Vectorizer |     Model      | Hyperparameters(max depth,min samples split) | Train AUC | Test AUC
|
+------------+----------------+-----------------------------------------------+-----------+---------
|    BOW     | Decision Trees |                  (10, 100)                    |   0.711   |  0.664
|
|   TFIDF    | Decision Trees |                  (10, 500)                    |   0.729   |  0.658
|
|  AVG W2V   | Decision Trees |                   (5, 500)                    |   0.671   |   0.65
|
| TFIDF W2V  | Decision Trees |                   (5, 50)                     |    0.68   |  0.643
|
+------------+----------------+-----------------------------------------------+-----------+---------
```