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` • `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*

Feature	Description
`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."
- __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 [103]:

```
%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
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

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

import time
from tqdm import tqdm
import os
import pickle

from chart_studio 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 [104]:

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

In [105]:

```
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 (109248, 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 [106]:

```
# 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[106]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	

In [107]:

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

# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'quantity':'sum', 'price':'sum'}).reset_index()

# Join two data frames
project_data = pd.merge(project_data, price_data, on='id', how='left')
project_data.head(5)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
        id                                          description  quantity  \
0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
1  p069063         Bouncy Bands for Desks (Blue support pipes)         3

    price
0  149.00
1   14.95
```

Out[107]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subje
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	
2	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Grades PreK-2	Litera
3	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	A
4	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	Litera

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]))
```

1.3 Text preprocessing

In [110]:

```
# 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 [111]:

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

Out[111]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus

In [112]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [113]:

```
# 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])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
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.
==================================================
I teach high school English to students with learning and behavioral disabilities. My students all
vary in their ability level. However, the ultimate goal is to increase all students literacy level
s. This includes their reading, writing, and communication levels.I teach a really dynamic group o
f students. However, my students face a lot of challenges. My students all live in poverty and in
a dangerous neighborhood. Despite these challenges, I have students who have the the desire to def
```

a dangerous neighborhood. Despite these challenges, I have students who have the the desire to def
eat these challenges. My students all have learning disabilities and currently all are performing
below grade level. My students are visual learners and will benefit from a classroom that fulfills
their preferred learning style.The materials I am requesting will allow my students to be prepared
for the classroom with the necessary supplies. Too often I am challenged with students who come t
o school unprepared for class due to economic challenges. I want my students to be able to focus
on learning and not how they will be able to get school supplies. The supplies will last all year
. Students will be able to complete written assignments and maintain a classroom journal. The ch
art paper will be used to make learning more visual in class and to create posters to aid students
in their learning. The students have access to a classroom printer. The toner will be used to pr
int student work that is completed on the classroom Chromebooks.I want to try and remove all barri
ers for the students learning and create opportunities for learning. One of the biggest barriers i
s the students not having the resources to get pens, paper, and folders. My students will be able
to increase their literacy skills because of this project.
==========
\"Life moves pretty fast. If you don't stop and look around once in awhile, you could miss it.\"
from the movie, Ferris Bueller's Day Off. Think back...what do you remember about your
grandparents? How amazing would it be to be able to flip through a book to see a day in their
lives?My second graders are voracious readers! They love to read both fiction and nonfiction books
. Their favorite characters include Pete the Cat, Fly Guy, Piggie and Elephant, and Mercy Watson.
They also love to read about insects, space and plants. My students are hungry bookworms! My stude
nts are eager to learn and read about the world around them. My kids love to be at school and are
like little sponges absorbing everything around them. Their parents work long hours and usually do
not see their children. My students are usually cared for by their grandparents or a family
friend. Most of my students do not have someone who speaks English at home. Thus it is difficult f
or my students to acquire language.Now think forward... wouldn't it mean a lot to your kids,
nieces or nephews or grandchildren, to be able to see a day in your life today 30 years from now?
Memories are so precious to us and being able to share these memories with future generations will
be a rewarding experience. As part of our social studies curriculum, students will be learning ab
out changes over time. Students will be studying photos to learn about how their community has ch
anged over time. In particular, we will look at photos to study how the land, buildings,
clothing, and schools have changed over time. As a culminating activity, my students will capture
a slice of their history and preserve it through scrap booking. Key important events in their
young lives will be documented with the date, location, and names. Students will be using photos
from home and from school to create their second grade memories. Their scrap books will preserve
their unique stories for future generations to enjoy.Your donation to this project will provide my
second graders with an opportunity to learn about social studies in a fun and creative manner. Th
rough their scrapbooks, children will share their story with others and have a historical document
for the rest of their lives.
==========
\"A person's a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the bi
ggest enthusiasm for learning. My students learn in many different ways using all of our senses an
d multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nSt
udents in my class come from a variety of different backgrounds which makes for wonderful sharing
of experiences and cultures, including Native Americans.\r\nOur school is a caring community of su
ccessful learners which can be seen through collaborative student project based learning in and ou
t of the classroom. Kindergarteners in my class love to work with hands-on materials and have many
different opportunities to practice a skill before it is mastered. Having the social skills to wor
k cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the
perfect place to learn about agriculture and nutrition. My students love to role play in our
pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try coo
king with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we
learn important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it's healthy for their bodies. This project w
ould expand our learning of nutrition and agricultural cooking recipes by having us peel our own a
pples to make homemade applesauce, make our own bread, and mix up healthy plants from our classroo
m garden in the spring. We will also create our own cookbooks to be printed and shared with famili
es. \r\nStudents will gain math and literature skills as well as a life long enjoyment for healthy
cooking.nannan
==========
My classroom consists of twenty-two amazing sixth graders from different cultures and backgrounds.
They are a social bunch who enjoy working in partners and working with groups. They are hard-worki
ng and eager to head to middle school next year. My job is to get them ready to make this
transition and make it as smooth as possible. In order to do this, my students need to come to
school every day and feel safe and ready to learn. Because they are getting ready to head to
middle school, I give them lots of choice- choice on where to sit and work, the order to complete
assignments, choice of projects, etc. Part of the students feeling safe is the ability for them to
come into a welcoming, encouraging environment. My room is colorful and the atmosphere is casual.
I want them to take ownership of the classroom because we ALL share it together. Because my time w
ith them is limited, I want to ensure they get the most of this time and enjoy it to the best of t
heir abilities.Currently, we have twenty-two desks of differing sizes, yet the desks are similar t
o the ones the students will use in middle school. We also have a kidney table with crates for sea
ting. I allow my students to choose their own spots while they are working independently or in
groups. More often than not, most of them move out of their desks and onto the crates. Believe it
or not, this has proven to be more successful than making them stay at their desks! It is because
of this that I am looking toward the “Flexible Seating” option for my classroom.\r\n The students
look forward to their work time so they can move around the room. I would like to get rid of the c

look forward to their work time so they can move around the room. I would like to get rid of the c
onstricting desks and move toward more “fun” seating options. I am requesting various seating so m
y students have more options to sit. Currently, I have a stool and a papasan chair I inherited fro
m the previous sixth-grade teacher as well as five milk crate seats I made, but I would like to gi
ve them more options and reduce the competition for the “good seats”. I am also requesting two rug
s as not only more seating options but to make the classroom more welcoming and appealing. In orde
r for my students to be able to write and complete work without desks, I am requesting a class set
of clipboards. Finally, due to curriculum that requires groups to work together, I am requesting t
ables that we can fold up when we are not using them to leave more room for our flexible seating o
ptions.\r\nI know that with more seating options, they will be that much more excited about coming
to school! Thank you for your support in making my classroom one students will remember
forever!nannan
==

In [114]:

```
# 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 [115]:

```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

\"A person is a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the b
iggest enthusiasm for learning. My students learn in many different ways using all of our senses a
nd multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nS
tudents in my class come from a variety of different backgrounds which makes for wonderful sharing
of experiences and cultures, including Native Americans.\r\nOur school is a caring community of su
ccessful learners which can be seen through collaborative student project based learning in and ou
t of the classroom. Kindergarteners in my class love to work with hands-on materials and have many
different opportunities to practice a skill before it is mastered. Having the social skills to wor
k cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the
perfect place to learn about agriculture and nutrition. My students love to role play in our
pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try coo
king with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we
learn important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies. This project
would expand our learning of nutrition and agricultural cooking recipes by having us peel our own
apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro
om garden in the spring. We will also create our own cookbooks to be printed and shared with famil
ies. \r\nStudents will gain math and literature skills as well as a life long enjoyment for health
y cooking.nannan
==

In [116]:

```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

 A person is a person, no matter how small. (Dr.Seuss) I teach the smallest students with the big
gest enthusiasm for learning. My students learn in many different ways using all of our senses and

multiple intelligences. I use a wide range of techniques to help all my students succeed. Students in my class come from a variety of different backgrounds which makes for wonderful sharing of experiences and cultures, including Native Americans. Our school is a caring community of successful learners which can be seen through collaborative student project based learning in a nd out of the classroom. Kindergarteners in my class love to work with hands-on materials and have many different opportunities to practice a skill before it is mastered. Having the social skills t o work cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the perfect place to learn about agriculture and nutrition. My students love to role play in our p retend kitchen in the early childhood classroom. I have had several kids ask me, Can we try cooki ng with REAL food? I will take their idea and create Common Core Cooking Lessons where we learn important math and writing concepts while cooking delicious healthy food for snack time. My students will have a grounded appreciation for the work that went into making the food and knowled ge of where the ingredients came from as well as how it is healthy for their bodies. This project would expand our learning of nutrition and agricultural cooking recipes by having us peel our own apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro om garden in the spring. We will also create our own cookbooks to be printed and shared with famil ies.   Students will gain math and literature skills as well as a life long enjoyment for healthy cooking.nannan

In [117]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

 A person is a person no matter how small Dr Seuss I teach the smallest students with the biggest enthusiasm for learning My students learn in many different ways using all of our senses and multi ple intelligences I use a wide range of techniques to help all my students succeed Students in my class come from a variety of different backgrounds which makes for wonderful sharing of experiences and cultures including Native Americans Our school is a caring community of successful learners which can be seen through collaborative student project based learning in and out of the classroom Kindergarteners in my class love to work with hands on materials and have many different opportunities to practice a skill before it is mastered Having the social skills to work cooperatively with friends is a crucial aspect of the kindergarten curriculum Montana is the perfect place to learn about agriculture and nutrition My students love to role play in our pretend kitchen in the early childhood classroom I have had several kids ask me Can we try cooking with REAL food I will take their idea and create Common Core Cooking Lessons where we learn important math and writing concepts while cooking delicious healthy food for snack time My students will have a grounded appreciation for the work that went into making the food and knowled ge of where the ingredients came from as well as how it is healthy for their bodies This project w ould expand our learning of nutrition and agricultural cooking recipes by having us peel our own a pples to make homemade applesauce make our own bread and mix up healthy plants from our classroom garden in the spring We will also create our own cookbooks to be printed and shared with families Students will gain math and literature skills as well as a life long enjoyment for healthy cooking nannan

In [118]:

```
# 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',\
```

```
"mightn't", "must",\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [119]:

```
# Create function that will filter sentance
def filterSentance(sentance):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    sent = sent.lower()
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    return sent.strip()
```

In [120]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    preprocessed_essays.append(filterSentance(sentance))
```

```
100%|██████████| 109248/109248 [00:56<00:00, 1940.32it/s]
```

In [121]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[121]:

```
'person person no matter small dr seuss teach smallest students biggest enthusiasm learning
students learn many different ways using senses multiple intelligences use wide range techniques h
elp students succeed students class come variety different backgrounds makes wonderful sharing exp
eriences cultures including native americans school caring community successful learners seen coll
aborative student project based learning classroom kindergarteners class love work hands materials
many different opportunities practice skill mastered social skills work cooperatively friends cruc
ial aspect kindergarten curriculum montana perfect place learn agriculture nutrition students love
role play pretend kitchen early childhood classroom several kids ask try cooking real food take id
ea create common core cooking lessons learn important math writing concepts cooking delicious heal
thy food snack time students grounded appreciation work went making food knowledge ingredients cam
e well healthy bodies project would expand learning nutrition agricultural cooking recipes us peel
apples make homemade applesauce make bread mix healthy plants classroom garden spring also create
cookbooks printed shared families students gain math literature skills well life long enjoyment he
althy cooking nannan'
```

1.4 Preprocessing of `project_title`

In [122]:

```
# similarly you can preprocess the titles also
# Combining all the above stundents
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    preprocessed_titles.append(filterSentance(sentance))
```

```
100%|██████████| 109248/109248 [00:02<00:00, 36613.25it/s]
```

In [123]:

```
# after preprocessing
```

```
print(preprocessed_titles[20000])
```

```
health nutritional cooking kindergarten
```

In [124]:

```
# similarly you can preprocess the project_resource_summary also
# Combining all the above stundents
from tqdm import tqdm
preprocessed_resource_summary = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_resource_summary'].values):
    preprocessed_resource_summary.append(filterSentance(sentance))
```

```
100%|██████████| 109248/109248 [00:05<00:00, 20559.73it/s]
```

In [125]:

```
# after preprocessing
print(preprocessed_resource_summary[20000])
```

```
students need cooking supplies help us healthy learn nutrition mixer apple spiralizer kitchen
tools nutrition kit kid friendly healthy literature ink make cookbooks
```

In [126]:

```
# Preprocess teacher_prefix
from tqdm import tqdm
preprocessed_teacher_prefix = []
# tqdm is for printing the status bar
for teacher_prefix in tqdm(project_data['teacher_prefix'].values):
    teacher_prefix = str(teacher_prefix)
    clean_teacher_prefix = decontracted(teacher_prefix)
    clean_teacher_prefix = clean_teacher_prefix.replace('\\r', ' ')
    clean_teacher_prefix = clean_teacher_prefix.replace('\\"', ' ')
    clean_teacher_prefix = clean_teacher_prefix.replace('\\n', ' ')
    clean_teacher_prefix = re.sub('[^A-Za-z0-9]+', ' ', clean_teacher_prefix)
    clean_teacher_prefix = clean_teacher_prefix.lower()
    if clean_teacher_prefix in stopwords:
        continue
    preprocessed_teacher_prefix.append(clean_teacher_prefix.strip())
```

```
100%|██████████| 109248/109248 [00:01<00:00, 83062.34it/s]
```

In [127]:

```
preprocessed_teacher_prefix[0:10]
```

Out[127]:

```
['mrs', 'ms', 'mrs', 'mrs', 'mrs', 'mrs', 'mrs', 'ms', 'ms', 'mrs']
```

In [128]:

```
# Preprocess project_grade_category
from tqdm import tqdm
preprocessed_project_grade_category = []
# tqdm is for printing the status bar
for project_grade_category in tqdm(project_data['project_grade_category'].values):
    project_grade_category = str(project_grade_category)
    clean_project_grade_category = decontracted(project_grade_category)
    clean_project_grade_category = clean_project_grade_category.replace('\\r', ' ')
    clean_project_grade_category = clean_project_grade_category.replace('\\"', ' ')
    clean_project_grade_category = clean_project_grade_category.replace('\\n', ' ')
    clean_project_grade_category = re.sub('[^A-Za-z0-9]+', ' ', clean_project_grade_category)
    clean_project_grade_category = clean_project_grade_category.lower()
    if clean_project_grade_category in stopwords:
        continue
    clean_project_grade_category = clean_project_grade_category.strip()
```

```
#     whitespace are creating problems because we are treating this as categorical feature
    preprocessed_project_grade_category.append(clean_project_grade_category.replace(' ', '_'))
```

```
100%|██████████| 109248/109248 [00:01<00:00, 81320.94it/s]
```

In [129]:

```
preprocessed_project_grade_category[0:10]
```

Out[129]:

```
['grades_prek_2',
 'grades_3_5',
 'grades_prek_2',
 'grades_prek_2',
 'grades_3_5',
 'grades_3_5',
 'grades_3_5',
 'grades_3_5',
 'grades_prek_2',
 'grades_3_5']
```

In [130]:

```
# Replace original columns with preprocessed column values
project_data['clean_essays'] = preprocessed_essays
project_data['clean_titles'] = preprocessed_titles
project_data['project_resource_summary'] = preprocessed_resource_summary
project_data['teacher_prefix'] = preprocessed_teacher_prefix
project_data['project_grade_category'] = preprocessed_project_grade_category
# Drop essays column
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
```

In [131]:

```
project_data.head(5)
```

Out[131]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	mrs	CA	2016-04-27 00:27:36	grades_prek_2	Engineering STEAM into the Primary Classroom
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	ms	UT	2016-04-27 00:31:25	grades_3_5	Sensory Tools for Focus
2	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	mrs	CA	2016-04-27 00:46:53	grades_prek_2	Mobile Learning with a Mobile Listening Center
3	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	mrs	GA	2016-04-27 00:53:00	grades_prek_2	Flexible Seating for Flexible Learning
4	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	mrs	WA	2016-04-27 01:05:25	grades_3_5	Going Deep: The Art of Inner Thinking!

In [132]:

```
project_data.tail(5)
```

Out[132]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	projec
109243	45036	p194916	29cf137e5a40b0f141d9fd7898303a5c	mrs	HI	2017-04-30 23:11:45	grades_9_12	Na F Pro
109244	12610	p162971	22fee80f2078c694c2d244d3ecb1c390	ms	NM	2017-04-30 23:23:24	grades_prek_2	Op Organ
109245	179833	p096829	c8c81a73e29ae3bdd4140be8ad0bea00	mrs	IL	2017-04-30 23:25:42	grades_3_5	B Agri Sustai t
109246	13791	p184393	65545a295267ad9df99f26f25c978fd0	mrs	HI	2017-04-30 23:27:07	grades_9_12	M N
109247	124250	p028318	1fff5a88945be8b2c728c6a85c31930f	mrs	CA	2017-04-30 23:45:08	grades_prek_2	Ne

In [133]:

```
print(set(preprocessed_project_grade_category))
```

```
{'grades_3_5', 'grades_prek_2', 'grades_6_8', 'grades_9_12'}
```

In [134]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna('null')
```

In [135]:

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

Out[135]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	mrs	CA	2016-04-27 00:27:36	grades_prek_2	Engineering STEAM into the Primary Classroom
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	ms	UT	2016-04-27 00:31:25	grades_3_5	Sensory Tools for Focus

Unnamed:	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title

1.5 Preparing data for models

In [136]:

```
project_data.columns
```

Out[136]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'quantity', 'price', 'clean_categories', 'clean_subcategories', 'essay',
       'clean_essays', 'clean_titles'],
      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

In [137]:

```
print(project_data.shape)

# I am taking 100% of data points for my analysis
project_data = project_data.sample(frac=1)

print(project_data.shape)
```

```
(109248, 18)
(109248, 18)
```

In [138]:

```
# Splitting data
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
X = project_data
project_data.shape
```

Out[138]:

```
(109248, 17)
```

In [139]:

```
# Split Train, CV and Test data
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)

print('Train Data Set', X_train.shape, y_train.shape)
print('Cross Validate Data Set', X_cv.shape, y_cv.shape)
```

```
print('Test Data Set', X_test.shape, y_test.shape)
```

```
Train Data Set (49041, 17) (49041,)
Cross Validate Data Set (24155, 17) (24155,)
Test Data Set (36052, 17) (36052,)
```

In [140]:

```
# Commented code as per your suggestion
# # Handle imblanced data set
# from imblearn.over_sampling import RandomOverSampler
# from collections import Counter

# ros = RandomOverSampler(sampling_strategy='minority', random_state=42)
# X_train, y_train = ros.fit_resample(X_train, y_train)
# print('Resampled Dataset Shape %s ' %Counter(y_train))

# X_train = pd.DataFrame(X_train, columns=X.columns)
# X_train.head(2)
```

In [141]:

```
print('Train Data Set', X_train.shape, y_train.shape)
print('Cross Validate Data Set', X_cv.shape, y_cv.shape)
print('Test Data Set', X_test.shape, y_test.shape)
print('*'*100)
```

```
Train Data Set (49041, 17) (49041,)
Cross Validate Data Set (24155, 17) (24155,)
Test Data Set (36052, 17) (36052,)
****************************************************************************************************
```

1.5.1 Vectorizing Categorical data

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

In [142]:

```
# One hot encoding of Categorical Feature
# - school_state : categorical data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values)# Fit has to happen only on train data

X_train_school_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_school_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_school_state_ohe = vectorizer.transform(X_test['school_state'].values)

school_state_features = vectorizer.get_feature_names()

print(X_train_school_state_ohe.shape, y_train.shape)
print(X_cv_school_state_ohe.shape, y_cv.shape)
print(X_test_school_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print('*'*100)
```

```
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm',
'nv', 'ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv
', 'wy']
****************************************************************************************************
```

In [143]:

```
# One hot encoding of Categorical Feature
# - clean_categories : categorical data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values)# Fit has to happen only on train data

X_train_clean_categories_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_clean_categories_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_clean_categories_ohe = vectorizer.transform(X_test['clean_categories'].values)

clean_categories_features = vectorizer.get_feature_names()

print(X_train_clean_categories_ohe.shape, y_train.shape)
print(X_cv_clean_categories_ohe.shape, y_cv.shape)
print(X_test_clean_categories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print('*'*100)
```

```
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language',
'math_science', 'music_arts', 'specialneeds', 'warmth']
****************************************************************************************************
```

In [144]:

```
# One hot encoding of Categorical Feature
# - clean_subcategories : categorical data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values)# Fit has to happen only on train data

X_train_clean_subcategories_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_clean_subcategories_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_clean_subcategories_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

clean_subcategories_features = vectorizer.get_feature_names()

print(X_train_clean_subcategories_ohe.shape, y_train.shape)
print(X_cv_clean_subcategories_ohe.shape, y_cv.shape)
print(X_test_clean_subcategories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print('*'*100)
```

```
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience',
'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness',
'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'm
athematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socia
lsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
****************************************************************************************************
```

In [145]:

```
print(X_train['project_grade_category'])
# One hot encoding of Categorical Feature
# - project_grade_category : categorical data
# Convert one hot encoding for project grade category
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values)# Fit has to happen only on train data

X_train_project_grade_category_ohe = vectorizer.transform(X_train['project_grade_category'].values
)
X_cv_project_grade_category_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_project_grade_category_ohe = vectorizer.transform(X_test['project_grade_category'].values)

project_grade_category_features = vectorizer.get_feature_names()

print(X_train_project_grade_category_ohe.shape, y_train.shape)
print(X_cv_project_grade_category_ohe.shape, y_cv.shape)
```

```
print(X_test_project_grade_category_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print('*'*100)
```

```
74657     grades_prek_2
46445        grades_6_8
73937       grades_9_12
19663       grades_9_12
19450     grades_prek_2
4297      grades_prek_2
56194        grades_6_8
41135     grades_prek_2
10082     grades_prek_2
45539        grades_3_5
105852       grades_3_5
53343     grades_prek_2
28322     grades_prek_2
53781        grades_3_5
15710        grades_3_5
56558     grades_prek_2
30472        grades_3_5
106717       grades_3_5
99527        grades_3_5
62392        grades_3_5
40877     grades_prek_2
52082        grades_3_5
80008     grades_prek_2
62168     grades_prek_2
78813     grades_prek_2
39710        grades_6_8
4181      grades_prek_2
76169        grades_3_5
23059     grades_prek_2
21656     grades_prek_2
              ...
29539     grades_prek_2
4878         grades_3_5
64470        grades_3_5
103162       grades_6_8
25085     grades_prek_2
14998     grades_prek_2
106699       grades_3_5
57677     grades_prek_2
66270     grades_prek_2
88707       grades_9_12
8551         grades_6_8
97604        grades_6_8
32271     grades_prek_2
65708        grades_3_5
78587     grades_prek_2
79981     grades_prek_2
27745     grades_prek_2
370          grades_3_5
79772     grades_prek_2
39033        grades_6_8
42122     grades_prek_2
39551        grades_6_8
71793        grades_6_8
84579     grades_prek_2
81071        grades_3_5
8314        grades_9_12
44980        grades_6_8
79623     grades_prek_2
69907        grades_3_5
28974     grades_prek_2
Name: project_grade_category, Length: 49041, dtype: object
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
****************************************************************************************************
```

In [146]:

```
print(X_train_project_grade_category_ohe.toarray())
```

```
[[0 0 0 1]
 [0 1 0 0]
 [0 0 1 0]
 ...
 [0 0 0 1]
 [1 0 0 0]
 [0 0 0 1]]
```

In [147]:

```
# One hot encoding of Categorical Feature
# - teacher_prefix : categorical data
print(X_train['teacher_prefix'])
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)# Fit has to happen only on train data

X_train_teacher_prefix_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_clean_teacher_prefix_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_clean_teacher_prefix_ohe = vectorizer.transform(X_test['teacher_prefix'].values)

teacher_prefix_features = vectorizer.get_feature_names()

print(X_train_teacher_prefix_ohe.shape, y_train.shape)
print(X_cv_clean_teacher_prefix_ohe.shape, y_cv.shape)
print(X_test_clean_teacher_prefix_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print('*'*100)
```

```
74657         mrs
46445          ms
73937          ms
19663         mrs
19450         mrs
4297           ms
56194          mr
41135         mrs
10082         mrs
45539         mrs
105852         mr
53343          ms
28322         mrs
53781          ms
15710          ms
56558         mrs
30472          ms
106717        mrs
99527          ms
62392         mrs
40877         mrs
52082         mrs
80008         mrs
62168          ms
78813         mrs
39710          ms
4181           ms
76169          ms
23059         mrs
21656     teacher
          ...
29539         mrs
4878          mrs
64470         mrs
103162         ms
25085         mrs
14998          ms
106699        mrs
57677          ms
66270         mrs
88707          mr
8551           ms
97604         mrs
32271          ms
65708         mrs
```

```
78587          mrs
79981          mrs
27745          mrs
370            mrs
79772           ms
39033           mr
42122          mrs
39551          mrs
71793           ms
84579           ms
81071           mr
8314           mrs
44980          mrs
79623          mrs
69907          mrs
28974           ms
Name: teacher_prefix, Length: 49041, dtype: object
(49041, 6) (49041,)
(24155, 6) (24155,)
(36052, 6) (36052,)
['dr', 'mr', 'mrs', 'ms', 'nan', 'teacher']
**************************************************************************************************
```

In [148]:

```
print(X_train_teacher_prefix_ohe.toarray())
```

```
[[0 0 1 0 0 0]
 [0 0 0 1 0 0]
 [0 0 0 1 0 0]
 ...
 [0 0 1 0 0 0]
 [0 0 1 0 0 0]
 [0 0 0 1 0 0]]
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [149]:

```
# # Sample code for bigram extraction using TFIDF
# from sklearn.feature_extraction.text import TfidfVectorizer
# corpus = [
#     'This is the first document.',
#     'This document is the second document.',
#     'And this is the third one.',
#     'Is this the first document?',
# ]
# vectorizer = TfidfVectorizer(ngram_range=(2,2))
# X = vectorizer.fit_transform(corpus)
# print(vectorizer.get_feature_names())

# print(X.shape)
```

In [150]:

```
# - project_title : text data
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['clean_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['clean_titles'].values)
```

```
X_train_title_bow = vectorizer.transform(X_train['clean_titles'].values)
X_cv_title_bow = vectorizer.transform(X_cv['clean_titles'].values)
X_test_title_bow = vectorizer.transform(X_test['clean_titles'].values)

clean_titles_bow_features = vectorizer.get_feature_names()

print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
# print(vectorizer.get_feature_names())
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
(49041, 3418) (49041,)
(24155, 3418) (24155,)
(36052, 3418) (36052,)
****************************************************************************************************
```

In [151]:

```
# - text : text data
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['clean_essays'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['clean_essays'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['clean_essays'].values)
X_test_essay_bow = vectorizer.transform(X_test['clean_essays'].values)

easy_bow_features = vectorizer.get_feature_names()

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
# print(vectorizer.get_feature_names())
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
****************************************************************************************************
```

In [152]:

```
# - project_resource_summary: text data (optinal)
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

# We are considering only the words which appeared in at least 10 documents(rows or projects).
```

```
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['project_resource_summary'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_resource_summary_bow = vectorizer.transform(X_train['project_resource_summary'].va
lues)
X_cv_project_resource_summary_bow = vectorizer.transform(X_cv['project_resource_summary'].values)
X_test_project_resource_summary_bow =
vectorizer.transform(X_test['project_resource_summary'].values)

project_resource_summary_bow_features = vectorizer.get_feature_names()

print("After vectorizations")
print(X_train_project_resource_summary_bow.shape, y_train.shape)
print(X_cv_project_resource_summary_bow.shape, y_cv.shape)
print(X_test_project_resource_summary_bow.shape, y_test.shape)
# print(vectorizer.get_feature_names())
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
****************************************************************************************************
```

1.5.2.2 TFIDF vectorizer

In [153]:

```
# - project_title : text data
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['clean_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['clean_titles'].values)
X_cv_title_tfidf = vectorizer.transform(X_cv['clean_titles'].values)
X_test_title_tfidf = vectorizer.transform(X_test['clean_titles'].values)

clean_titles_tfidf_features = vectorizer.get_feature_names()

print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_cv_title_tfidf.shape, y_test.shape)
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
(49041, 1996) (49041,)
(24155, 1996) (24155,)
(24155, 1996) (36052,)
****************************************************************************************************
```

In [154]:

```
# - text : text data
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = TfidfVectorizer(min_df=10)#, ngram_range=(2,2), max_features=5000
vectorizer.fit(X_train['clean_essays'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer.transform(X_train['clean_essays'].values)
X_cv_essay_tfidf = vectorizer.transform(X_cv['clean_essays'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['clean_essays'].values)

easy_tfidf_features = vectorizer.get_feature_names()

print("After vectorizations")
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)
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
(49041, 12036) (49041,)
(24155, 12036) (24155,)
(36052, 12036) (36052,)
****************************************************************************************************
```

In [155]:

```
# - project_resource_summary: text data (optinal)
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("*"*100)

from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['project_resource_summary'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_resource_summary_tfidf = vectorizer.transform(X_train['project_resource_summary'].
values)
X_cv_project_resource_summary_tfidf = vectorizer.transform(X_cv['project_resource_summary'].values
)
X_test_project_resource_summary_tfidf =
vectorizer.transform(X_test['project_resource_summary'].values)

project_resource_summary_tfidf_features = vectorizer.get_feature_names()

print("After vectorizations")
print(X_train_project_resource_summary_tfidf.shape, y_train.shape)
print(X_cv_project_resource_summary_tfidf.shape, y_cv.shape)
print(X_test_project_resource_summary_tfidf.shape, y_test.shape)
print("*"*100)
```

```
(49041, 17) (49041,)
(24155, 17) (24155,)
(36052, 17) (36052,)
****************************************************************************************************

After vectorizations
```

```
(49041, 3854) (49041,)
(24155, 3854) (24155,)
(36052, 3854) (36052,)
**********************************************************************************************************
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [156]:

```
'''
# 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[156]:

```
'\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 [157]:

```
# 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', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [158]:

```
# average Word2Vec for train text
# compute average word2vec for each review.
avg_w2v_vectors_text_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_text_train.append(vector)

print(len(avg_w2v_vectors_text_train))
print(len(avg_w2v_vectors_text_train[0]))
```

```
100%|██████████| 49041/49041 [00:11<00:00, 4109.10it/s]
```

```
49041
300
```

In [159]:

```
# average Word2Vec for CV text
# compute average word2vec for each review.
avg_w2v_vectors_text_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_text_cv.append(vector)

print(len(avg_w2v_vectors_text_cv))
print(len(avg_w2v_vectors_text_cv[0]))
```

```
100%|██████████| 24155/24155 [00:06<00:00, 3855.15it/s]
```

```
24155
300
```

In [160]:

```
# average Word2Vec for test text
# compute average word2vec for each review.
avg_w2v_vectors_text_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_text_test.append(vector)

print(len(avg_w2v_vectors_text_test))
print(len(avg_w2v_vectors_text_test[0]))
```

```
100%|██████████| 36052/36052 [00:09<00:00, 3963.99it/s]
```

```
36052
300
```

In [161]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_title_train.append(vector)

print(len(avg_w2v_vectors_title_train))
print(len(avg_w2v_vectors_title_train[0]))
```

```
100%|██████████| 49041/49041 [00:00<00:00, 87129.20it/s]
```

```
49041
300
```

In [162]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_title_cv.append(vector)

print(len(avg_w2v_vectors_title_cv))
print(len(avg_w2v_vectors_title_cv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 86474.85it/s]
```

```
24155
300
```

In [163]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_title_test.append(vector)

print(len(avg_w2v_vectors_title_test))
print(len(avg_w2v_vectors_title_test[0]))
```

```
100%|██████████| 36052/36052 [00:00<00:00, 87711.81it/s]
```

```
36052
300
```

In [164]:

```
# Similarly you can vectorize for project_resource_summary also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_project_resource_summary_train = []; # the avg-w2v for each sentence/review is sto
red in this list
for sentence in tqdm(X_train['project_resource_summary']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_resource_summary_train.append(vector)

print(len(avg_w2v_vectors_project_resource_summary_train))
print(len(avg_w2v_vectors_project_resource_summary_train[0]))
```

```
100%|██████████| 49041/49041 [00:01<00:00, 39726.65it/s]
```

```
49041
300
```

In [165]:

```
# Similarly you can vectorize for project_resource_summary also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_project_resource_summary_cv = []; # the avg-w2v for each sentence/review is stored
in this list
for sentence in tqdm(X_cv['project_resource_summary']): # for each review/sentence
```

```
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_resource_summary_cv.append(vector)

print(len(avg_w2v_vectors_project_resource_summary_cv))
print(len(avg_w2v_vectors_project_resource_summary_cv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 39537.82it/s]
```

```
24155
300
```

In [166]:

```
# Similarly you can vectorize for project_resource_summary also
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_project_resource_summary_test = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm(X_test['project_resource_summary']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_resource_summary_test.append(vector)

print(len(avg_w2v_vectors_project_resource_summary_test))
print(len(avg_w2v_vectors_project_resource_summary_test[0]))
```

```
100%|██████████| 36052/36052 [00:01<00:00, 30623.75it/s]
```

```
36052
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(X_train['clean_essays'])
# 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.
tfidf_w2v_vectors_text_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
```

```
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_text_train.append(vector)

print(len(tfidf_w2v_vectors_text_train))
print(len(tfidf_w2v_vectors_text_train[0]))
```

```
100%|██████████| 49041/49041 [01:46<00:00, 460.31it/s]
```

```
49041
300
```

In [169]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_text_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_text_cv.append(vector)

print(len(tfidf_w2v_vectors_text_cv))
print(len(tfidf_w2v_vectors_text_cv[0]))
```

```
100%|██████████| 24155/24155 [00:50<00:00, 479.28it/s]
```

```
24155
300
```

In [170]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_text_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_text_test.append(vector)

print(len(tfidf_w2v_vectors_text_test))
print(len(tfidf_w2v_vectors_text_test[0]))
```

```
100%|██████████| 36052/36052 [01:14<00:00, 482.25it/s]
```

```
36052
300
```

In [171]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_titles'])
# 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 [172]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_train.append(vector)

print(len(tfidf_w2v_vectors_title_train))
print(len(tfidf_w2v_vectors_title_train[0]))
```

```
100%|██████████| 49041/49041 [00:01<00:00, 26915.61it/s]
```

```
49041
300
```

In [173]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_cv.append(vector)

print(len(tfidf_w2v_vectors_title_cv))
```

```
print(len(tfidf_w2v_vectors_title_cv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 30066.45it/s]
```

```
24155
300
```

In [174]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_test.append(vector)

print(len(tfidf_w2v_vectors_title_test))
print(len(tfidf_w2v_vectors_title_test[0]))
```

```
100%|██████████| 36052/36052 [00:01<00:00, 32306.80it/s]
```

```
36052
300
```

In [175]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['project_resource_summary'])
# 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 [176]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_project_resource_summary_train = []; # the avg-w2v for each sentence/review is s
tored in this list
for sentence in tqdm(X_train['project_resource_summary']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_resource_summary_train.append(vector)
```

```
print(len(tfidf_w2v_vectors_project_resource_summary_train))
print(len(tfidf_w2v_vectors_project_resource_summary_train[0]))
```

```
100%|██████████| 49041/49041 [00:05<00:00, 9170.30it/s]
```

```
49041
300
```

In [177]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_project_resource_summary_cv = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm(X_cv['project_resource_summary']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_resource_summary_cv.append(vector)

print(len(tfidf_w2v_vectors_project_resource_summary_cv))
print(len(tfidf_w2v_vectors_project_resource_summary_cv[0]))
```

```
100%|██████████| 24155/24155 [00:02<00:00, 8335.50it/s]
```

```
24155
300
```

In [178]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_project_resource_summary_test = []; # the avg-w2v for each sentence/review is st
ored in this list
for sentence in tqdm(X_test['project_resource_summary']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_resource_summary_test.append(vector)

print(len(tfidf_w2v_vectors_project_resource_summary_test))
print(len(tfidf_w2v_vectors_project_resource_summary_test[0]))
```

```
100%|██████████| 36052/36052 [00:04<00:00, 7844.75it/s]
```

```
36052
300
```

1.5.3 Vectorizing Numerical features

In [179]:

```
# You no need to perform standardization/normalization on numerical data,
# because you will classify data by using gini impurity in decision tree classifier.
# - quantity : numerical (optional)

X_train_quantity_norm = X_train['quantity'].values.reshape(-1,1)
X_cv_quantity_norm = X_cv['quantity'].values.reshape(-1,1)
X_test_quantity_norm = X_test['quantity'].values.reshape(-1,1)

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

In [180]:

```
# You no need to perform standardization/normalization on numerical data,
# because you will classify data by using gini impurity in decision tree classifier.
# One hot encoding of numerical feature
# - teacher_number_of_previously_posted_projects : numerical
X_train_teacher_number_of_previously_posted_projects_norm =
X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
X_cv_teacher_number_of_previously_posted_projects_norm =
X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
X_test_teacher_number_of_previously_posted_projects_norm =
X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)

print("After vectorizations")
print(X_train_teacher_number_of_previously_posted_projects_norm.shape, y_train.shape)
print(X_cv_teacher_number_of_previously_posted_projects_norm.shape, y_cv.shape)
print(X_test_teacher_number_of_previously_posted_projects_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

In [181]:

```
# You no need to perform standardization/normalization on numerical data,
# because you will classify data by using gini impurity in decision tree classifier.
# - price : numerical

X_train_price_norm = X_train['price'].values.reshape(-1,1)
X_cv_price_norm = X_cv['price'].values.reshape(-1,1)
X_test_price_norm = X_test['price'].values.reshape(-1,1)

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
==========================================================================================================
```

1.5.4 Merging all the above features

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

In [182]:

```
# print(categories_one_hot.shape)
# print(sub_categories_one_hot.shape)
# print(text_bow.shape)
# print(price_standardized.shape)
print('Categorical Features')
print('*'*100)
print(X_train_school_state_ohe.shape, y_train.shape)
print(X_cv_school_state_ohe.shape, y_cv.shape)
print(X_test_school_state_ohe.shape, y_test.shape)
print('*'*100)
print(X_train_clean_categories_ohe.shape, y_train.shape)
print(X_cv_clean_categories_ohe.shape, y_cv.shape)
print(X_test_clean_categories_ohe.shape, y_test.shape)
print('*'*100)
print(X_train_clean_subcategories_ohe.shape, y_train.shape)
print(X_cv_clean_subcategories_ohe.shape, y_cv.shape)
print(X_test_clean_subcategories_ohe.shape, y_test.shape)
print('*'*100)
print(X_train_project_grade_category_ohe.shape, y_train.shape)
print(X_cv_project_grade_category_ohe.shape, y_cv.shape)
print(X_test_project_grade_category_ohe.shape, y_test.shape)
print('*'*100)
print(X_train_teacher_prefix_ohe.shape, y_train.shape)
print(X_cv_clean_teacher_prefix_ohe.shape, y_cv.shape)
print(X_test_clean_teacher_prefix_ohe.shape, y_test.shape)
print('*'*100)
print('Text Encoding Features')
print('*'*100)
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
print('*'*100)
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print('*'*100)
print(X_train_project_resource_summary_bow.shape, y_train.shape)
print(X_cv_project_resource_summary_bow.shape, y_cv.shape)
print(X_test_project_resource_summary_bow.shape, y_test.shape)
print('*'*100)
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_cv_title_tfidf.shape, y_test.shape)
print('*'*100)
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)
print('*'*100)
print(X_train_project_resource_summary_tfidf.shape, y_train.shape)
print(X_cv_project_resource_summary_tfidf.shape, y_cv.shape)
print(X_test_project_resource_summary_tfidf.shape, y_test.shape)
print('*'*100)
print(len(avg_w2v_vectors_text_train))
print(len(avg_w2v_vectors_text_train[0]))
print('*'*100)
print(len(avg_w2v_vectors_text_cv))
print(len(avg_w2v_vectors_text_cv[0]))
print('*'*100)
print(len(avg_w2v_vectors_text_test))
```

```
print(len(avg_w2v_vectors_text_test[0]))
print('*'*100)
print(len(avg_w2v_vectors_title_train))
print(len(avg_w2v_vectors_title_train[0]))
print('*'*100)
print(len(avg_w2v_vectors_title_cv))
print(len(avg_w2v_vectors_title_cv[0]))
print('*'*100)
print(len(avg_w2v_vectors_title_test))
print(len(avg_w2v_vectors_title_test[0]))
print('*'*100)
print(len(avg_w2v_vectors_project_resource_summary_train))
print(len(avg_w2v_vectors_project_resource_summary_train[0]))
print('*'*100)
print(len(avg_w2v_vectors_project_resource_summary_cv))
print(len(avg_w2v_vectors_project_resource_summary_cv[0]))
print('*'*100)
print(len(avg_w2v_vectors_project_resource_summary_test))
print(len(avg_w2v_vectors_project_resource_summary_test[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_text_train))
print(len(tfidf_w2v_vectors_text_train[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_text_cv))
print(len(tfidf_w2v_vectors_text_cv[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_text_test))
print(len(tfidf_w2v_vectors_text_test[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_title_train))
print(len(tfidf_w2v_vectors_title_train[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_title_cv))
print(len(tfidf_w2v_vectors_title_cv[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_title_test))
print(len(tfidf_w2v_vectors_title_test[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_project_resource_summary_train))
print(len(tfidf_w2v_vectors_project_resource_summary_train[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_project_resource_summary_cv))
print(len(tfidf_w2v_vectors_project_resource_summary_cv[0]))
print('*'*100)
print(len(tfidf_w2v_vectors_project_resource_summary_test))
print(len(tfidf_w2v_vectors_project_resource_summary_test[0]))
print('*'*100)
print('Numerical Features')
print('*'*100)
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print('*'*100)
print(X_train_teacher_number_of_previously_posted_projects_norm.shape, y_train.shape)
print(X_cv_teacher_number_of_previously_posted_projects_norm.shape, y_cv.shape)
print(X_test_teacher_number_of_previously_posted_projects_norm.shape, y_test.shape)
print('*'*100)
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
```

```
Categorical Features
****************************************************************************************************

(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
****************************************************************************************************

(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
****************************************************************************************************

(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
```

(36052, 30) (36052,)
****

(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
****

(49041, 6) (49041,)
(24155, 6) (24155,)
(36052, 6) (36052,)
****

Text Encoding Features
****

(49041, 3418) (49041,)
(24155, 3418) (24155,)
(36052, 3418) (36052,)
****

(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
****

(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
****

(49041, 1996) (49041,)
(24155, 1996) (24155,)
(24155, 1996) (36052,)
****

(49041, 12036) (49041,)
(24155, 12036) (24155,)
(36052, 12036) (36052,)
****

(49041, 3854) (49041,)
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49041
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**********************************************************************************************************

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Numerical Features
**********************************************************************************************************

(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
**********************************************************************************************************

(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
**********************************************************************************************************

(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [183]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
# X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
# X.shape

X_train_real = X_train
X_cv_real = X_cv
X_test_real = X_test

X_train = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, X
_train_title_bow, X_train_essay_bow, X_train_project_resource_summary_bow, X_train_title_tfidf,
X_train_essay_tfidf, X_train_project_resource_summary_tfidf, avg_w2v_vectors_text_train,
avg_w2v_vectors_title_train, avg_w2v_vectors_project_resource_summary_train,
tfidf_w2v_vectors_text_train, tfidf_w2v_vectors_title_train,
```

```
tfidf_w2v_vectors_project_resource_summary_train, X_train_quantity_norm,
X_train_teacher_number_of_previously_posted_projects_norm, X_train_price_norm)).tocsr()
X_cv = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe, X_cv_clean_subcategories_ohe,
X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe, X_cv_title_bow, X_cv_essay_bow, X_c
v_project_resource_summary_bow, X_cv_title_tfidf, X_cv_essay_tfidf,
X_cv_project_resource_summary_tfidf, avg_w2v_vectors_text_cv, avg_w2v_vectors_title_cv,
avg_w2v_vectors_project_resource_summary_cv, tfidf_w2v_vectors_text_cv, tfidf_w2v_vectors_title_cv
, tfidf_w2v_vectors_project_resource_summary_cv, X_cv_quantity_norm,
X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr()
X_test = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
,X_test_title_bow, X_test_essay_bow, X_test_project_resource_summary_bow, X_test_title_tfidf,
X_test_essay_tfidf, X_test_project_resource_summary_tfidf, avg_w2v_vectors_text_test,
avg_w2v_vectors_title_test, avg_w2v_vectors_project_resource_summary_test,
tfidf_w2v_vectors_text_test, tfidf_w2v_vectors_title_test,
tfidf_w2v_vectors_project_resource_summary_test, X_test_quantity_norm,
X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)).tocsr()

print(X_train_real.shape)
print(X_cv_real.shape)
print(X_test_real.shape)
print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
```

```
(49041, 17)
(24155, 17)
(36052, 17)
(49041, 33207)
(24155, 33207)
(36052, 33207)
```

Computing Sentiment Scores

In [184]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students w
ith the biggest enthusiasm \
for learning my students learn in many different ways using all of our senses and multiple intelli
gences i use a wide range\
of techniques to help all my students succeed students in my class come from a variety of differen
t backgrounds which makes\
for wonderful sharing of experiences and cultures including native americans our school is a carin
g community of successful \
learners which can be seen through collaborative student project based learning in and out of the
classroom kindergarteners \
in my class love to work with hands on materials and have many different opportunities to practice
a skill before it is\
mastered having the social skills to work cooperatively with friends is a crucial aspect of the ki
ndergarten curriculum\
montana is the perfect place to learn about agriculture and nutrition my students love to role pla
y in our pretend kitchen\
in the early childhood classroom i have had several kids ask me can we try cooking with real food
i will take their idea \
and create common core cooking lessons where we learn important math and writing concepts while co
oking delicious healthy \
food for snack time my students will have a grounded appreciation for the work that went into maki
ng the food and knowledge \
of where the ingredients came from as well as how it is healthy for their bodies this project woul
d expand our learning of \
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade apple
sauce make our own bread \
and mix up healthy plants from our classroom garden in the spring we will also create our own cook
books to be printed and \
shared with families students will gain math and literature skills as well as a life long enjoymen
t for healthy cooking \
nannan'
```

```
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
neg: 0.01, neu: 0.745, pos: 0.245, compound: 0.9975,
```

Assignment 8: DT

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **Hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**
    - Find the best hyper parameter which will give the maximum AUC value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning
3. **Graphviz**
    - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
    - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
    - Make sure to print the words in each node of the decision tree instead of printing its index.
    - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.
4. **Representation of results**
    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
    - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points
    - Once after you plot the confusion matrix with the test data, get all the `false positive data points`
        - Plot the WordCloud WordCloud
        - Plot the box plot with the `price` of these `false positive data points`
        - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`
5. **[Task-2]**
    - Select 5k best features from features of Set 2 using`feature_importances_`, discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3
6. **Conclusion**
    - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakage, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data

3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

2. Decision Tree

Note: I already completed steps 2.1, 2.2 & 2.3 previously, So I didn't copy code in below cells.

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

In [185]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [186]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [187]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4 Appling Decision Tree on different kind of featurization as mentioned in the instructions

Apply Decision Tree on different kind of featurization as mentioned in the instructions
For Every model that you work on make sure you do the step 2 and step 3 of instrucations

In [188]:

```
#function to get heatmap confusion matrix
def get_confusion_matrix(clf,X_te,y_test):
```

```
def get_confusion_matrix(clf,X_te,y_test):
    y_pred = clf.predict(X_te)
    df_cm = pd.DataFrame(confusion_matrix(y_test, y_pred), range(2),range(2))
    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})
    sns.set(font_scale=1.4)#for label size
    sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')
```

In [189]:

```
# function to collect prediction

def collect_prediction(prob, threshould, fpr, tpr):
    predictions = []
    t = threshould[np.argmax(fpr*(1-tpr))]
    for i in prob:
        if(i>=t):
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [190]:

```
# function to collect fpr
def collect_fpr(y_test, predictions):
    fpr = []
    for i in range(len(y_test)):
        if(y_test[i] == 0 and predictions[i]==1):
            fpr.append(i)
    return fpr
```

2.4.1 Applying Decision Trees on BOW, SET 1

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

In [91]:

```
%%time
# Please write all the code with proper documentation

# Prepare data for BOW
X_train_bow = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, X
_train_title_bow, X_train_essay_bow, X_train_project_resource_summary_bow, X_train_quantity_norm,
X_train_teacher_number_of_previously_posted_projects_norm, X_train_price_norm)).tocsr()
X_cv_bow = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe, X_cv_clean_subcategories_ohe,
X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe, X_cv_title_bow, X_cv_essay_bow, X_c
v_project_resource_summary_bow, X_cv_quantity_norm,
X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr()
X_test_bow = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
,X_test_title_bow, X_test_essay_bow, X_test_project_resource_summary_bow, X_test_quantity_norm,
X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)).tocsr()

print(X_train_bow.shape, y_train.shape)
print(X_cv_bow.shape, y_cv.shape)
print(X_test_bow.shape, y_test.shape)

import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import learning_curve, GridSearchCV

dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_train_bow, y_train)
```

```
(49041, 13523) (49041,)
(24155, 13523) (24155,)
(36052, 13523) (36052,)
```

```
CPU times: user 6.8 s, sys: 520 ms, total: 7.32 s
Wall time: 14min 34s
```

Out[91]:

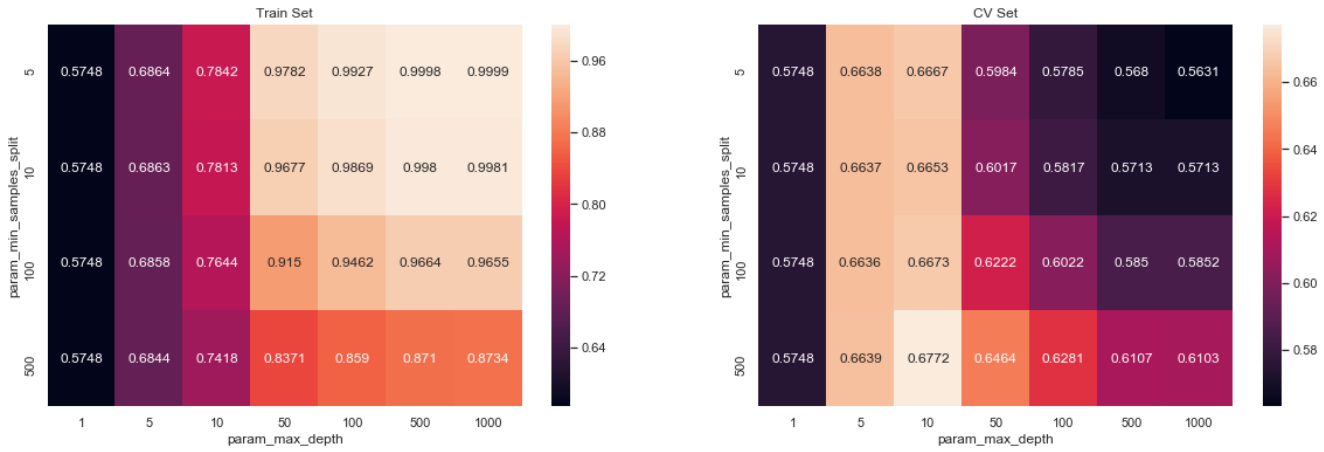
```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort=False, random_state=None,
                                              splitter='best'),
             iid='warn', n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50, 100, 500, 1000],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [92]:

```
# Print results
# clf.cv_results_
```

In [93]:

```
# Find best hyper parameter max_depth and min_samples_split
import seaborn as sns; sns.set()
max_scores = pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split', 'param_max_depth'])
.max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [94]:

```
# Print params
print(clf.best_estimator_)
print(clf.score(X_train_bow, y_train))
print(clf.score(X_test_bow, 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')
0.7372286968456021
```

0.6813805833398057

In [95]:

```
max_depth = 10
min_samples_split = 500
```

In [96]:

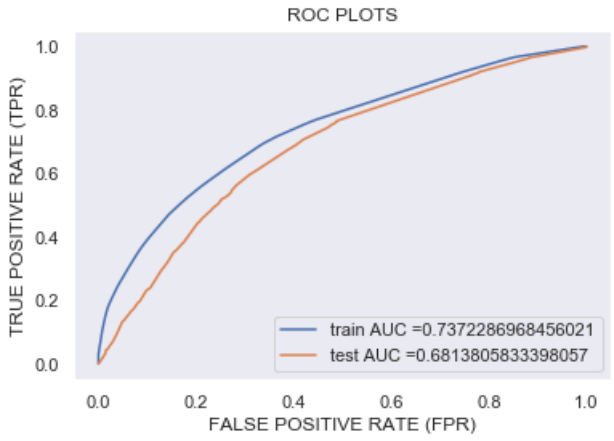
```
%%time

# Create ROC Plot for Test Set
parameters = {'max_depth':[max_depth], 'min_samples_split':[min_samples_split]}
dt=GridSearchCV(DecisionTreeClassifier(class_weight='balanced', max_depth=max_depth,
min_samples_split=min_samples_split), parameters, cv=3, scoring='roc_auc', n_jobs=-1,
return_train_score=True)
dt.fit(X_train_bow, y_train);

y_train_pred = clf.predict_proba(X_train_bow)[:,1]
y_test_pred = clf.predict_proba(X_test_bow)[:,1]

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 (FPR)")
plt.ylabel("TRUE POSITIVE RATE (TPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

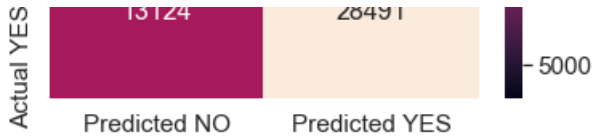


CPU times: user 6.17 s, sys: 178 ms, total: 6.35 s
Wall time: 10.5 s

In [97]:

```
%%time
get_confusion_matrix(dt,X_train_bow,y_train)
```

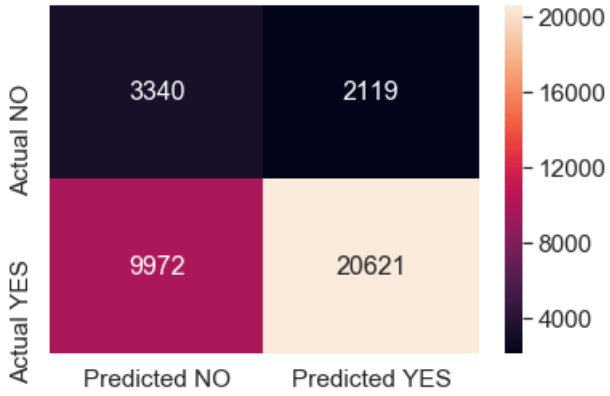
CPU times: user 405 ms, sys: 187 ms, total: 592 ms
Wall time: 506 ms



In [98]:

```
%%time
get_confusion_matrix(dt,X_test_bow,y_test)
```

```
CPU times: user 210 ms, sys: 21.6 ms, total: 232 ms
Wall time: 141 ms
```



2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [99]:

```
# Collect all features name and create graph of features

features_bow = school_state_features + clean_categories_features + clean_subcategories_features + p
roject_grade_category_features + teacher_prefix_features + clean_titles_bow_features +
easy_bow_features + \
project_resource_summary_bow_features
features_bow.append('quantity')
features_bow.append('price')
features_bow.append('teacher_number_of_previously_posted_projects')

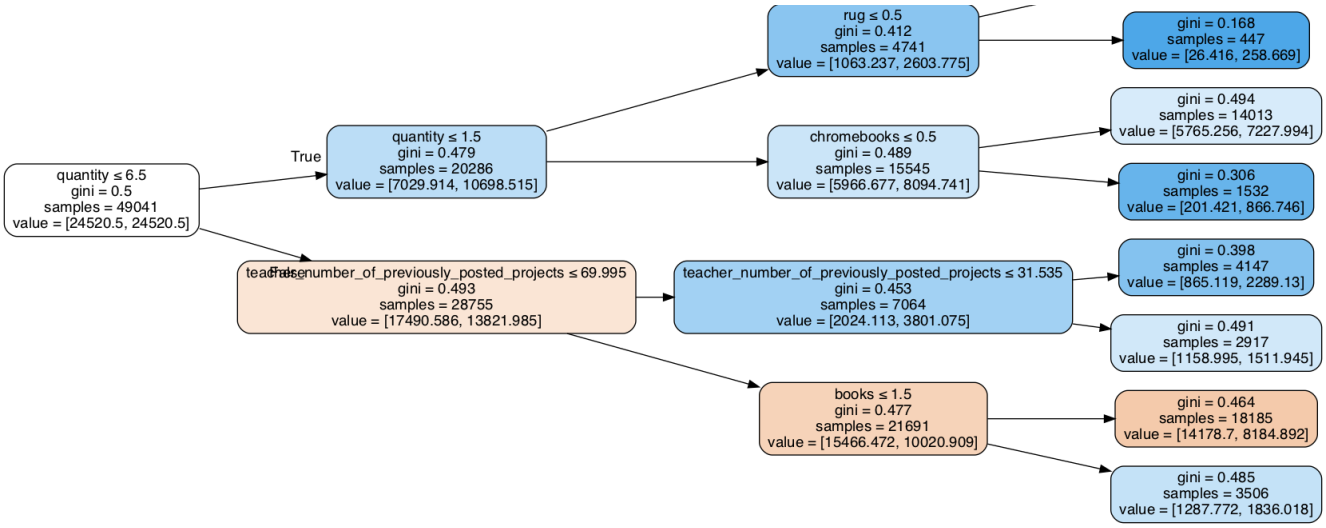
dt=DecisionTreeClassifier(class_weight='balanced', max_depth=3,
min_samples_split=min_samples_split)
dt.fit(X_train_bow, y_train);
```

In [100]:

```
%%time
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(dt, out_file=dot_data, feature_names=features_bow, filled=True, rounded=True, speci
al_characters=True, rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
CPU times: user 144 ms, sys: 22.5 ms, total: 167 ms
Wall time: 976 ms
```

Out[100]:



In [195]:

```
# Collect false positive data

predictions = collect_prediction(y_test_pred, te_thresholds, test_fpr, test_tpr)

# train_fpr, train_tpr, tr_thresholds
fpr = collect_fpr(y_test, predictions)

essay = X_test_real['clean_essays'].to_frame()
essay = essay.reset_index()

price = X_test_real['price'].to_frame()
price = price.reset_index()

teacher_number_of_previously_posted_projects =
X_test_real['teacher_number_of_previously_posted_projects'].to_frame()
teacher_number_of_previously_posted_projects =
teacher_number_of_previously_posted_projects.reset_index()

flase_essays = []
false_price = []
false_teacher_number_of_previously_posted_projects = []
for i in fpr:
    flase_essays.append(essay.values[i][1:][0])
    false_price.append(price.values[i][1:][0])

false_teacher_number_of_previously_posted_projects.append(teacher_number_of_previously_posted_proje
ts.values[i][1:][0])

# print(len(flase_essays), len(false_price),
len(false_teacher_number_of_previously_posted_projects))
```

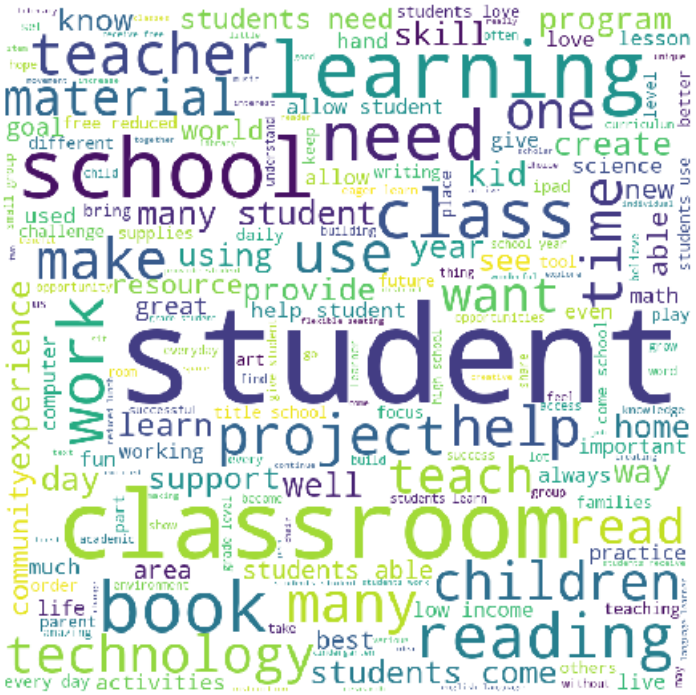
In [266]:

```
# create world cloud
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in flase_essays:
    val = str(val)
    val = val.lower()
    tokens = val.split()
    for words in tokens:
        if(words == 'nan' or words == 'nannan'):
            continue
        comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_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()
```

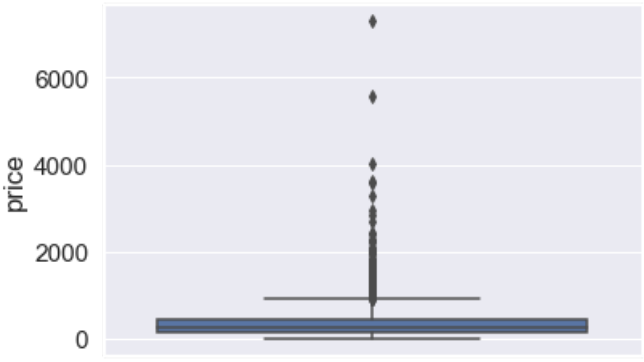


In [197]:

```
# Plot the box plot with the `price` of these `false positive data points`
df1 = pd.DataFrame({'price':false_price})
sns.boxplot(y='price', data=df1)
```

Out[197]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a321f8a90>
```



In [209]:

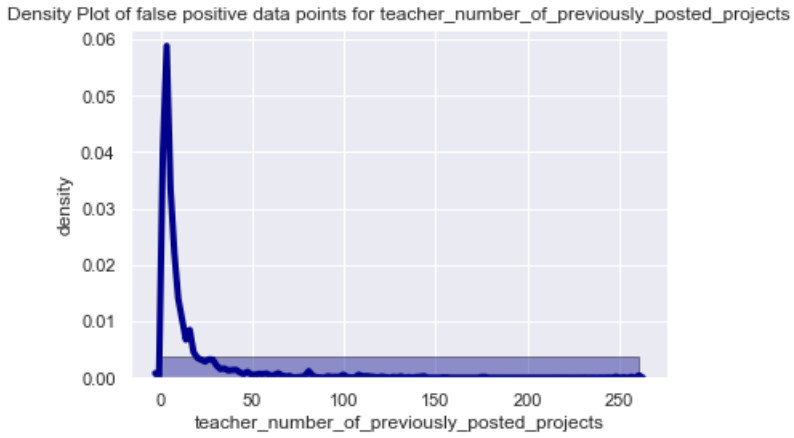
```
# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
ta points`
sns.distplot(false_teacher_number_of_previously_posted_projects, hist=True, kde=True,
             bins=1, color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4})

plt.title('Density Plot of false positive data points for
teacher_number_of_previously_posted_projects')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.ylabel('density')
plt.show()

# plt.figure(figsize=(8,5))
# counts, bin_edges = np.histogram(false_teacher_number_of_previously_posted_projects,
bins='auto', density=True)
# pdf = counts/sum(counts)
# cdf = np.cumsum(pdf)
```

```
# cdf = np.cumsum(pdf)

# pdfP, = plt.plot(bin_edges[1:], pdf)
# cdfP, = plt.plot(bin_edges[1:], cdf)
# plt.legend([pdfP, cdfP], ["PDF", "CDF"])
# plt.xlabel('teacher_number_of_previously_posted_projects')
# plt.show()
```



2.4.2 Applying Decision Trees on TFIDF, SET 2

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

In [210]:

```
%%time
# Please write all the code with proper documentation
# Prepare data for TFIDF
X_train_tfidf = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, X
_train_title_tfidf, X_train_essay_tfidf, X_train_project_resource_summary_tfidf,
X_train_quantity_norm, X_train_teacher_number_of_previously_posted_projects_norm,
X_train_price_norm)).tocsr()
X_cv_tfidf = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe,
X_cv_clean_subcategories_ohe, X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe,
X_cv_title_tfidf, X_cv_essay_tfidf, X_cv_project_resource_summary_tfidf, X_cv_quantity_norm,
X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr()
X_test_tfidf = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
, X_test_title_tfidf, X_test_essay_tfidf, X_test_project_resource_summary_tfidf,
X_test_quantity_norm, X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)
).tocsr()

print(X_train_tfidf.shape)
print(X_cv_tfidf.shape)
print(X_test_tfidf.shape)


import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import learning_curve, GridSearchCV

dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_train_tfidf, y_train)
```

```
(49041, 17989)
(24155, 17989)
(36052, 17989)
CPU times: user 9.72 s, sys: 513 ms, total: 10.2 s
Wall time: 17min 40s
```

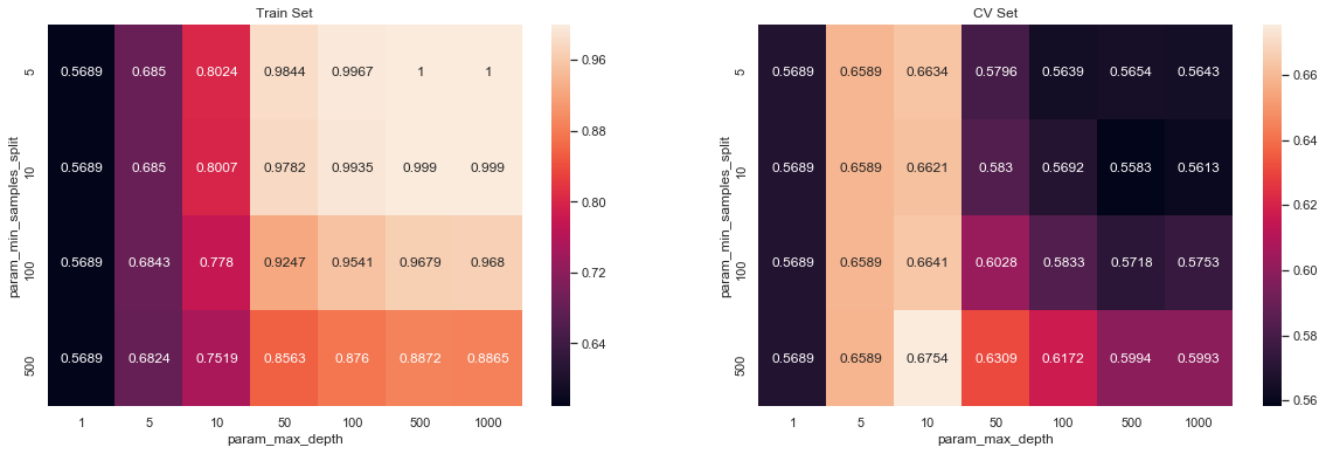
Out[210]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
```

```
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort=False, random_state=None,
                                              splitter='best'),
             iid='warn', n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50, 100, 500, 1000],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [211]:

```
# Find best hyper parameter max_depth and min_samples_split
import seaborn as sns; sns.set()
max_scores = pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split', 'param_max_depth'])
.max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [213]:

```
# Print params
print(clf.best_estimator_)
print(clf.score(X_train_tfidf, y_train))
print(clf.score(X_test_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')
0.745306991334485
0.6828680971675787
```

In [214]:

```
max_depth = 10
min_samples_split = 500
```

In [215]:

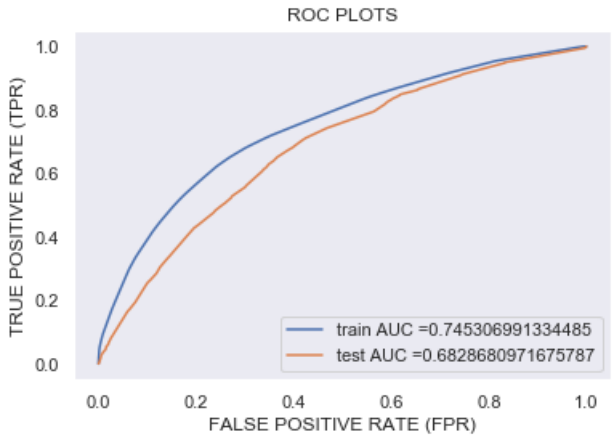
```
%%time
```

```
# Create ROC Plot for Test Set
parameters = {'max_depth':[max_depth], 'min_samples_split':[min_samples_split]}
dt=GridSearchCV(DecisionTreeClassifier(class_weight='balanced', max_depth=max_depth,
min_samples_split=min_samples_split), parameters, cv=3, scoring='roc_auc', n_jobs=-1,
return_train_score=True)
dt.fit(X_train_tfidf, y_train);

y_train_pred = clf.predict_proba(X_train_tfidf)[:,1]
y_test_pred = clf.predict_proba(X_test_tfidf)[:,1]

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 (FPR)")
plt.ylabel("TRUE POSITIVE RATE (TPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

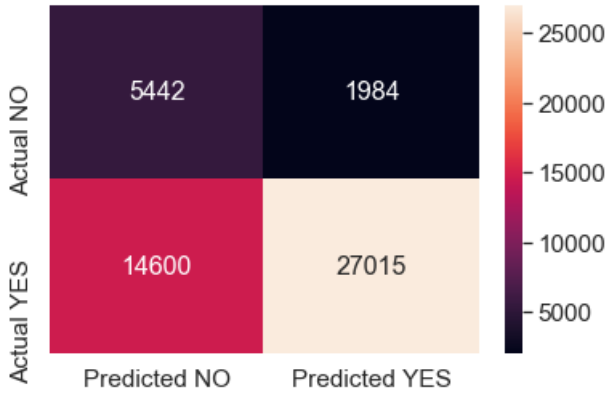



```
CPU times: user 9.51 s, sys: 167 ms, total: 9.68 s
Wall time: 17.9 s
```

In [216]:

```
%%time
get_confusion_matrix(dt,X_train_tfidf,y_train)
```

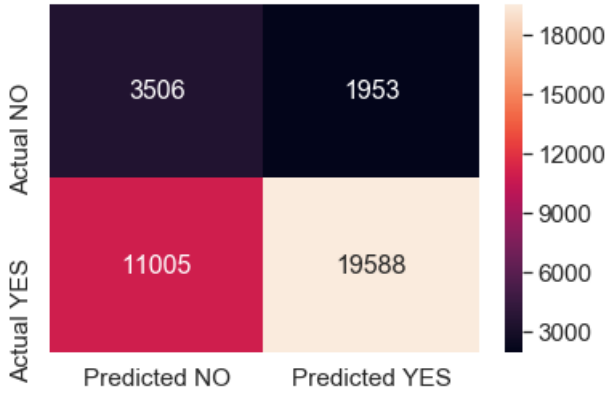
```
CPU times: user 224 ms, sys: 11.9 ms, total: 236 ms
Wall time: 134 ms
```



In [217]:

```
%%time
get_confusion_matrix(dt,X_test_tfidf,y_test)
```

```
CPU times: user 199 ms, sys: 21.8 ms, total: 220 ms
Wall time: 120 ms
```



2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [218]:

```
# Collect all features name and create graph of features

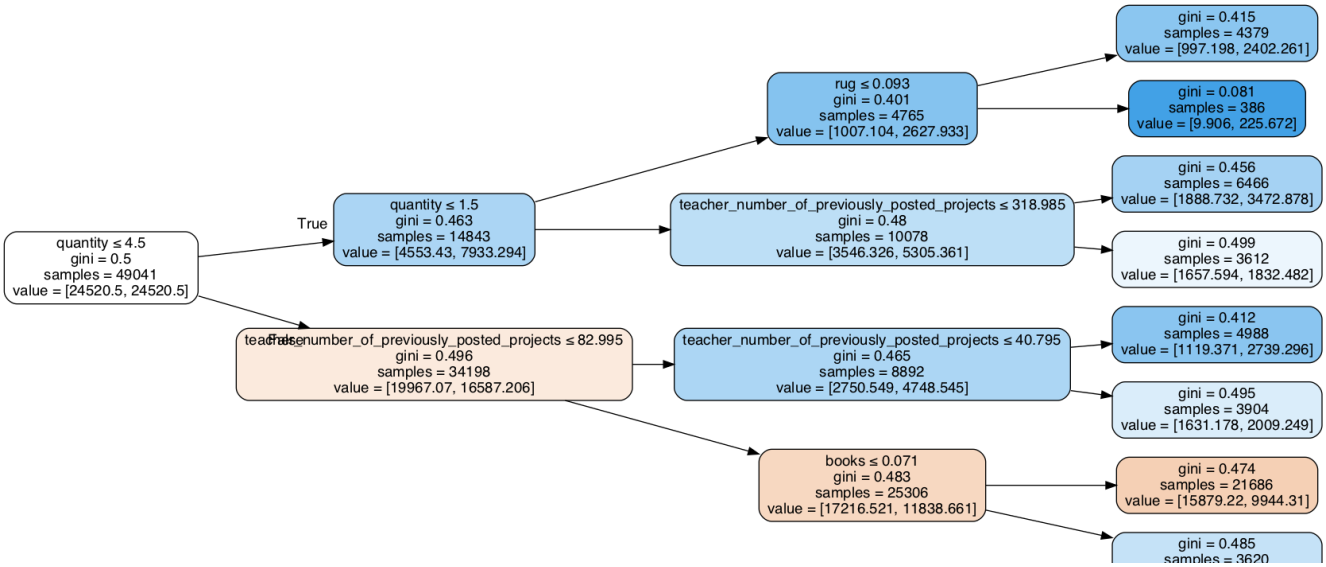
features_tfidf = school_state_features + clean_categories_features + clean_subcategories_features +
project_grade_category_features + teacher_prefix_features + clean_titles_tfidf_features +
easy_tfidf_features + project_resource_summary_tfidf_features
features_tfidf.append('quantity')
features_tfidf.append('price')
features_tfidf.append('teacher_number_of_previously_posted_projects')

dt=DecisionTreeClassifier(class_weight='balanced', max_depth=3,
min_samples_split=min_samples_split)
dt.fit(X_train_tfidf, y_train);
```

In [219]:

```
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(dt, out_file=dot_data, feature_names=features_tfidf, filled=True, rounded=True, spe
cial_characters=True, rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[219]:



value = [1337.302, 1894.351]

In [220]:

```
# Collect false positive data

predictions = collect_prediction(y_test_pred, te_thresholds, test_fpr, test_tpr)

# # train_fpr, train_tpr, tr_thresholds
fpr = collect_fpr(y_test, predictions)

essay = X_test_real['clean_essays'].to_frame()
essay = essay.reset_index()

price = X_test_real['price'].to_frame()
price = price.reset_index()

teacher_number_of_previously_posted_projects =
X_test_real['teacher_number_of_previously_posted_projects'].to_frame()
teacher_number_of_previously_posted_projects =
teacher_number_of_previously_posted_projects.reset_index()

flase_essays = []
false_price = []
false_teacher_number_of_previously_posted_projects = []
for i in fpr:
    flase_essays.append(essay.values[i][1:][0])
    false_price.append(price.values[i][1:][0])

false_teacher_number_of_previously_posted_projects.append(teacher_number_of_previously_posted_proje
ts.values[i][1:][0])

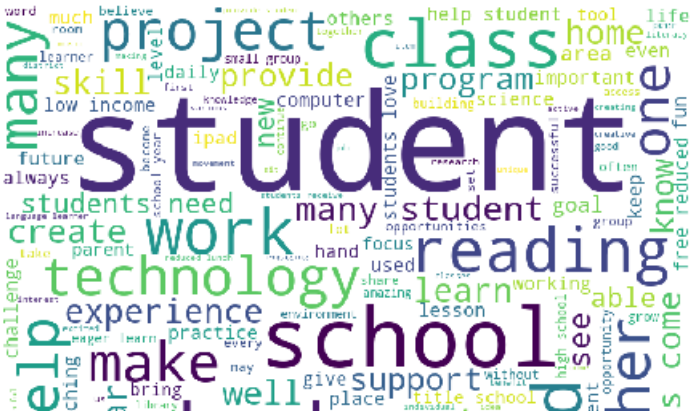
# print(len(flase_essays), len(false_price),
len(false_teacher_number_of_previously_posted_projects))
```

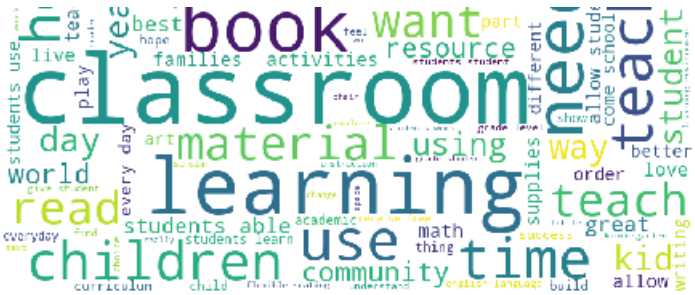
In [267]:

```
# create world cloud
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in flase_essays:
    val = str(val)
    val = val.lower()
    tokens = val.split()
    for words in tokens:
        if(words == 'nan' or words == 'nannan'):
            continue
        comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_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()
```



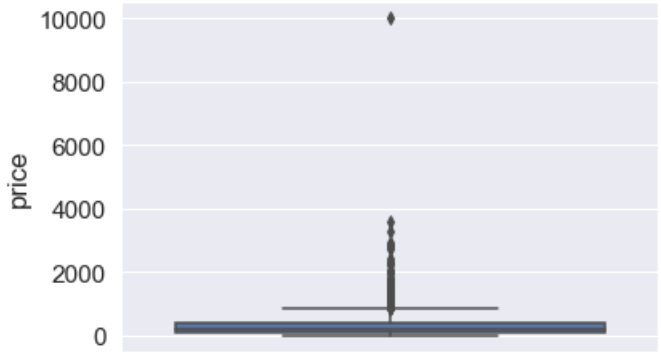


In [222]:

```
# Plot the box plot with the `price` of these `false positive data points`
df1 = pd.DataFrame({'price':false_price})
sns.boxplot(y='price', data=df1)
```

Out[222]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a292b7eb8>
```



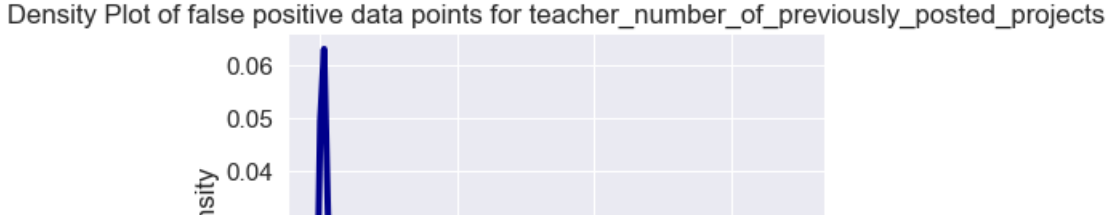
In [223]:

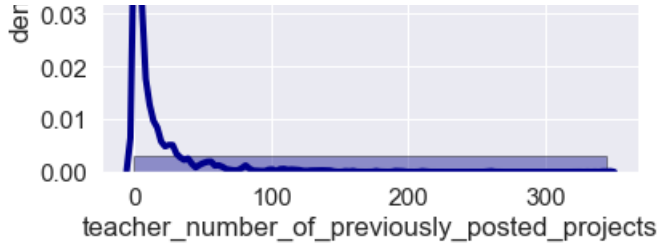
```
# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
ta points`
sns.distplot(false_teacher_number_of_previously_posted_projects, hist=True, kde=True,
             bins=1, color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4})

plt.title('Density Plot of false positive data points for
teacher_number_of_previously_posted_projects')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.ylabel('density')
plt.show()

# # Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive
data points`
# plt.figure(figsize=(8,5))
# counts, bin_edges = np.histogram(false_teacher_number_of_previously_posted_projects,
bins='auto', density=True)
# pdf = counts/sum(counts)
# cdf = np.cumsum(pdf)

# pdfP, = plt.plot(bin_edges[1:], pdf)
# cdfP, = plt.plot(bin_edges[1:], cdf)
# plt.legend([pdfP, cdfP], ["PDF", "CDF"])
# plt.xlabel('teacher_number_of_previously_posted_projects')
# plt.show()
```





2.4.3 Applying Decision Trees on AVG W2V, SET 3

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

In [224]:

```
%%time
# I reduced data points to perform AVG W2V for 10K data points, For large data points it was not c
ompleted within 12hrs.
# Please write all the code with proper documentation
# Prepare data for BOW
X_train_avgw2v = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, a
vg_w2v_vectors_text_train, avg_w2v_vectors_title_train,
avg_w2v_vectors_project_resource_summary_train, X_train_quantity_norm,
X_train_teacher_number_of_previously_posted_projects_norm, X_train_price_norm)).tocsr()
X_cv_avgw2v = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe,
X_cv_clean_subcategories_ohe, X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe,
avg_w2v_vectors_text_cv, avg_w2v_vectors_title_cv, avg_w2v_vectors_project_resource_summary_cv, X_
cv_quantity_norm, X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr(
)
X_test_avgw2v = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
, avg_w2v_vectors_text_test, avg_w2v_vectors_title_test,
avg_w2v_vectors_project_resource_summary_test, X_test_quantity_norm,
X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)).tocsr()


print(X_train_avgw2v.shape)
print(X_cv_avgw2v.shape)
print(X_test_avgw2v.shape)


import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import learning_curve, GridSearchCV

dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_train_avgw2v, y_train)
```

```
(49041, 1003)
(24155, 1003)
(36052, 1003)
CPU times: user 33.5 s, sys: 4.38 s, total: 37.9 s
Wall time: 3h 43min 34s
```

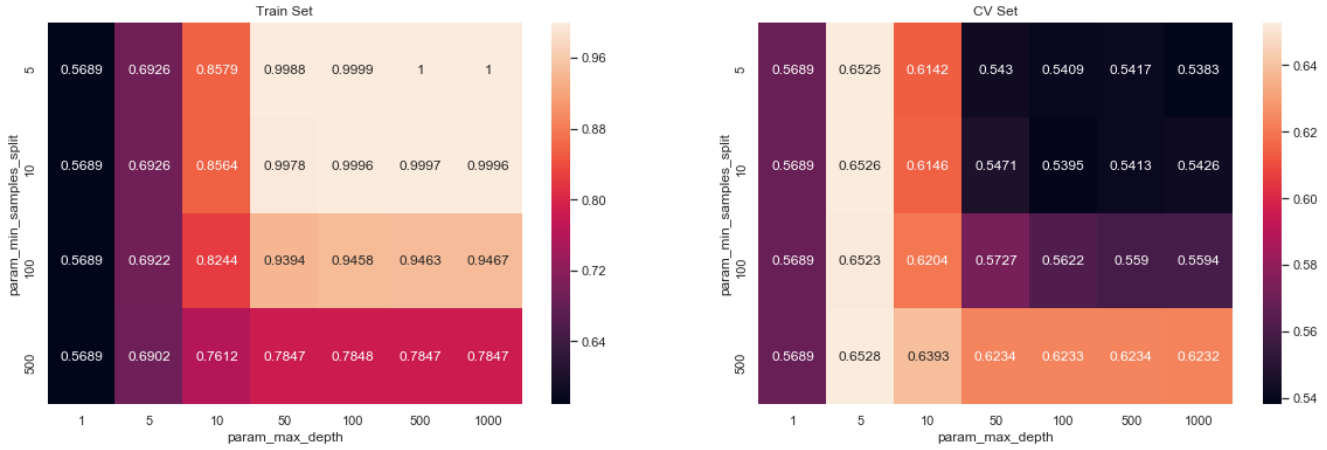
Out[224]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort=False, random_state=None,
                                              splitter='best'),
```

```
            iid='warn', n_jobs=-1,
            param_grid={'max_depth': [1, 5, 10, 50, 100, 500, 1000],
                        'min_samples_split': [5, 10, 100, 500]},
            pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
            scoring='roc_auc', verbose=0)
```

In [225]:

```
# Find best hyper parameter max_depth and min_samples_split
import seaborn as sns; sns.set()
max_scores = pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split', 'param_max_depth'])
.max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [226]:

```
# Print params
print(clf.best_estimator_)
print(clf.score(X_train_avgw2v, y_train))
print(clf.score(X_test_avgw2v, 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')
0.6890382884364546
0.6581139199715997
```

In [268]:

```
max_depth = 5
min_samples_split = 500
```

In [274]:

```
%%time

# Create ROC Plot for Test Set
parameters = {'max_depth':[max_depth], 'min_samples_split':[min_samples_split]}
dt=GridSearchCV(DecisionTreeClassifier(class_weight='balanced', max_depth=max_depth,
min_samples_split=min_samples_split), parameters, cv=3, scoring='roc_auc', n_jobs=-1,
return_train_score=True)
dt.fit(X_train_avgw2v, y_train);

y_train_pred = clf.predict_proba(X_train_avgw2v)[:,1]
y_test_pred = clf.predict_proba(X_test_avgw2v)[:,1]
```

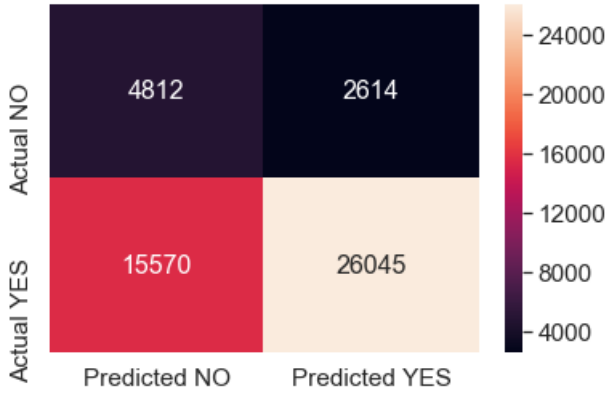
```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

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 (FPR)")
plt.ylabel("TRUE POSITIVE RATE (TPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

In [270]:

```
%%time
get_confusion_matrix(dt,X_train_avgw2v,y_train)
```

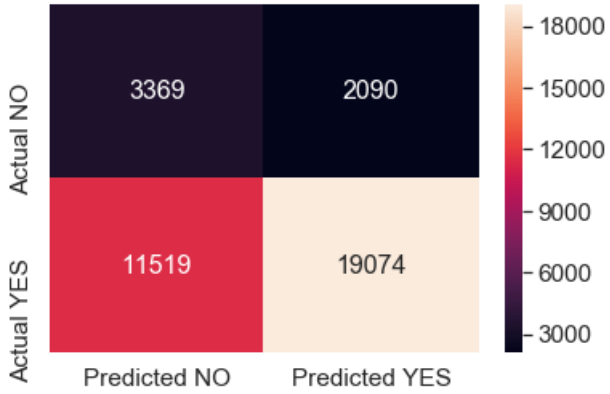
```
CPU times: user 510 ms, sys: 135 ms, total: 645 ms
Wall time: 346 ms
```



In [271]:

```
%%time
get_confusion_matrix(dt,X_test_avgw2v,y_test)
```

```
CPU times: user 330 ms, sys: 90.8 ms, total: 420 ms
Wall time: 268 ms
```



In [272]:

```
# Collect false positive data

predictions = collect_prediction(y_test_pred, te_thresholds, test_fpr, test_tpr)

# train_fpr, train_tpr, tr_thresholds
fpr = collect_fpr(y_test, predictions)

essay = X_test_real['clean_essays'].to_frame()
essay = essay.reset_index()
```

```
price = X_test_real['price'].to_frame()
price = price.reset_index()

teacher_number_of_previously_posted_projects =
X_test_real['teacher_number_of_previously_posted_projects'].to_frame()
teacher_number_of_previously_posted_projects =
teacher_number_of_previously_posted_projects.reset_index()

flase_essays = []
false_price = []
false_teacher_number_of_previously_posted_projects = []
for i in fpr:
    flase_essays.append(essay.values[i][1:][0])
    false_price.append(price.values[i][1:][0])

false_teacher_number_of_previously_posted_projects.append(teacher_number_of_previously_posted_proje
ts.values[i][1:][0])

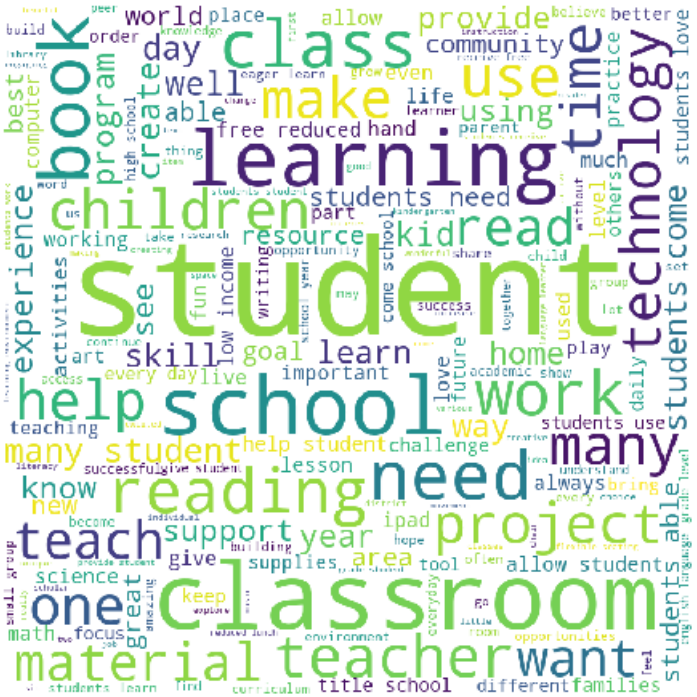
# print(len(flase_essays), len(false_price),
len(false_teacher_number_of_previously_posted_projects))
```

In [273]:

```
# create world cloud
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in flase_essays:
    val = str(val)
    val = val.lower()
    tokens = val.split()
    for words in tokens:
        if(words == 'nan' or words == 'nannan'):
            continue
        comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_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()
```

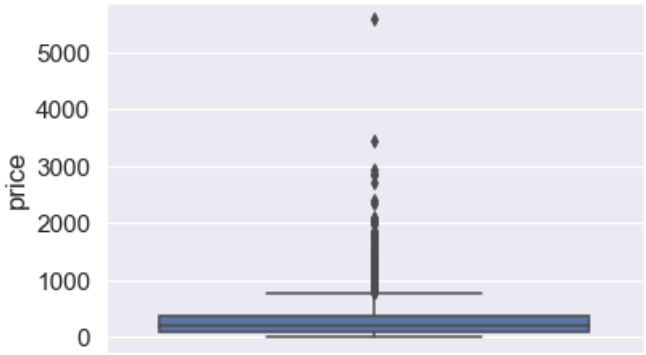


In [233]:

```
# Plot the box plot with the `price` of these `false positive data points`
df1 = pd.DataFrame({'price':false_price})
sns.boxplot(y='price', data=df1)
```

Out[233]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a28e45470>
```



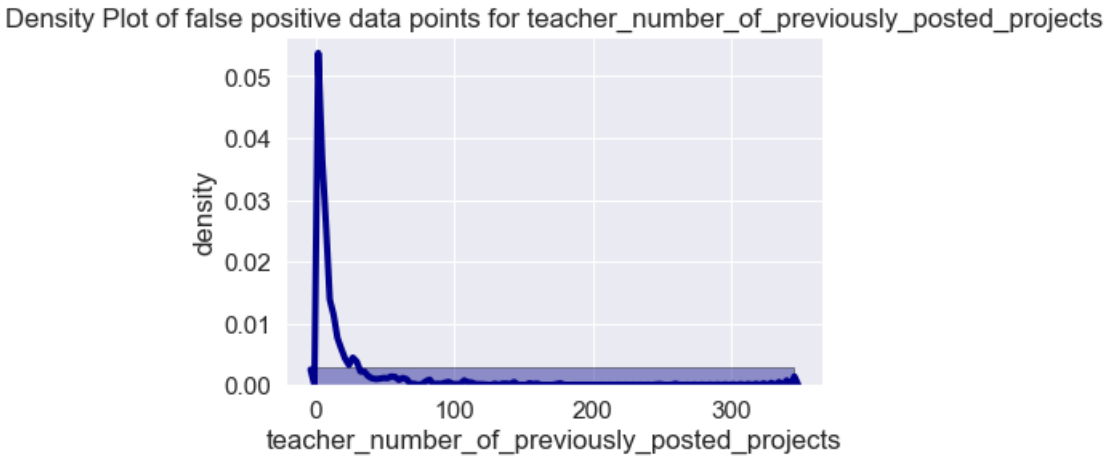
In [234]:

```
# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
ta points`
sns.distplot(false_teacher_number_of_previously_posted_projects, hist=True, kde=True,
             bins=1, color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4})

plt.title('Density Plot of false positive data points for
teacher_number_of_previously_posted_projects')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.ylabel('density')
plt.show()

# # Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive
data points`
# plt.figure(figsize=(8,5))
# counts, bin_edges = np.histogram(false_teacher_number_of_previously_posted_projects,
bins='auto', density=True)
# pdf = counts/sum(counts)
# cdf = np.cumsum(pdf)

# pdfP, = plt.plot(bin_edges[1:], pdf)
# cdfP, = plt.plot(bin_edges[1:], cdf)
# plt.legend([pdfP, cdfP], ["PDF", "CDF"])
# plt.xlabel('teacher_number_of_previously_posted_projects')
# plt.show()
```



2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

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

In [235]:

```
%%time
# I reduced data points to perform AVG W2V for 10K data points, For large data points it was not c
ompleted within 12hrs.
# Please write all the code with proper documentation
# Prepare data for BOW
X_train_tfidfw2v = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, t
fidf_w2v_vectors_text_train, tfidf_w2v_vectors_title_train,
tfidf_w2v_vectors_project_resource_summary_train, X_train_quantity_norm,
X_train_teacher_number_of_previously_posted_projects_norm, X_train_price_norm)).tocsr()
X_cv_tfidfw2v = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe,
X_cv_clean_subcategories_ohe, X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe,
tfidf_w2v_vectors_text_cv, tfidf_w2v_vectors_title_cv,
tfidf_w2v_vectors_project_resource_summary_cv, X_cv_quantity_norm,
X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr()
X_test_tfidfw2v = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
, tfidf_w2v_vectors_text_test, tfidf_w2v_vectors_title_test,
tfidf_w2v_vectors_project_resource_summary_test, X_test_quantity_norm,
X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)).tocsr()


print(X_train_tfidfw2v.shape)
print(X_cv_tfidfw2v.shape)
print(X_test_tfidfw2v.shape)


import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import learning_curve, GridSearchCV

dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_train_tfidfw2v, y_train)
```

```
(49041, 1003)
(24155, 1003)
(36052, 1003)
CPU times: user 33 s, sys: 4.36 s, total: 37.3 s
Wall time: 8h 8min 20s
```

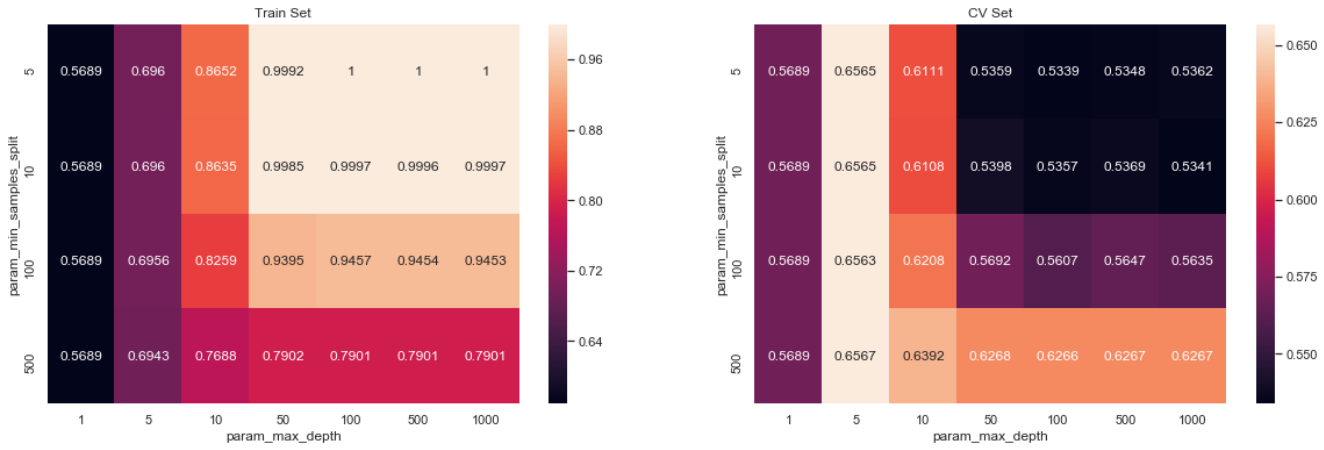
Out[235]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort=False, random_state=None,
                                              splitter='best'),
             iid='warn', n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50, 100, 500, 1000],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=0)
```

In [236]:

```
# Find best hyper parameter max_depth and min_samples_split
import seaborn as sns; sns.set()
max_scores = pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split', 'param_max_depth'])
.max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
```

```
sns.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [237]:

```
# Print params
print(clf.best_estimator_)
print(clf.score(X_train_tfidfw2v, y_train))
print(clf.score(X_test_tfidfw2v, 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')
0.68949661167243
0.6529840748709813
```

In [275]:

```
max_depth = 5
min_samples_split = 500
```

In [239]:

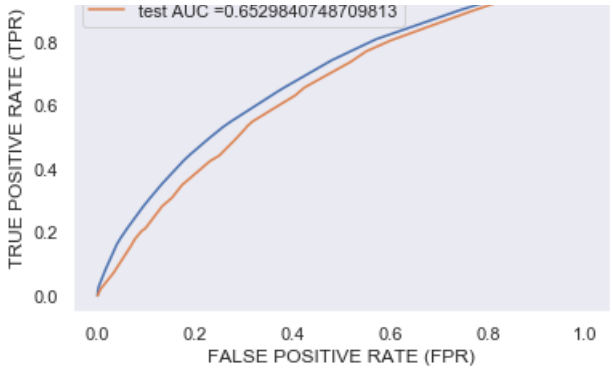
```
%%time

# Create ROC Plot for Test Set
parameters = {'max_depth':[max_depth], 'min_samples_split':[min_samples_split]}
dt=GridSearchCV(DecisionTreeClassifier(class_weight='balanced', max_depth=max_depth,
min_samples_split=min_samples_split), parameters, cv=3, scoring='roc_auc', n_jobs=-1,
return_train_score=True)
dt.fit(X_train_tfidfw2v, y_train);

y_train_pred = clf.predict_proba(X_train_tfidfw2v)[:,1]
y_test_pred = clf.predict_proba(X_test_tfidfw2v)[:,1]

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 (FPR)")
plt.ylabel("TRUE POSITIVE RATE (TPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

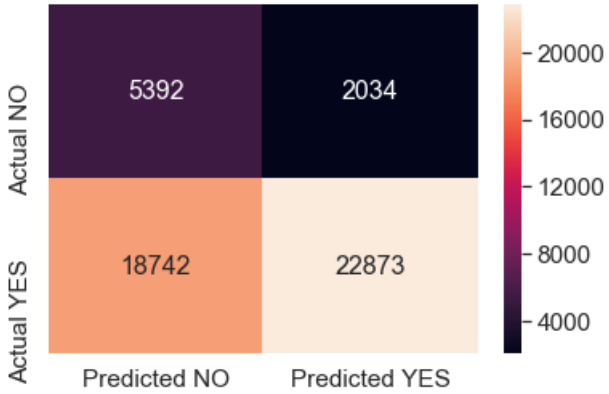



```
CPU times: user 29.6 s, sys: 1.07 s, total: 30.7 s
Wall time: 59.5 s
```

In [240]:

```
%%time
get_confusion_matrix(dt,X_train_tfidfw2v,y_train)
```

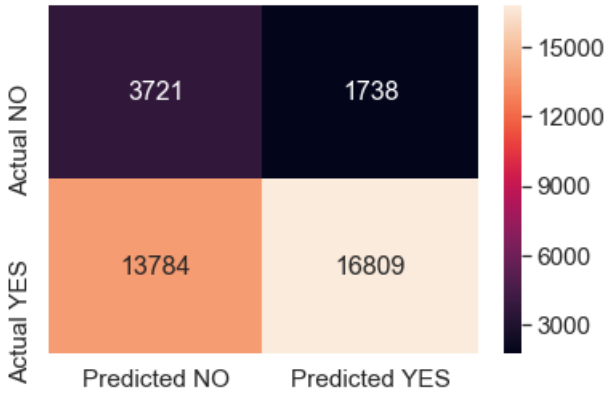
```
CPU times: user 515 ms, sys: 215 ms, total: 730 ms
Wall time: 506 ms
```



In [241]:

```
%%time
get_confusion_matrix(dt,X_test_tfidfw2v,y_test)
```

```
CPU times: user 320 ms, sys: 95.5 ms, total: 416 ms
Wall time: 243 ms
```



In [242]:

```
# Collect false positive data

predictions = collect_prediction(y_test_pred, te_thresholds, test_fpr, test_tpr)
```

```
# train_fpr, train_tpr, tr_thresholds
fpr = collect_fpr(y_test, predictions)

essay = X_test_real['clean_essays'].to_frame()
essay = essay.reset_index()

price = X_test_real['price'].to_frame()
price = price.reset_index()

teacher_number_of_previously_posted_projects =
X_test_real['teacher_number_of_previously_posted_projects'].to_frame()
teacher_number_of_previously_posted_projects =
teacher_number_of_previously_posted_projects.reset_index()

flase_essays = []
false_price = []
false_teacher_number_of_previously_posted_projects = []
for i in fpr:
    flase_essays.append(essay.values[i][1:][0])
    false_price.append(price.values[i][1:][0])

false_teacher_number_of_previously_posted_projects.append(teacher_number_of_previously_posted_proje
ts.values[i][1:][0])

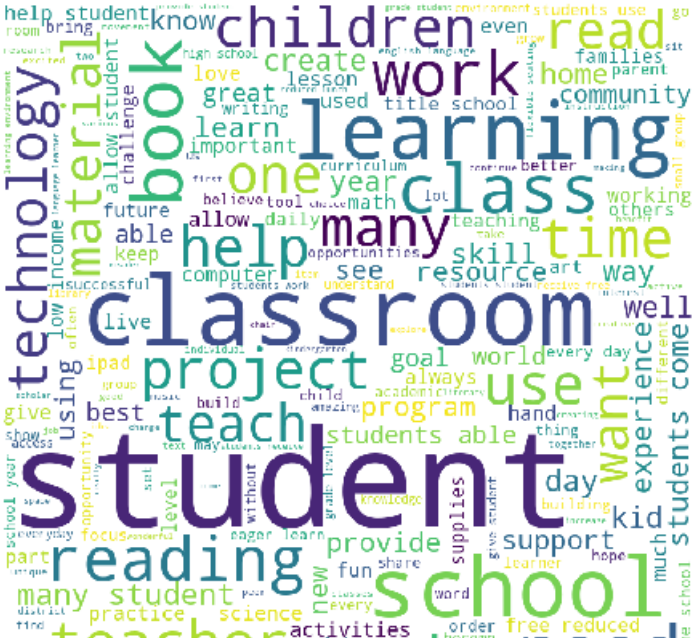
# print(len(flase_essays), len(false_price),
len(false_teacher_number_of_previously_posted_projects))
```

In [276]:

```
# create world cloud
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in flase_essays:
    val = str(val)
    val = val.lower()
    tokens = val.split()
    for words in tokens:
        if(words == 'nan' or words == 'nannan'):
            continue
        comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_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()
```

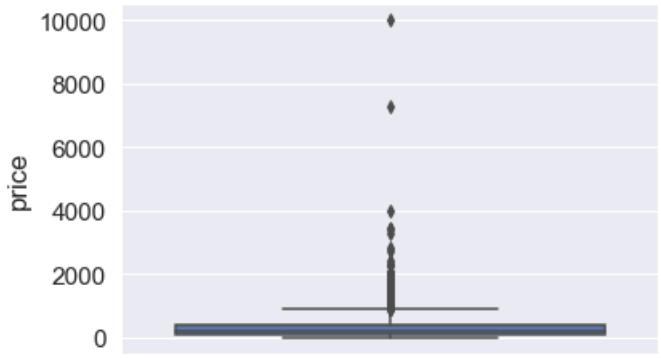


In [244]:

```
# Plot the box plot with the `price` of these `false positive data points`
df1 = pd.DataFrame({'price':false_price})
sns.boxplot(y='price', data=df1)
```

Out[244]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a2aeda978>
```



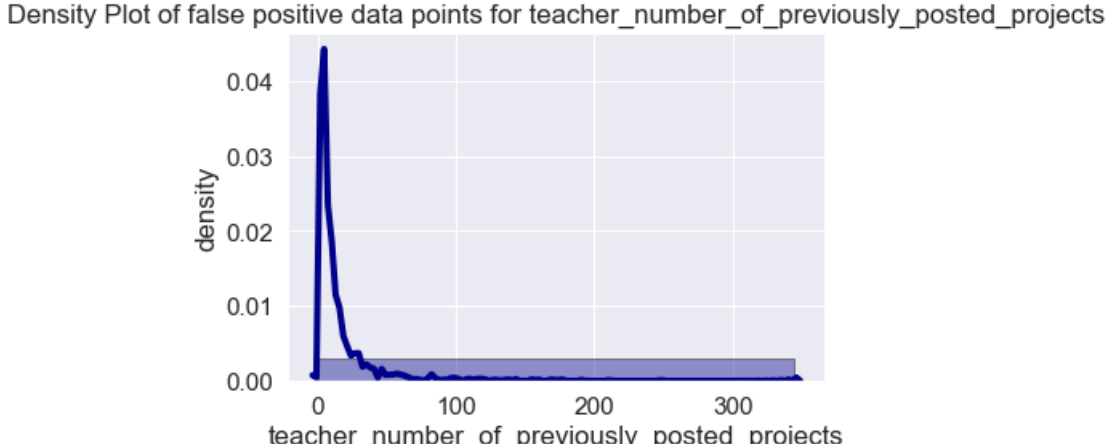
In [245]:

```
# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
ta points`
sns.distplot(false_teacher_number_of_previously_posted_projects, hist=True, kde=True,
             bins=1, color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4})

plt.title('Density Plot of false positive data points for
teacher_number_of_previously_posted_projects')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.ylabel('density')
plt.show()

# # Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive
data points`
# plt.figure(figsize=(8,5))
# counts, bin_edges = np.histogram(false_teacher_number_of_previously_posted_projects,
bins='auto', density=True)
# pdf = counts/sum(counts)
# cdf = np.cumsum(pdf)

# pdfP, = plt.plot(bin_edges[1:], pdf)
# cdfP, = plt.plot(bin_edges[1:], cdf)
# plt.legend([pdfP, cdfP], ["PDF", "CDF"])
# plt.xlabel('teacher_number_of_previously_posted_projects')
# plt.show()
```



2.5 Decision Tree with added Features `Set 5`

[Task-2]

Select 5k best features from features of Set 2 using `feature_importances_`, discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

In [246]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

In [247]:

```
%%time
# Please write all the code with proper documentation
# Prepare data for TFIDF
X_train_tfidf = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe,
X_train_clean_subcategories_ohe, X_train_project_grade_category_ohe, X_train_teacher_prefix_ohe, X
_train_title_tfidf, X_train_essay_tfidf, X_train_project_resource_summary_tfidf,
X_train_quantity_norm, X_train_teacher_number_of_previously_posted_projects_norm,
X_train_price_norm)).tocsr()
X_cv_tfidf = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe,
X_cv_clean_subcategories_ohe, X_cv_project_grade_category_ohe, X_cv_clean_teacher_prefix_ohe,
X_cv_title_tfidf, X_cv_essay_tfidf, X_cv_project_resource_summary_tfidf, X_cv_quantity_norm,
X_cv_teacher_number_of_previously_posted_projects_norm, X_cv_price_norm)).tocsr()
X_test_tfidf = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe,
X_test_clean_subcategories_ohe, X_test_project_grade_category_ohe, X_test_clean_teacher_prefix_ohe
, X_test_title_tfidf, X_test_essay_tfidf, X_test_project_resource_summary_tfidf,
X_test_quantity_norm, X_test_teacher_number_of_previously_posted_projects_norm, X_test_price_norm)
).tocsr()

print(X_train_tfidf.shape)
print(X_cv_tfidf.shape)
print(X_test_tfidf.shape)

from sklearn.ensemble import RandomForestClassifier
from sklearn.feature_selection import SelectFromModel

sel = SelectFromModel(RandomForestClassifier(n_estimators = 100))
sel.fit(X_train_tfidf, y_train)

print(sel.get_support())
print(len(sel.get_support()))
```

```
(49041, 17989)
(24155, 17989)
(36052, 17989)
[False  True  True ...  True  True  True]
17989
CPU times: user 1min 57s, sys: 941 ms, total: 1min 58s
Wall time: 1min 58s
```

In [248]:

```
#https://stackoverflow.com/questions/47111434/randomforestregressor-and-feature-importa nces-error
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV

def selectKImportance(model, X, k=5):
    return X[:,model.best_estimator_.feature_importances_.argsort()[::-1][:k]]
```

In [249]:

```
dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_train_tfidf, y_train)


X_set5_train = selectKImportance(clf, X_train_tfidf,5000)
X_set5_test = selectKImportance(clf, X_test_tfidf, 5000)
print(X_set5_train.shape)
print(X_set5_test.shape)
```

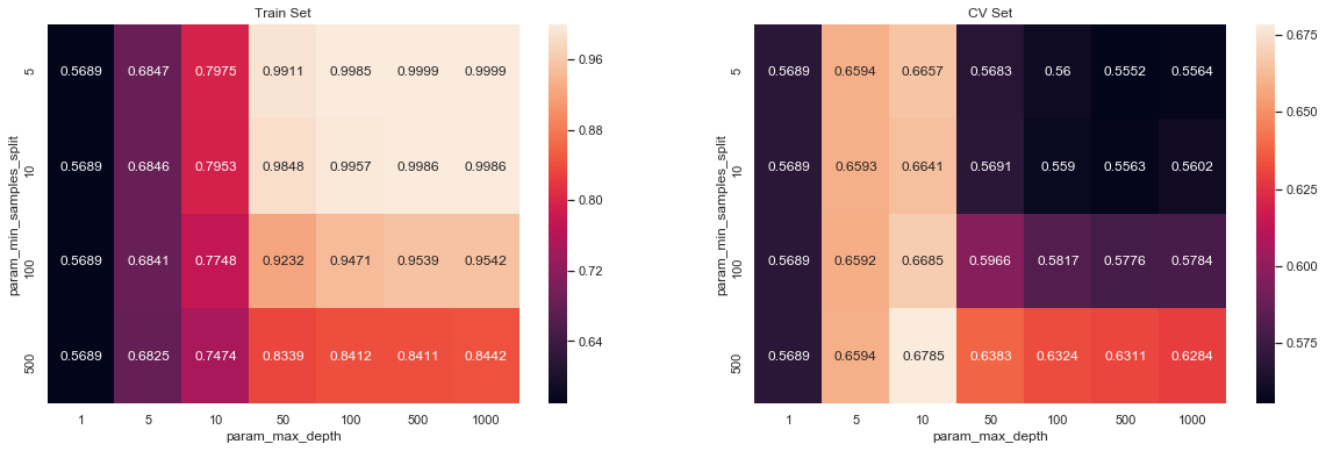
```
(49041, 5000)
(36052, 5000)
```

In [250]:

```
%%time
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import learning_curve, GridSearchCV

dt = DecisionTreeClassifier(class_weight='balanced')
parameters = {'max_depth':[1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}
clf=GridSearchCV(dt, parameters, cv=3, scoring='roc_auc', n_jobs=-1, return_train_score=True)
clf.fit(X_set5_train, y_train)

# Find best hyper parameter max_depth and min_samples_split
import seaborn as sns; sns.set()
max_scores = pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split', 'param_max_depth'])
.max().unstack()[['mean_test_score', 'mean_train_score']]
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```




```
CPU times: user 4.7 s, sys: 125 ms, total: 4.83 s
Wall time: 5min 25s
```

In [251]:

```
# Print params
print(clf.best_estimator_)
print(clf.score(X_set5_train, y_train))
print(clf.score(X_set5_test, 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')
0.7454381245833981
0.6839138186310509
```

In [252]:

```
max_depth = 10
min_samples_split = 500
```

In [253]:

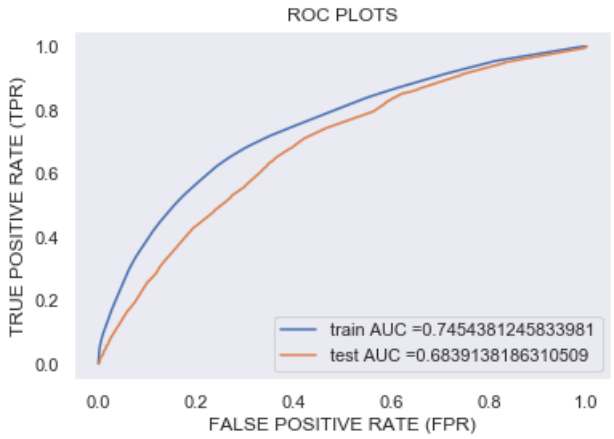
```
%%time

# Create ROC Plot for Test Set
parameters = {'max_depth':[max_depth], 'min_samples_split':[min_samples_split]}
dt=GridSearchCV(DecisionTreeClassifier(class_weight='balanced', max_depth=max_depth,
min_samples_split=min_samples_split), parameters, cv=3, scoring='roc_auc', n_jobs=-1,
return_train_score=True)
dt.fit(X_set5_train, y_train);

y_train_pred = clf.predict_proba(X_set5_train)[:,1]
y_test_pred = clf.predict_proba(X_set5_test)[:,1]

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 (FPR)")
plt.ylabel("TRUE POSITIVE RATE (TPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

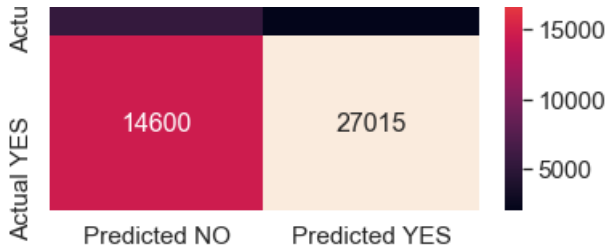



```
CPU times: user 4.43 s, sys: 63 ms, total: 4.49 s
Wall time: 7.02 s
```

In [254]:

```
%%time
get_confusion_matrix(dt,X_set5_train,y_train)
```

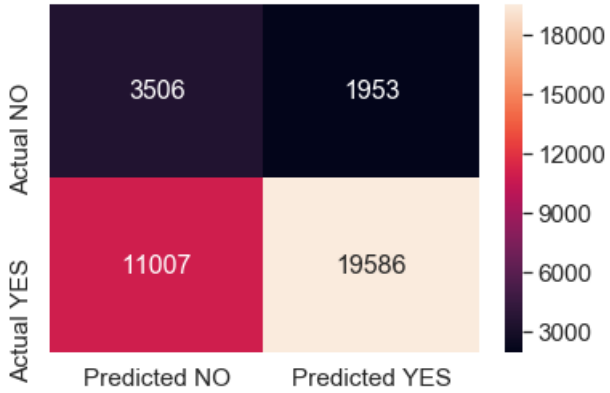
```
CPU times: user 165 ms, sys: 3.99 ms, total: 169 ms
Wall time: 86.9 ms
```



In [255]:

```
%%time
get_confusion_matrix(dt,X_set5_test,y_test)
```

```
CPU times: user 148 ms, sys: 6.48 ms, total: 154 ms
Wall time: 77.5 ms
```



In [256]:

```
# Collect false positive data

predictions = collect_prediction(y_test_pred, te_thresholds, test_fpr, test_tpr)

# train_fpr, train_tpr, tr_thresholds
fpr = collect_fpr(y_test, predictions)

essay = X_test_real['clean_essays'].to_frame()
essay = essay.reset_index()

price = X_test_real['price'].to_frame()
price = price.reset_index()

teacher_number_of_previously_posted_projects =
X_test_real['teacher_number_of_previously_posted_projects'].to_frame()
teacher_number_of_previously_posted_projects =
teacher_number_of_previously_posted_projects.reset_index()

flase_essays = []
false_price = []
false_teacher_number_of_previously_posted_projects = []
for i in fpr:
    flase_essays.append(essay.values[i][1:][0])
    false_price.append(price.values[i][1:][0])

false_teacher_number_of_previously_posted_projects.append(teacher_number_of_previously_posted_proje
ts.values[i][1:][0])

# print(len(flase_essays), len(false_price),
len(false_teacher_number_of_previously_posted_projects))
```

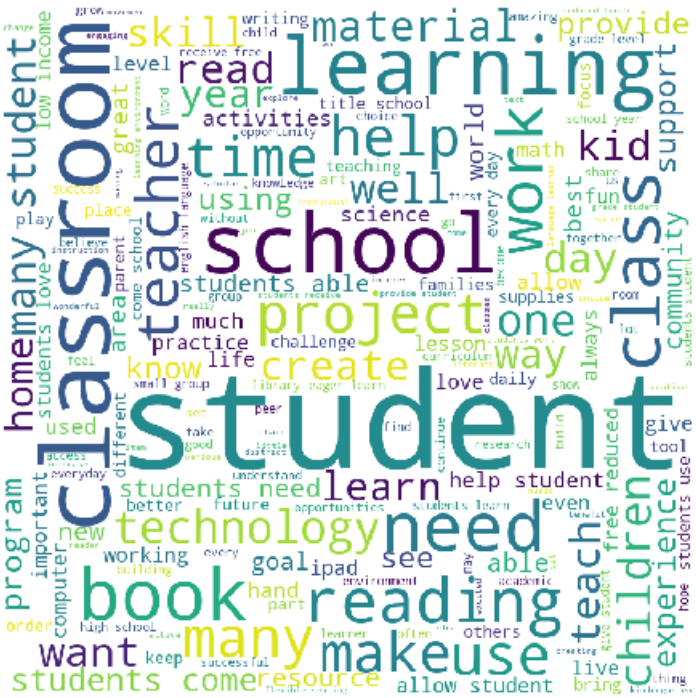
In [277]:

```
# create world cloud
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
```

```
for val in flase_essays:
    val = str(val)
    val = val.lower()
    tokens = val.split()
    for words in tokens:
        if(words == 'nan' or words == 'nannan'):
            continue
        comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,
min_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()
```

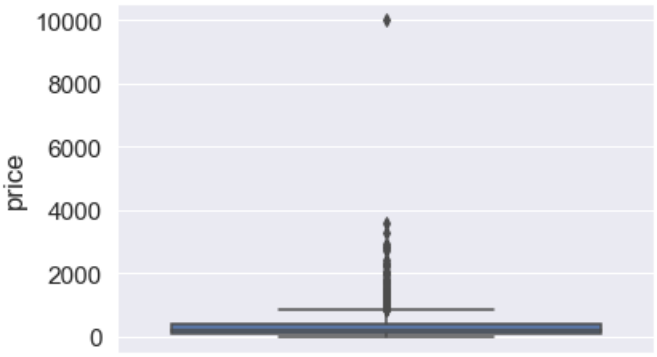


In [258]:

```
# Plot the box plot with the `price` of these `false positive data points`
df1 = pd.DataFrame({'price':false_price})
sns.boxplot(y='price', data=df1)
```

Out[258]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a2af1d710>
```



In [259]:

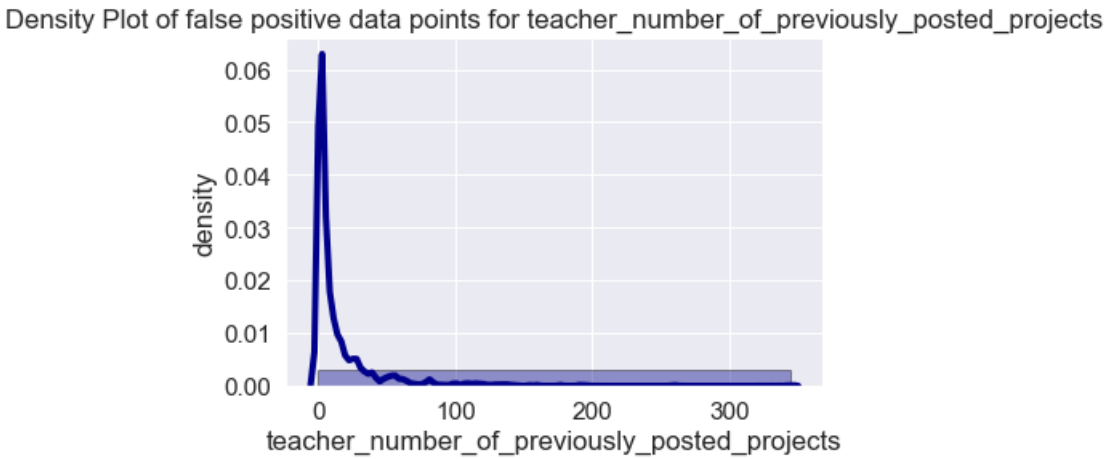
```
# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
```

```
ta points
sns.distplot(false_teacher_number_of_previously_posted_projects, hist=True, kde=True,
             bins=1, color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4})

plt.title('Density Plot of false positive data points for
teacher_number_of_previously_posted_projects')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.ylabel('density')
plt.show()

# Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive da
ta points`
# plt.figure(figsize=(8,5))
# counts, bin_edges = np.histogram(false_teacher_number_of_previously_posted_projects,
bins='auto', density=True)
# pdf = counts/sum(counts)
# cdf = np.cumsum(pdf)

# pdfP, = plt.plot(bin_edges[1:], pdf)
# cdfP, = plt.plot(bin_edges[1:], cdf)
# plt.legend([pdfP, cdfP], ["PDF", "CDF"])
# plt.xlabel('teacher_number_of_previously_posted_projects')
# plt.show()
```



3. Conclusions

In [279]:

```
# Please compare all your models using Prettytable library
# Please compare all your models using Prettytable library
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Max Depth", "Min Samples Split", "AUC"]
x.add_row(["Bag of Words", "Decision Tree", 10, 500, 0.68])
x.add_row(["TFIDF", "Decision Tree", 10, 500, 0.68])
x.add_row(["AVG W2V", "Decision Tree", 5, 500, 0.65])
x.add_row(["TFIDF W2V", "Decision Tree", 5, 500, 0.65])
x.add_row(["Top 5K Feature", "Decision Tree", 10, 500, 0.68,])


print(x)
```

```
+----------------+---------------+-----------+-------------------+------+
|   Vectorizer   |     Model     | Max Depth | Min Samples Split | AUC  |
+----------------+---------------+-----------+-------------------+------+
|  Bag of Words  | Decision Tree |     10    |        500        | 0.68 |
|     TFIDF      | Decision Tree |     10    |        500        | 0.68 |
|    AVG W2V     | Decision Tree |     5     |        500        | 0.65 |
|   TFIDF W2V    | Decision Tree |     5     |        500        | 0.65 |
| Top 5K Feature | Decision Tree |     10    |        500        | 0.68 |
+----------------+---------------+-----------+-------------------+------+
```

In [ ]:

```
```