DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom number of volunteers is needed to manually screen each submission before it's approved to be pc

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, th solve:

- How to scale current manual processes and resources to screen 500,000 projects so that th as possible
- How to increase the consistency of project vetting across different volunteers to improve th
- 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 sub the text of project descriptions as well as additional metadata about the project, teacher, and sch 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 th • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the projec • `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). **Exam**

Feature	Description
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the pr • Literacy • Literature & Writing, Social Scienc
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • My students need hands on literacy r
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** 2016
`teacher_id`	A unique identifier for the teacher of the proposed project. **Exampl**
`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

* 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 ea resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** p0365
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds`
`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 tr 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 proje

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 f following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific d neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of proje

```
# importing required libraries

%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.model_selection import GridSearchCV
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

from tqdm import tqdm
import os

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

```
from sklearn.model_selection import GridSearchCV
```

1.1 Reading Data

```
from google.colab import drive

# This will prompt for authorization.
drive.mount('/content/drive',force_remount=True)
```

```
Mounted at /content/drive
```

```
!ls "/content/drive/My Drive/Colab Notebooks/Dataset/Assignments_DonorsChoose_2018
```

```
'06 Implement SGD.ipynb'              confusion_matrix.png
 10_DonorsChoose_Clustering.ipynb     cooc.JPG
 11_DonorsChoose_TruncatedSVD.ipynb   glove_vectors
 2_DonorsChoose_EDA_TSNE.ipynb        haberman.csv
 2letterstabbrev.pdf                  haberman.xlsx
 3d_plot.JPG                          heat_map.JPG
 3d_scatter_plot.ipynb                imdb.txt
 4_DonorsChoose_NB.ipynb              resources.csv
 5_DonorsChoose_LR.ipynb              response.JPG
 7_DonorsChoose_SVM.ipynb             summary.JPG
 8_DonorsChoose_DT.ipynb              test_data.csv
 9_DonorsChoose_RF_GBDT.ipynb         train_cv_auc.JPG
 Assignment_SAMPLE_SOLUTION.ipynb     train_data.csv
'Assignment_tips(1).docx'             train_test_auc.JPG
 Assignment_tips.docx
```

```
# Reading data from project and resources data file

project_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/Dataset/Assign
resource_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/Dataset/Assig



# Getting basic information about the data

print("Number of data points in Project_train data", project_data.shape)
print('-'*100)
print("The attributes of Project_train data :", project_data.columns.values)
print('='*100)
print("Number of data points in Resource_train data", resource_data.shape)
print('-'*100)
print("The attributes of Resource_train data :", resource_data.columns.values)
```

```
Number of data points in Project_train data (109248, 17)
---------------------------------------------------------------------------
The attributes of Project_train data : ['Unnamed: 0' 'id' 'teacher_id' 'teach
 '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']
===========================================================================
Number of data points in Resource_train data (1541272, 4)
---------------------------------------------------------------------------
The attributes of Resource_train data : ['id' 'description' 'quantity' 'price
```

1.2 Data Pre-Processing

```
# Merge two column text dataframe:
# Merge 4 essays into one:
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)

# Merge Price information from resource data to project data
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).re
project_data = pd.merge(project_data, price_data, on='id', how='left')

# find how many digits are present in each project_resource_summary coloumn
summary = list(project_data['project_resource_summary'].values)
presence_of_numeric_data=[]
for i in summary:
    count = 0
    for j in i.split(' '):
        if j.isdigit():
            count+=1
    presence_of_numeric_data.append(count)

# Replace Text summary coloumn with new numerical coloumn presence_of_numeric_data
project_data['numerical_data_in_resource_summary'] = presence_of_numeric_data
project_data.drop(['project_resource_summary'], axis=1, inplace=True)

# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_dat

#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/
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/13148611/40840
project_data = project_data[cols]

# https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.drop
# Here we drop 3 rows where teacher_prefix is having np.nan value
```

```
# Here we drop 3 rows where teacher_prefix is having np.nan value
project_data.dropna(axis=0,subset=['teacher_prefix'], inplace=True)

project_data.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	

1.2.1 Pre-Processing Essay Text

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

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom
==================================================
I teach high school English to students with learning and behavioral disabili
==================================================
```

```
# 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)
```

```
    phrase = re.sub(r" \'m ", " am ", phrase)
    return phrase


# 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', "y
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'h
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that'
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because',
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'thr
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off'
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all',
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than',
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've"
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "did
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't
            'won', "won't", 'wouldn', "wouldn't"]


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

# Adding preprocessed_essays coloumn to our data matrix

project_data['preprocessed_essays']=preprocessed_essays
```

```
100%|██████████| 109245/109245 [01:05<00:00, 1679.72it/s]
```

```
# after preprocesing
preprocessed_essays[100]
```

```
'a typical day campus exciting my students love learning always put smile fac
```

1.2.2 Pre-Processing Project Title Text

```
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for title in tqdm(project_data['project_title'].values):
```

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

    # Adding preprocessed_titles coloumn to our data matrix

    project_data['preprocessed_titles']=preprocessed_titles
    preprocessed_titles[1000]
```

```
    100%|██████████| 109245/109245 [00:02<00:00, 38812.80it/s]
    'empowering students through art learning about then now'
```

1.2.3 Pre-Processing Project Grades

```
# Remove special characters from grades
from tqdm import tqdm
preprocessed_grade_categories = []
# tqdm is for printing the status bar
for categories in tqdm(project_data['project_grade_category'].values):
    categories = decontracted(categories)
    # https://gist.github.com/sebleier/554280
    categories = '_'.join(e for e in categories.split(' ') if e not in stopwords)
    categories = '_'.join(e for e in categories.split('-') if e not in stopwords)
    preprocessed_grade_categories.append(categories.lower().strip())

# Adding preprocessed_titles coloumn to our data matrix

project_data['preprocessed_grade_category']=preprocessed_grade_categories

project_data.head(5)
```

```
100%|██████████| 109245/109245 [00:02<00:00, 50732.99it/s]
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

1.2.4 preprocessing of `project_subject_categories`

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in
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", "W
        if 'The' in j.split(): # this will split each of the catogory based on spa
            j=j.replace('The','') # if we have the words "The" we are going to rep
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
```

```
        j = j.replace('  ',' ') # we are placeing all the '  '(space) with ' '(empty)
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailin
        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)
```

1.2.5 preprocessing of `project_subject_subcategories`

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

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

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", "W
        if 'The' in j.split(): # this will split each of the catogory based on spa
            j=j.replace('The','') # if we have the words "The" we are going to rep
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailin
        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)



# Drop all unnecessary featurs like project_grade_category, project_essay_1, etc.
project_data.drop(['project_grade_category'], axis=1, inplace=True)
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)
project_data.drop(['essay'], axis=1, inplace=True)



project_data.head(5)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

1.2.6 Add Sentiment Score of Preprocessed Essays

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

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
True
```

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
neg_essay=[]
neu_essay=[]
pos_essay=[]
comp_essay=[]

sid = SentimentIntensityAnalyzer()

for sent in preprocessed_titles:

    ss = sid.polarity_scores(sent)
    neg_essay.append(ss.get('neg'))
    neu_essay.append(ss.get('neu'))
    pos_essay.append(ss.get('pos'))
    comp_essay.append(ss.get('compound'))

project_data['neg_essay']=neg_essay
project_data['neu_essay']=neu_essay
project_data['pos_essay']=pos_essay
project_data['comp_essay']=comp_essay
```

```
# 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
```

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

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

1.2.7 Adding number of words in title and number of words in essay features

```
number_of_words_in_title=[]
for title in project_data['project_title'].values:
    list_of_words = title.split()
    number_of_words_in_title.append(len(list_of_words))

number_of_words_in_essays=[]
for title in project_data['preprocessed_essays'].values:
    list_of_words = title.split()
    number_of_words_in_essays.append(len(list_of_words))

project_data['number_of_words_in_title'] = number_of_words_in_title
project_data['number_of_words_in_essays'] = number_of_words_in_essays
```

```
project_data.head()
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

1.3 Sampling data for Clustering Assignment

```
project_data['project_is_approved'].value_counts()
```

```
1    92703
0    16542
Name: project_is_approved, dtype: int64
```

```
data = project_data
data['project_is_approved'].value_counts()
```

```
1    92703
0    16542
Name: project_is_approved, dtype: int64
```

```
data.head(5)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	

```
# Split the class label from data
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)
X.head(5)
print(y.shape)
```

```
(109245,)
```

```
data = X
data.shape
```

```
(109245, 22)
```

2.1 Make Data Model Ready:

2.1.1 Encoding numerical, categorical features

2.1.1.1 Encoding School State

```
# Encoding School State

vectorizer = CountVectorizer()
vectorizer.fit(data['school_state'].values) # fit has to happen only on train data
```

```
# we use the fitted CountVectorizer to convert the text to vector
data_state_ohe = vectorizer.transform(data['school_state'].values)

print("After vectorizations")
print(data_state_ohe.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109245, 51)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia'
====================================================================================
```

2.1.1.2 Encoding Teacher Prefix

```
vectorizer = CountVectorizer()
vectorizer.fit(data['teacher_prefix'].values) # fit has to happen only on train da

# we use the fitted CountVectorizer to convert the text to vector
data_teacher_ohe = vectorizer.transform(data['teacher_prefix'].values)

print("After vectorizations")
print(data_teacher_ohe.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109245, 5)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================
```

2.1.1.3 Encoding preprocessed_grade_category

```
vectorizer = CountVectorizer()
vectorizer.fit(data['preprocessed_grade_category'].values) # fit has to happen onl

# we use the fitted CountVectorizer to convert the text to vector
data_grade_ohe = vectorizer.transform(data['preprocessed_grade_category'].values)

print("After vectorizations")
print(data_grade_ohe.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109245, 4)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
====================================================================================
```

2.1.1.4 Encoding numerical feature Price

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['price'].values.reshape(1,-1))

data_price_norm = normalizer.transform(data['price'].values.reshape(1,-1))

data_price_norm = data_price_norm.reshape(-1,1)



print("After vectorizations")
print(data_price_norm.shape)
print(data_price_norm)

print("="*100)
```

```
After vectorizations
(109245, 1)
[[4.63569227e-03]
 [1.36203231e-03]
 [2.10350012e-03]
 ...
 [2.55105333e-03]
 [1.83963553e-03]
 [3.51648955e-05]]
====================================================================================================
```

2.1.1.5 Encoding numeric feature Quantity

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['quantity'].values.reshape(1,-1))

data_quantity_norm = normalizer.transform(data['quantity'].values.reshape(1,-1))
data_quantity_norm = data_quantity_norm.reshape(-1,1)
print(data_quantity_norm)
print("After vectorizations")
print(data_quantity_norm.shape)

print("="*100)
```

```
[[3.87895138e-04]
 [7.75790277e-04]
 [9.69737846e-05]
 ...
 [4.84868923e-04]
 [3.87895138e-04]
 [2.42434461e-03]]
After vectorizations
(109245, 1)
==========================================================================
```

2.1.1.6 Encoding numeric feature teacher_number_of_previously_posted_proje

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['teacher_number_of_previously_posted_projects'].values.reshape
#List_of_imp_features.append('teacher_number_of_previously_posted_projects')
data_teacher_number_of_previously_posted_projects_norm = normalizer.transform(data
data_teacher_number_of_previously_posted_projects_norm = data_teacher_number_of_pr

print("After vectorizations")
print(data_teacher_number_of_previously_posted_projects_norm.shape)
print("="*100)
```

```
After vectorizations
(109245, 1)
==========================================================================
```

2.1.1.7 Encoding numeric feature numerical_data_in_resource_summary

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['numerical_data_in_resource_summary'].values.reshape(1,-1))
data_numerical_data_in_resource_summary_norm = normalizer.transform(data['numerica

data_numerical_data_in_resource_summary_norm = data_numerical_data_in_resource_sum

print("After vectorizations")
print(data_numerical_data_in_resource_summary_norm.shape)
```

```
print("="*100)
```

```
After vectorizations
(109245, 1)
====================================================================================================
```

2.1.1.8 Encoding numeric feature number_of_words_in_title

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['number_of_words_in_title'].values.reshape(1,-1))

data_number_of_words_in_title = normalizer.transform(data['number_of_words_in_titl

data_number_of_words_in_title = data_number_of_words_in_title.reshape(-1,1)

print("After vectorizations")
print(data_number_of_words_in_title.shape)
print(data_number_of_words_in_title)

print("="*100)
```

```
After vectorizations
(109245, 1)
[[0.00326648]
 [0.00217765]
 [0.00381089]
 ...
 [0.00489971]
 [0.00217765]
 [0.00163324]]
====================================================================================================
```

2.1.1.9 Encoding numeric feature number_of_words_in_essay

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(data['number_of_words_in_essays'].values.reshape(1,-1))

data_number_of_words_in_essay = normalizer.transform(data['number_of_words_in_essa
```

```
data_number_of_words_in_essay = data_number_of_words_in_essay.reshape(-1,1)

print("After vectorizations")
print(data_number_of_words_in_essay.shape)
print(data_number_of_words_in_essay)
print("="*100)
```

```
After vectorizations
(109245, 1)
[[0.00338651]
 [0.00346391]
 [0.00224477]
 ...
 [0.0032704 ]
 [0.00239958]
 [0.00232218]]
====================================================================================
```

2.1.1.10 Encoding numeric features of sentiment Score

```
data_neg_essay = data['neg_essay'].values.reshape(-1,1)
data_neu_essay = data['neu_essay'].values.reshape(-1,1)
data_pos_essay = data['pos_essay'].values.reshape(-1,1)
data_comp_essay = data['comp_essay'].values.reshape(-1,1)
```

2.4 Dimensionality Reduction on the selected features

2.2 Appling Clustering on TFIDF featurization

2.2.1 Applying Clustering on TFIDF encoding eassay, and project_titl

2.2.1.1 Encoding preprocessed_titles TFIDF

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)

#vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=10000)
vectorizer.fit(data['preprocessed_titles'].values) # fit has to happen only on tra

# we use the fitted CountVectorizer to convert the text to vector
data_titles_tfidf = vectorizer.transform(data['preprocessed_titles'].values)

print("After vectorizations")
print(data_titles_tfidf.shape)
print("="*100)
```

```
After vectorizations
(109245, 3329)
==========================================================================
```

2.2.1.2 Encoding preprocessed_essays TFIDF

```
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=10000)
vectorizer.fit(data['preprocessed_essays'].values) # fit has to happen only on tra

# we use the fitted CountVectorizer to convert the text to vector
data_essay_tfidf = vectorizer.transform(data['preprocessed_essays'].values)

print("After vectorizations")
print(data_essay_tfidf.shape)
print("="*100)
```

```
After vectorizations
(109245, 10000)
==========================================================================
```

2.2.1.3 Merge all the features and obtain final data matrix

```
from sklearn.feature_selection import SelectKBest, chi2
from scipy.sparse import hstack
data_train = hstack((data_titles_tfidf[:5000,:],data_essay_tfidf[:5000,:], data_st

print("Final Data matrix")
print(data_train.shape)

print("="*100)

# Select best K features
# https://www.w3cschool.cn/doc_scikit_learn/scikit_learn-modules-generated-sklearn
# https://www.programcreek.com/python/example/93974/sklearn.feature_selection.Sele

X_new = SelectKBest(chi2, k=5000).fit(data_train,y[:5000])
data_train_best_k = X_new.transform(data_train)
print(data_train_best_k.shape)
```

```
Final Data matrix
(5000, 13393)
==========================================================================
(5000, 5000)
```

2.2.2 K-Means Clustering

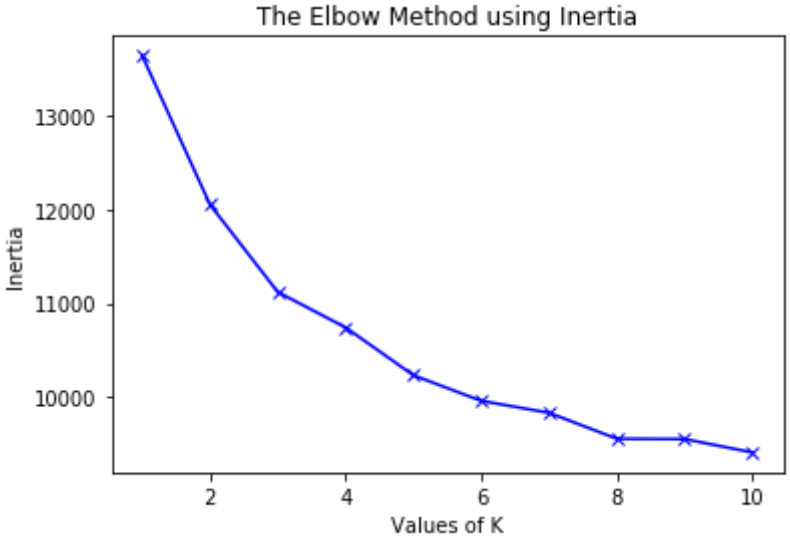
2.2.2.1 Find best K in K-means

```
# Find best K using elbow method k-means
# https://www.geeksforgeeks.org/elbow-method-for-optimal-value-of-k-in-kmeans/

from sklearn.cluster import KMeans
from sklearn import metrics
from scipy.spatial.distance import cdist
import numpy as np
import matplotlib.pyplot as plt
inertias = []
mapping = {}
K = range(1,11)

for k in tqdm(K):
  #Building and fitting the model
  kmeanModel = KMeans(n_clusters=k).fit(data_train_best_k)
  kmeanModel.fit(data_train_best_k)
  inertias.append(kmeanModel.inertia_)
  mapping[k] = kmeanModel.inertia_
```

```
100%|██████████| 10/10 [04:15<00:00, 29.32s/it]
```

```
# https://www.geeksforgeeks.org/elbow-method-for-optimal-value-of-k-in-kmeans/

for key,val in mapping.items():
    print(str(key)+' : '+str(val))

plt.plot(K, inertias, 'bx-')
plt.xlabel('Values of K')
plt.ylabel('Inertia')
plt.title('The Elbow Method using Inertia')
plt.show()
```

```
1 : 13635.873158010869
2 : 12049.628197527496
3 : 11117.85477140785
4 : 10740.63318672
5 : 10231.326085158418
6 : 9958.712920229018
7 : 9831.32366635334
8 : 9554.609353460295
9 : 9551.586223409699
10 : 9408.724927873958
```



2.2.2.2 Apply K-Means on Best K

```
optimal_k = 7
kmeans = KMeans(n_clusters=optimal_k, n_jobs=-1).fit(data_train_best_k)
```

```
essay = data['preprocessed_essays'].iloc[0:5000].values
print(essay)
```

```
['i fortunate enough use fairy tale stem kits classroom well stem journals st
 'imagine 8 9 years old you third grade classroom you see bright lights kid n
 'having class 24 students comes diverse learners some students learn best au
 ...
 'why students special put good mood everyday i arrive school we located one
 'the students i serve attending college preparatory school our school high p
 'the fifth graders classroom often times struggle read home many not books t
```

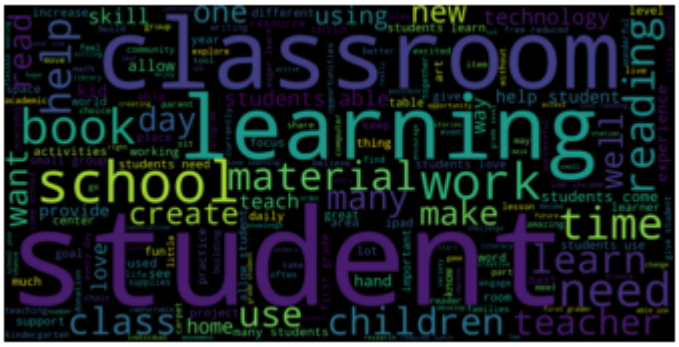
2.2.2.3 Plot Word cloud for each Cluster

```
# How to plot word cloud for each cluster
# https://www.datacamp.com/community/tutorials/wordcloud-python
# https://stackoverflow.com/questions/56050925/plotting-wordcloud-for-each-cluster

cluster_1 = []
cluster_2 = []
cluster_3 = []
```

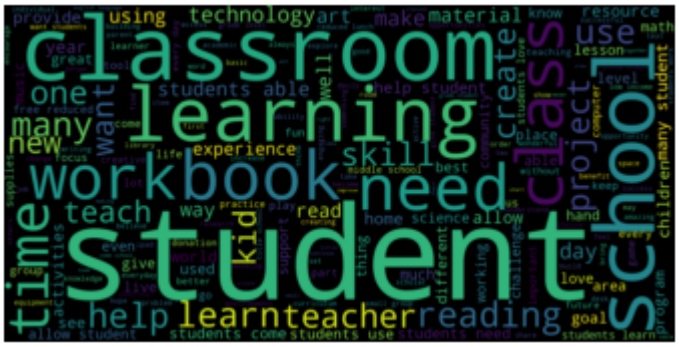
```
cluster_4 = []
cluster_5 = []
cluster_6 = []
cluster_7 = []
for i in range(kmeans.labels_.shape[0]):
  if kmeans.labels_[i] == 0:
    cluster_1.append(essay[i])
  if kmeans.labels_[i] == 1:
    cluster_2.append(essay[i])
  if kmeans.labels_[i] == 2:
    cluster_3.append(essay[i])
  if kmeans.labels_[i] == 3:
    cluster_4.append(essay[i])
  if kmeans.labels_[i] == 4:
    cluster_5.append(essay[i])
  if kmeans.labels_[i] == 5:
    cluster_6.append(essay[i])
  if kmeans.labels_[i] == 6:
    cluster_7.append(essay[i])
```

```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_1:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```


```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_2:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

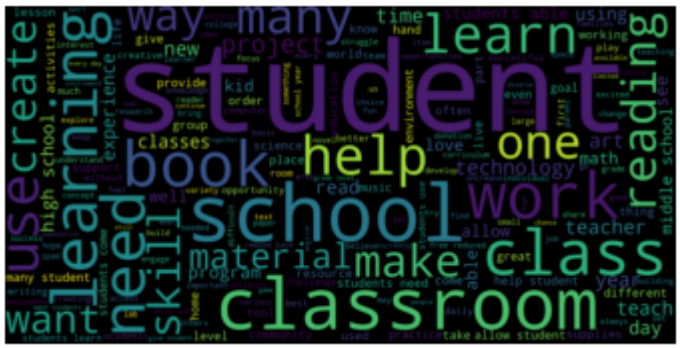



```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_3:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

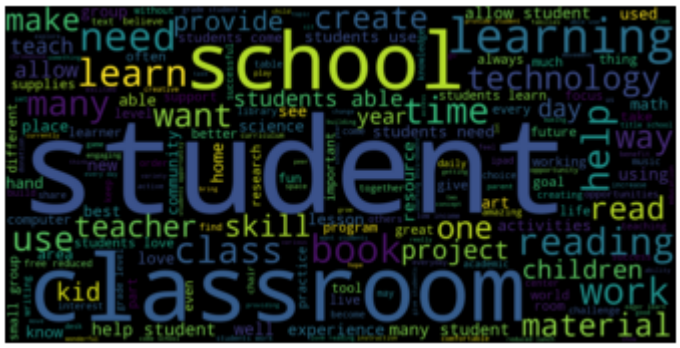



```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_4:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_5:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```




```
from wordcloud import WordCloud

words_in_cluster=''
for i in cluster_6:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



2.2.3 Agglomerative Clustering

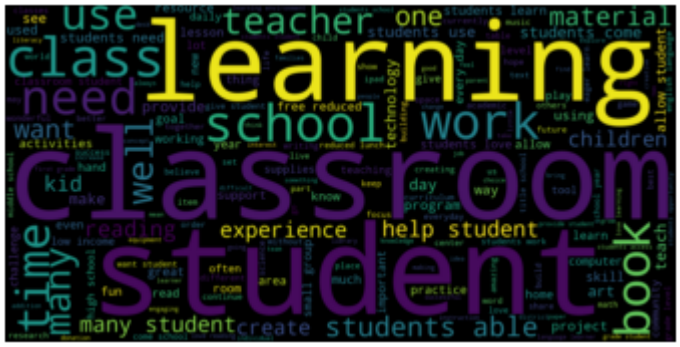
2.2.3.1 Agglomerative clustering for 2 clusters

```
# https://www.geeksforgeeks.org/implementing-agglomerative-clustering-using-sklear
# https://scikit-learn.org/stable/modules/generated/sklearn.cluster.AgglomerativeC
# https://stackabuse.com/hierarchical-clustering-with-python-and-scikit-learn/
```

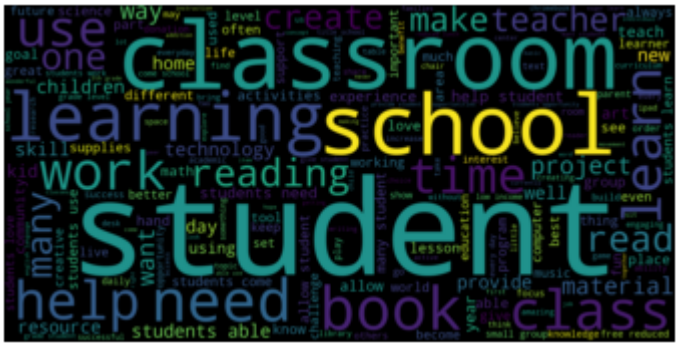
```
from sklearn.cluster import AgglomerativeClustering
ac2=AgglomerativeClustering(n_clusters=2).fit(data_train_best_k.toarray())


cluster_1 = []
cluster_2 = []

for i in range(ac2.labels_.shape[0]):
  if ac2.labels_[i] == 0:
    cluster_1.append(essay[i])
  if ac2.labels_[i] == 1:
    cluster_2.append(essay[i])
```

2.2.3.2 Plotting word cloud for 2 clusters

```
words_in_cluster=''
for i in cluster_1:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```




```
words_in_cluster=''
for i in cluster_2:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



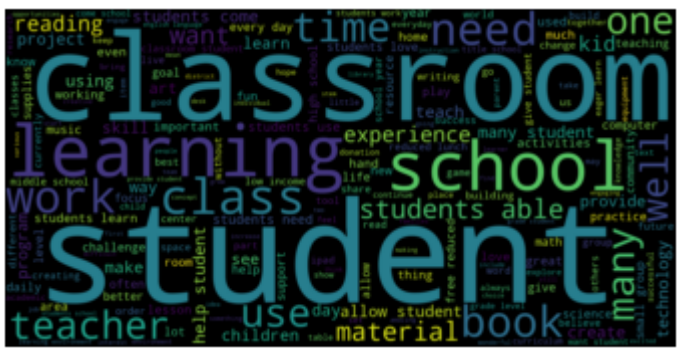
2.2.3.3 Agglomerative Clustering for 3 clusters

```
from sklearn.cluster import AgglomerativeClustering
ac2=AgglomerativeClustering(n_clusters=3).fit(data_train_best_k.toarray())
```

```
cluster_1 = []
cluster_2 = []
cluster_3 = []
for i in range(ac2.labels_.shape[0]):
  if ac2.labels_[i] == 0:
    cluster_1.append(essay[i])
  if ac2.labels_[i] == 1:
    cluster_2.append(essay[i])
  if ac2.labels_[i] == 2:
    cluster_3.append(essay[i])
```

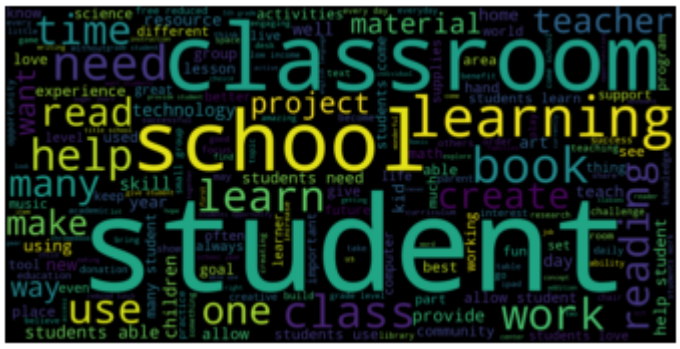
2.2.3.4 PLotting word cloud for 3 clusters

```
words_in_cluster=''
for i in cluster_1:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

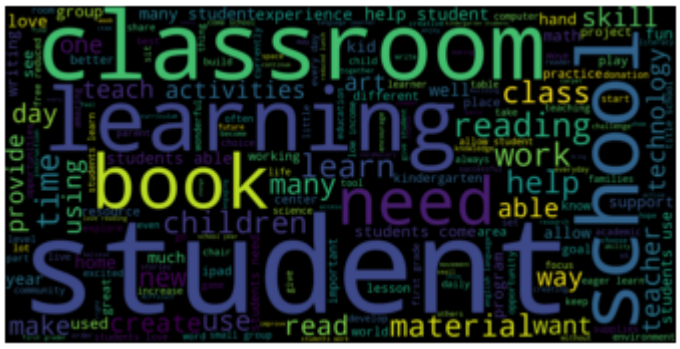



```
words_in_cluster=''
```

```
for i in cluster_2:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```




```
words_in_cluster=''
for i in cluster_3:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



2.2.3.5 Agglomerative clustering for 4 clusters

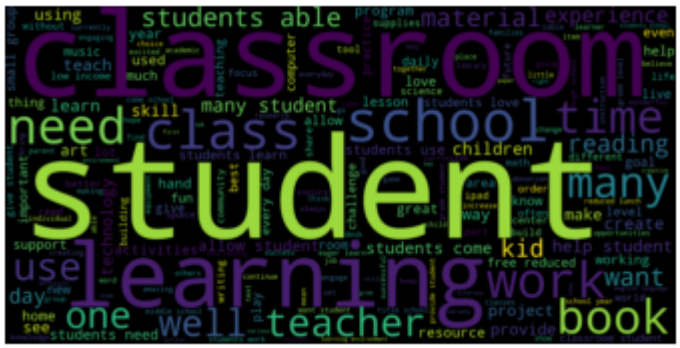
```
from sklearn.cluster import AgglomerativeClustering
ac2=AgglomerativeClustering(n_clusters=4).fit(data_train_best_k.toarray())
```

```
cluster_1 = []
cluster_2 = []
cluster_3 = []
cluster_4 = []
for i in range(ac2.labels_.shape[0]):
  if ac2.labels_[i] == 0:
    cluster_1.append(essay[i])
  if ac2.labels_[i] == 1:
    cluster_2.append(essay[i])
  if ac2.labels_[i] == 2:
```

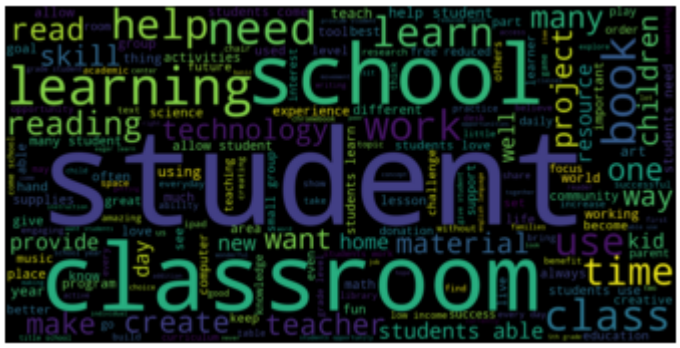
```
    if ac2.labels_[i] == 2:
      cluster_3.append(essay[i])
    if ac2.labels_[i] == 3:
      cluster_4.append(essay[i])
```

2.2.3.6 Plotting word cloud for 4 clusters

```
words_in_cluster=''
for i in cluster_1:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

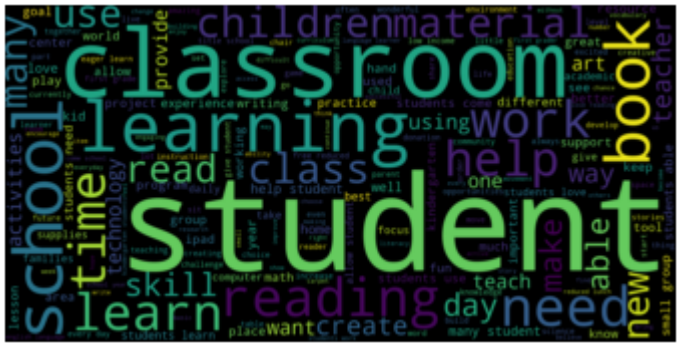



```
words_in_cluster=''
for i in cluster_2:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

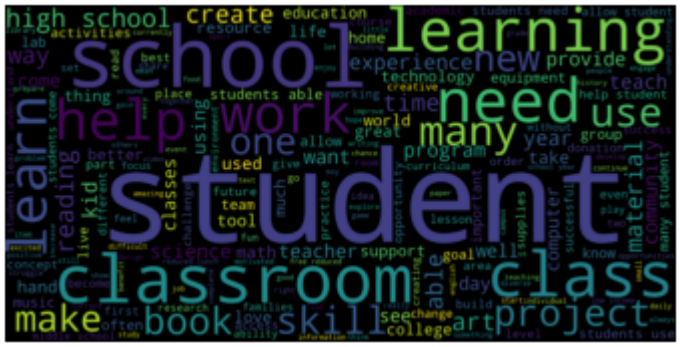



```
words_in_cluster=''
for i in cluster_3:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
```

```
plt.show()
```




```
words_in_cluster=''
for i in cluster_4:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
#wordcloud = WordCloud(background_color="white").generate(words)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



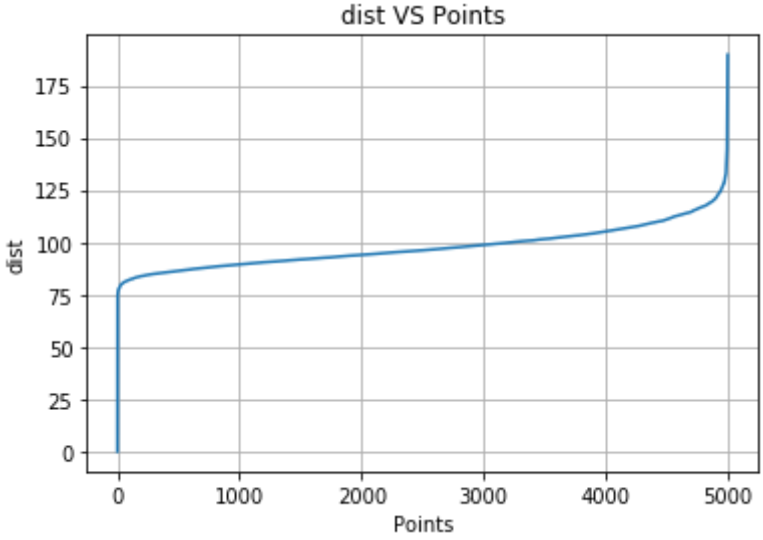
2.2.4 DBSCAN Algorithm

2.2.4.1 Find best eps using distance vs points graph

```
# How to choose eps in DBSCAN
# https://askdatascience.com/646/dbscan-algorithm-how-should-choose-optimal-minimu
# https://towardsdatascience.com/machine-learning-clustering-dbscan-determine-the-

min_points = 2000
from sklearn.preprocessing import StandardScaler
from sklearn.metrics.pairwise import euclidean_distances

eps_data = data_train_best_k.toarray();
eps_data=StandardScaler().fit_transform(eps_data)
distance=[]
for point in tqdm(eps_data):
  dist = euclidean_distances(eps_data, point.reshape(1, -1))
  distance.append(dist[min_points])
```

```
sorted_distance = np.sort(np.array(distance))
sorted_dist = np.sort(sorted_distance.reshape(1,-1)[0])

points = [i for i in range(len(eps_data))]
plt.plot(points, sorted_dist)
plt.xlabel('Points')
plt.ylabel('dist')
plt.title('dist VS Points')
plt.grid()
plt.show()
```

```
100%|██████████| 5000/5000 [05:13<00:00, 15.91it/s]
```



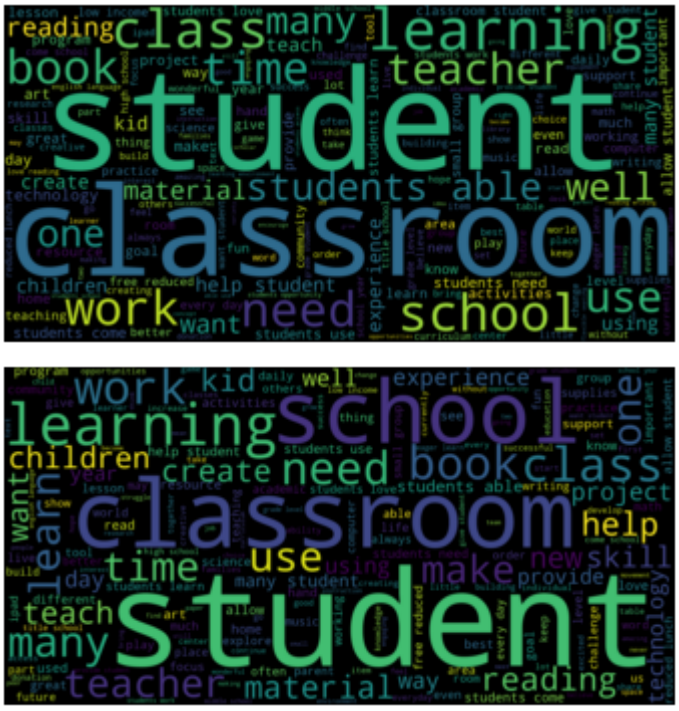
2.2.4.2 Use best eps and min points for finding number of clusters

```
from sklearn.cluster import DBSCAN
dbscan = DBSCAN(eps=80,n_jobs=-1)
dbscan.fit(eps_data)
print('No of clusters: ',len(set(dbscan.labels_)))
```

```
No of clusters:  2
```

```
cluster_1=[]
cluster_2=[]
for i in range(dbscan.labels_.shape[0]):
  if dbscan.labels_[i] == 0:
    cluster_1.append(essay[i])
  if dbscan.labels_[i] == -1:
    cluster_2.append(essay[i])
words_in_cluster=''
for i in cluster_1:
  words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
words_in_cluster=''
for i in cluster_2:
```

```
    words_in_cluster = words_in_cluster + str(i)
wordcloud = WordCloud(width = 2000, height = 1000).generate(words_in_cluster)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



3.1 Conclusions of Clustering on Donors choose

3.1.1 K-Means Clustering

1. Since the dataset is large, only first 5k points are taken under consideration.
2. SelectKBest is used to select best 5000 features.
3. Optimal K is selected from range 1 to 11, which turned out to be 7 using elbow method. (Inertia vs K plot)
4. Trained the model and separated essay text feature into 7 different clusters. Word cloud is plotted for all

3.1.2 Agglomerative Clustering

1. Since the dataset is large, only first 5k points are taken under consideration.
2. SelectKBest is used to select best 5000 features. So data matrix is 5k X 5k
3. Trained Agglomerative clustering on 2,3 and 4 clusters.
4. Word cloud is plotted for all of the 2,3 and 4 clusters.

3.1.3 DBSCAN Algorithm

1. Covert sparse matrix to dense matrix.
2. Two hyperparameters are to be taken under consideration. MinPoint and eps.
3. If we select very low minpts, then there is a high chance of creating a cluster for outliers. One heuristic ap
   points to be clustered.
4. To select epsilon, elbow - knee method has been used by plotting a graph of distance vs points.
5. From the above graph, best eps is selected as 80.
6. Trained DBSCAN on min points = 2000 and eps =80
7. Plotted the word cloud for noise and non noise clusters.

3.2 Summary

```
# To summarize the results:
# summary table in jupyter notebook
# http://zetcode.com/python/prettytable/
# https://stackoverflow.com/questions/35160256/how-do-i-output-lists-as-a-table-in

from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Algorithm","Vectorizer","Hyperparameter/s"]

x.add_row(["K-Means", "TF-IDF","K = 7"])
x.add_row(["Agglomerative","TF-IDF", "Number of clusters = 2,3,4"])
x.add_row(["DBSCAN", "TF_IDF","MinPts = 2000, eps = 90, clusters = 2"])


print(x)
```

```
+---------------+------------+---------------------------------------+
|   Algorithm   | Vectorizer |            Hyperparameter/s           |
+---------------+------------+---------------------------------------+
|    K-Means    |   TF-IDF   |                 K = 7                 |
| Agglomerative |   TF-IDF   |       Number of clusters = 2,3,4      |
|     DBSCAN    |   TF_IDF   | MinPts = 2000, eps = 90, clusters = 2 |
+---------------+------------+---------------------------------------+
```