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	Desc
`project_id`	A unique identifier for the proposed project. **Example:** `p0`
`project_title`	Title of the project. **Exa** • `Art Will Make You H` • `First Grad`
`project_grade_category`	Grade level of students for which the project is targeted. One of the fo enumerated v • `Grades P` • `Grade` • `Grade` • `Grades`

Feature	Desc
`project_subject_categories`	One or more (comma-separated) subject categories for the project fr following enumerated list of v • `Applied Lea` • `Care & H` • `Health & S` • `History & C` • `Literacy & Lan` • `Math & Sc` • `Music & The` • `Special` • `W` **Exar** • `Music & The` • `Literacy & Language, Math & Sc`
`school_state`	State where school is located ([Two-letter U.S. post (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_c](https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_c) **Exampl**
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the p **Exar** • `Lit` • `Literature & Writing, Social Sci`
`project_resource_summary`	An explanation of the resources needed for the project. **Exa** • `My students need hands on literacy materials to ma sensory needs!<`
`project_essay_1`	First application
`project_essay_2`	Second application
`project_essay_3`	Third application
`project_essay_4`	Fourth application
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-( 12:43:5`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Exa** `bdf8baa8fedef6bfeec7ae4ff1c`
`teacher_prefix`	Teacher's title. One of the following enumerated v • • • • • • `Tea`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same te **Examp**

[*] 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`

Feature	Description
`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 [0]:

```
!pip install chart_studio
```

```
...
```

In [0]:

```
%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

from tqdm import tqdm
import os

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

In [0]:

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

```
...
```

1.1 Reading Data

In [0]:

```
project_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/train_data.csv')
resource_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/resources.csv')
```

In [0]:

```
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' 's
chool_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 [0]:

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

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

Out[52]:

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

In [0]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [0]:

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

Out[54]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

1.2 preprocessing of `project_subject_categories`

In [0]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

# 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", '
        if 'The' in j.split(): # this will split each of the catogory based on space "Math
            j=j.replace('The','') # if we have the words "The" we are going to replace it w
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math
        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 [0]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

# 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", '
        if 'The' in j.split(): # this will split each of the catogory based on space "Math
            j=j.replace('The','') # if we have the words "The" we are going to replace it w
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math
        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 [0]:

```
# 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 [0]:

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

Out[58]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

In [0]:

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

In [0]:

```
# 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)
```

```
My students are English learners that are working on English as their second
or third languages. We are a melting pot of refugees, immigrants, and native
-born Americans bringing the gift of language to our school. \r\n\r\n We hav
e over 24 languages represented in our English Learner program with students
at every level of mastery.  We also have over 40 countries represented with
the families within our school.  Each student brings a wealth of knowledge a
nd experiences to us that open our eyes to new cultures, beliefs, and respec
t.\"The limits of your language are the limits of your world.\"-Ludwig Wittg
enstein  Our English learner's have a strong support system at home that beg
s for more resources.  Many times our parents are learning to read and speak
English along side of their children.  Sometimes this creates barriers for p
arents to be able to help their child learn phonetics, letter recognition, a
nd other reading skills.\r\n\r\nBy providing these dvd's and players, studen
ts are able to continue their mastery of the English language even if no one
at home is able to assist.  All families with students within the Level 1 pr
oficiency status, will be a offered to be a part of this program.  These edu
cational videos will be specially chosen by the English Learner Teacher and
will be sent home regularly to watch.  The videos are to help the child deve
lop early reading skills.\r\n\r\nParents that do not have access to a dvd pl
ayer will have the opportunity to check out a dvd player to use for the yea
r.  The plan is to use these videos and educational dvd's for the years to c
ome for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year a
ll love learning, at least most of the time. At our school, 97.3% of the stu
dents receive free or reduced price lunch. Of the 560 students, 97.3% are mi
nority students. \r\nThe school has a vibrant community that loves to get to
gether and celebrate. Around Halloween there is a whole school parade to sho
w off the beautiful costumes that students wear. On Cinco de Mayo we put on
a big festival with crafts made by the students, dances, and games. At the e
nd of the year the school hosts a carnival to celebrate the hard work put in
during the school year, with a dunk tank being the most popular activity.My
students will use these five brightly colored Hokki stools in place of regul
ar, stationary, 4-legged chairs. As I will only have a total of ten in the c
lassroom and not enough for each student to have an individual one, they wil
l be used in a variety of ways. During independent reading time they will be
used as special chairs students will each use on occasion. I will utilize th
em in place of chairs at my small group tables during math and reading time
s. The rest of the day they will be used by the students who need the highes
t amount of movement in their life in order to stay focused on school.\r\n\r
\nWhenever asked what the classroom is missing, my students always say more
Hokki Stools. They can't get their fill of the 5 stools we already have. Whe
n the students are sitting in group with me on the Hokki Stools, they are al
ways moving, but at the same time doing their work. Anytime the students get
to pick where they can sit, the Hokki Stools are the first to be taken. Ther
e are always students who head over to the kidney table to get one of the st
ools who are disappointed as there are not enough of them. \r\n\r\nWe ask a
```

lot of students to sit for 7 hours a day. The Hokki stools will be a comprom
ise that allow my students to do desk work and move at the same time. These
stools will help students to meet their 60 minutes a day of movement by allo
wing them to activate their core muscles for balance while they sit. For man
y of my students, these chairs will take away the barrier that exists in sch
ools for a child who can't sit still.nannan
==
How do you remember your days of school? Was it in a sterile environment wit
h plain walls, rows of desks, and a teacher in front of the room? A typical
day in our room is nothing like that. I work hard to create a warm inviting
themed room for my students look forward to coming to each day.\r\n\r\nMy cl
ass is made up of 28 wonderfully unique boys and girls of mixed races in Ark
ansas.\r\nThey attend a Title I school, which means there is a high enough p
ercentage of free and reduced-price lunch to qualify. Our school is an \"ope
n classroom\" concept, which is very unique as there are no walls separating
the classrooms. These 9 and 10 year-old students are very eager learners; th
ey are like sponges, absorbing all the information and experiences and keep
on wanting more.With these resources such as the comfy red throw pillows and
the whimsical nautical hanging decor and the blue fish nets, I will be able
to help create the mood in our classroom setting to be one of a themed nauti
cal environment. Creating a classroom environment is very important in the s
uccess in each and every child's education. The nautical photo props will be
used with each child as they step foot into our classroom for the first time
on Meet the Teacher evening. I'll take pictures of each child with them, hav
e them developed, and then hung in our classroom ready for their first day o
f 4th grade. This kind gesture will set the tone before even the first day
of school! The nautical thank you cards will be used throughout the year by
the students as they create thank you cards to their team groups.\r\n\r\nYou
r generous donations will help me to help make our classroom a fun, invitin
g, learning environment from day one.\r\n\r\nIt costs lost of money out of m
y own pocket on resources to get our classroom ready. Please consider helpin
g with this project to make our new school year a very successful one. Thank
you!nannan
==
My kindergarten students have varied disabilities ranging from speech and la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations. \r\n\r\nThe materials we have are the ones I seek out for my stu
dents. I teach in a Title I school where most of the students receive free o
r reduced price lunch. Despite their disabilities and limitations, my stude
nts love coming to school and come eager to learn and explore.Have you ever
felt like you had ants in your pants and you needed to groove and move as yo
u were in a meeting? This is how my kids feel all the time. The want to be a
ble to move as they learn or so they say.Wobble chairs are the answer and I
love then because they develop their core, which enhances gross motor and in
Turn fine motor skills. \r\nThey also want to learn through games, my kids d
on't want to sit and do worksheets. They want to learn to count by jumping a
nd playing. Physical engagement is the key to our success. The number toss a
nd color and shape mats can make that happen. My students will forget they a
re doing work and just have the fun a 6 year old deserves.nannan
==
The mediocre teacher tells. The good teacher explains. The superior teacher
demonstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school
has 803 students which is makeup is 97.6% African-American, making up the la
rgest segment of the student body. A typical school in Dallas is made up of
23.2% African-American students. Most of the students are on free or reduced
lunch. We aren't receiving doctors, lawyers, or engineers children from rich
backgrounds or neighborhoods. As an educator I am inspiring minds of young c
hildren and we focus not only on academics but one smart, effective, efficie
nt, and disciplined students with good character.In our classroom we can uti
lize the Bluetooth for swift transitions during class. I use a speaker which

```
doesn't amplify the sound enough to receive the message. Due to the volume o
f my speaker my students can't hear videos or books clearly and it isn't mak
ing the lessons as meaningful. But with the bluetooth speaker my students wi
ll be able to hear and I can stop, pause and replay it at any time.\r\nThe c
art will allow me to have more room for storage of things that are needed fo
r the day and has an extra part to it I can use.  The table top chart has al
l of the letter, words and pictures for students to learn about different le
tters and it is more accessible.nannan
==================================================
```

In [0]:

```python
# 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 [0]:

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

```
My kindergarten students have varied disabilities ranging from speech and la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations. \r\n\r\nThe materials we have are the ones I seek out for my stu
dents. I teach in a Title I school where most of the students receive free o
r reduced price lunch.  Despite their disabilities and limitations, my stude
nts love coming to school and come eager to learn and explore.Have you ever 
felt like you had ants in your pants and you needed to groove and move as yo
u were in a meeting? This is how my kids feel all the time. The want to be a
ble to move as they learn or so they say.Wobble chairs are the answer and I 
love then because they develop their core, which enhances gross motor and in
Turn fine motor skills. \r\nThey also want to learn through games, my kids d
o not want to sit and do worksheets. They want to learn to count by jumping 
and playing. Physical engagement is the key to our success. The number toss 
and color and shape mats can make that happen. My students will forget they 
are doing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [0]:

```
# \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)
```

```
My kindergarten students have varied disabilities ranging from speech and la
nguage delays, cognitive delays, gross/fine motor delays, to autism. They ar
e eager beavers and always strive to work their hardest working past their l
imitations.     The materials we have are the ones I seek out for my student
s. I teach in a Title I school where most of the students receive free or re
duced price lunch.  Despite their disabilities and limitations, my students
love coming to school and come eager to learn and explore.Have you ever felt
like you had ants in your pants and you needed to groove and move as you wer
e in a meeting? This is how my kids feel all the time. The want to be able t
o move as they learn or so they say.Wobble chairs are the answer and I love
then because they develop their core, which enhances gross motor and in Turn
fine motor skills.   They also want to learn through games, my kids do not w
ant to sit and do worksheets. They want to learn to count by jumping and pla
ying. Physical engagement is the key to our success. The number toss and col
or and shape mats can make that happen. My students will forget they are doi
ng work and just have the fun a 6 year old deserves.nannan
```

In [0]:

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

```
My kindergarten students have varied disabilities ranging from speech and la
nguage delays cognitive delays gross fine motor delays to autism They are ea
ger beavers and always strive to work their hardest working past their limit
ations The materials we have are the ones I seek out for my students I teach
in a Title I school where most of the students receive free or reduced price
lunch Despite their disabilities and limitations my students love coming to
school and come eager to learn and explore Have you ever felt like you had a
nts in your pants and you needed to groove and move as you were in a meeting
This is how my kids feel all the time The want to be able to move as they le
arn or so they say Wobble chairs are the answer and I love then because they
develop their core which enhances gross motor and in Turn fine motor skills
They also want to learn through games my kids do not want to sit and do work
sheets They want to learn to count by jumping and playing Physical engagemen
t is the key to our success The number toss and color and shape mats can mak
e that happen My students will forget they are doing work and just have the
fun a 6 year old deserves nannan
```

In [0]:

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

In [0]:

```
# 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):
    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())
```

```
100%|██████████| 109248/109248 [01:02<00:00, 1747.49it/s]
```

In [0]:

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

Out[67]:

```
'my kindergarten students varied disabilities ranging speech language delays
cognitive delays gross fine motor delays autism they eager beavers always st
rive work hardest working past limitations the materials ones i seek student
s i teach title i school students receive free reduced price lunch despite d
isabilities limitations students love coming school come eager learn explore
have ever felt like ants pants needed groove move meeting this kids feel tim
e the want able move learn say wobble chairs answer i love develop core enha
nces gross motor turn fine motor skills they also want learn games kids not
want sit worksheets they want learn count jumping playing physical engagemen
t key success the number toss color shape mats make happen my students forge
t work fun 6 year old deserves nannan'
```

In [0]:

```
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
project_data.head(2)
```

Out[68]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

1.4 Preprocessing of `project_title`

In [0]:

```
# printing some random project title.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[99999])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
We Need To Move It While We Input It!
==================================================
Inspiring Minds by Enhancing the Educational Experience
==================================================
```

In [0]:

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

```
We Need To Move It While We Input It!
==================================================
```

In [0]:

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

```
100%|██████████| 109248/109248 [00:02<00:00, 40529.59it/s]
```

In [0]:

```
#after preprocessing
preprocessed_titles[20000]
```

Out[72]:

```
'we need to move it while we input it'
```

In [0]:

```
project_data['preprocessed_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(2)
```

Out[73]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

1.5 Preprocessing project_resource_summary

In [0]:

```
# printing some random project_resource_summary.
print(project_data['project_resource_summary'].values[0])
print("="*50)
print(project_data['project_resource_summary'].values[150])
print("="*50)
print(project_data['project_resource_summary'].values[1000])
print("="*50)
print(project_data['project_resource_summary'].values[20000])
print("="*50)
print(project_data['project_resource_summary'].values[99999])
print("="*50)
```

```
My students need opportunities to practice beginning reading skills in Engli
sh at home.
==================================================
My students need 5 Hokki stools to increase their movement even while sittin
g.
==================================================
My students need nautical themed items such as red throw pillows and photo b
ooth props for a great start to a new 4th grade year!
==================================================
My students need wobble chairs, number toss games and colors and shapes mats
to make our learning fun, hands on and physically engaging!
==================================================
My students need a CD bluetooth player so they can hear their music clearly
and I can already have it on my phone for great transitions. Plus the flanne
l/ easel for mobility.
==================================================
```

In [0]:

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

```
My students need wobble chairs, number toss games and colors and shapes mats
to make our learning fun, hands on and physically engaging!
==================================================
```

In [0]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_resources = []
# tqdm is for printing the status bars
for sentance in tqdm(project_data['project_resource_summary'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = sent.replace('My students need', ' ')
    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_resources.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:05<00:00, 19707.19it/s]
```

In [0]:

```
preprocessed_resources[20000]
```

Out[77]:

```
'wobble chairs number toss games colors shapes mats make learning fun hands
physically engaging'
```

In [0]:

```
project_data['preprocessed_resources'] = preprocessed_resources
project_data.drop(['project_resource_summary'], axis=1, inplace=True)
project_data.head(2)
```

Out[78]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

1.6 Preprocessing teacher_prefix

In [0]:

```
x = project_data['teacher_prefix'].replace(to_replace= np.nan, value= "mrs")
teacher_prefix_list = list(x.values)
preprocessed_teacher_prefix=[]
for l in tqdm (teacher_prefix_list):
    n = ""
    for e in l:
        e = e.replace('.', '')
        e = e.replace(',', '')
        n+= e
    preprocessed_teacher_prefix.append(n.lower().strip())

print(len(preprocessed_teacher_prefix))
```

```
100%|██████████| 109248/109248 [00:00<00:00, 437852.19it/s]

109248
```

In [0]:

```
project_data['preprocessed_teacher_prefix'] = preprocessed_teacher_prefix
project_data.drop(['teacher_prefix'], axis=1, inplace=True)
project_data.head(2)
```

Out[80]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_date
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:4
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:2

In [0]:

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

In [0]:

```
teacher_prefix_dict = dict(my_counter)
sorted_teacher_prefix_dict = dict(sorted(teacher_prefix_dict.items(), key=lambda kv: kv[1])
print(sorted_teacher_prefix_dict)
```

```
{'dr': 13, 'teacher': 2360, 'mr': 10648, 'ms': 38955, 'mrs': 57272}
```

1.7 Preprocessing project_grade_category

In [0]:

```
project_grade_category_list = list(project_data['project_grade_category'].values)
preprocessed_project_grade_category=[]
for l in tqdm (project_grade_category_list):
    n = ""
    for e in l:
        e = e.replace(' ', '_')
        e = e.replace('-', '_')
        n+= e
    preprocessed_project_grade_category.append(n.lower().strip())

print(len(preprocessed_project_grade_category))
```

```
100%|██████████| 109248/109248 [00:00<00:00, 158446.32it/s]

109248
```

In [0]:

```
project_data['preprocessed_project_grade_category'] = preprocessed_project_grade_category
project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data.head(2)
```

Out[84]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_date
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:4
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:2

Assignment 10: Clustering

- step 1: Choose any vectorizer (data matrix) that you have worked in any of the assignments, and got the best AUC value.
- step 2: Choose any of the feature selection (https://scikit-learn.org/stable/modules/feature_selection.html)/reduction algorithms (https://scikit-learn.org/stable/modules/decomposition.html) ex: selectkbest features, pretrained word vectors, model based feature selection etc and reduce the number of features to 5k features.
- step 3: Apply all three kmeans, Agglomerative clustering, DBSCAN
  - **K-Means Clustering:**
    ● Find the best 'k' using the elbow-knee method (plot k vs inertia_)
  - **Agglomerative Clustering:**
    ● Apply agglomerative algorithm (https://stackabuse.com/hierarchical-clustering-with-python-and-scikit-learn/) and try a different number of clusters like 2,5 etc.
    ● As this is very computationally expensive, take **5k** datapoints only to perform hierarchical clustering because they do take a considerable amount of time to run.
  - **DBSCAN Clustering:**
    ● Find the best 'eps' using the elbow-knee method (https://stackoverflow.com/a/48558030/4084039).
    ● Take **5k** datapoints only.
- step 4: Summarize each cluster by manually observing few points from each cluster.
- step 5: You need to plot the word cloud with essay text for each cluster for each of algorithms mentioned in step 3.

2. Clustering

2.1 Choose the best data matrix on which you got the best AUC

In [0]:

```
project_data.to_csv('data.csv',index=False)
```

In [0]:

```
data = pd.read_csv('data.csv')
data.head(2)
```

Out[86]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_date
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:4
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:2

In [0]:

```
y_train = data['project_is_approved'].values
X_train = data.drop(['project_is_approved'], axis=1)
X_train.head(2)
```

Out[87]:

	Unnamed: 0	id	teacher_id	school_state	project_submitted_date
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	IN	2016-12-05 13:4
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	FL	2016-10-25 09:2

2.2 Make Data Model Ready: encoding numerical, categorical features

2.2.1. encoding categorical features: clean_category

In [0]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_categories_ohe = vectorizer.transform(X_train['clean_categories'].values)
#X_cv_categories_ohe = vectorizer.transform(X_cv['clean_categories'].values)
#X_test_categories_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_categories_ohe.shape, y_train.shape)
#print(X_cv_categories_ohe.shape, y_cv.shape)
#print(X_test_categories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109248, 9) (109248,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'liter
acy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
============================================================================
========================
```

2.2.2.encoding categorical features: clean_sub_category

In [0]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only on train dat

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcategories_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
#X_cv_subcategories_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
#X_test_subcategories_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcategories_ohe.shape, y_train.shape)
#print(X_cv_subcategories_ohe.shape, y_cv.shape)
#print(X_test_subcategories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109248, 30) (109248,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_governmen
t', 'college_careerprep', 'communityservice', 'earlydevelopment', 'economic
s', 'environmentalscience', 'esl', 'extracurricular', 'financialliteracy',
'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_wellness',
'history_geography', 'literacy', 'literature_writing', 'mathematics', 'musi
c', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 's
ocialsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
============================================================================
========================
```

2.2.3. encoding categorical features: School State

In [0]:

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

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = state_vectorizer.transform(X_train['school_state'].values)
#X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
#X_test_state_ohe = state_vectorizer.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
#print(X_cv_state_ohe.shape, y_cv.shape)
#print(X_test_state_ohe.shape, y_test.shape)
print(state_vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109248, 51) (109248,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'i
a', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo',
'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'o
r', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv',
'wy']
============================================================================
========================
```

2.2.4 encoding categorical features: teacher_prefix

In [0]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['preprocessed_teacher_prefix'].values) # fit has to happen only on t

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['preprocessed_teacher_prefix'].values)
#X_cv_teacher_ohe = vectorizer.transform(X_cv['preprocessed_teacher_prefix'].values)
#X_test_teacher_ohe = vectorizer.transform(X_test['preprocessed_teacher_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
#print(X_cv_teacher_ohe.shape, y_cv.shape)
#print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109248, 5) (109248,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
============================================================================
========================
```

In [0]:

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

Out[92]:

```
mrs        57272
ms         38955
mr         10648
teacher     2360
dr            13
Name: preprocessed_teacher_prefix, dtype: int64
```

2.2.5. encoding categorical features: project_grade_category

In [0]:

```
grade_vectorizer = CountVectorizer()
grade_vectorizer.fit(X_train['preprocessed_project_grade_category'].values) # fit has to ha

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = grade_vectorizer.transform(X_train['preprocessed_project_grade_category
#X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
#X_test_grade_ohe = grade_vectorizer.transform(X_test['preprocessed_project_grade_category'

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
#print(X_cv_grade_ohe.shape, y_cv.shape)
#print(X_test_grade_ohe.shape, y_test.shape)
print(grade_vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(109248, 4) (109248,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
============================================================================
========================
```

2.2.6. encoding numerical features: price

In [0]:

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

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard dev
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])

# Now standardize the data with above maen and variance.
price_standardized_train = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
#price_standardized_test = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
print(price_standardized_train.shape,y_train.shape)
#print(price_standardized_test.shape,y_test.shape)
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
(109248, 1) (109248,)
```

In [0]:

```
price_standardized_train
```

Out[95]:

```
array([[-0.3905327 ],
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

2.2.7 encoding numerical features: teacher_number_of_previously_posted_projects

In [0]:

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

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.
# Reshape your data either using array.reshape(-1, 1)

prev_projects_scalar = StandardScaler()
prev_projects_scalar.fit((X_train['teacher_number_of_previously_posted_projects'].values.as
print(f"Mean : {prev_projects_scalar.mean_[0]}, Standard deviation : {np.sqrt(prev_projects

# Now standardize the data with above maen and variance.
prev_projects_standardized_train = prev_projects_scalar.transform((X_train['teacher_number_
#prev_projects_standardized_test = prev_projects_scalar.transform((X_test['teacher_number_o
print(prev_projects_standardized_train.shape,y_train.shape)
#print(prev_projects_standardized_test.shape,y_test.shape)
```

```
Mean : 11.153165275336848, Standard deviation : 27.77702641477403
(109248, 1) (109248,)
```

In [0]:

```
print(prev_projects_standardized_train)
```

```
[[-0.40152481]
 [-0.14951799]
 [-0.36552384]
 ...
 [-0.29352189]
 [-0.40152481]
 [-0.40152481]]
```

2.2.7 encoding numerical features: quantity

In [0]:

```
quantity_scalar = StandardScaler()
quantity_scalar.fit((X_train['quantity'].values.astype(float)).reshape(-1,1)) # finding the
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.va

# Now standardize the data with above mean and variance.
quantity_standardized_train = quantity_scalar.transform((X_train['quantity'].values.astype(
#quantity_standardized_test = quantity_scalar.transform((X_test['quantity'].values.astype(f
print(quantity_standardized_train.shape,y_train.shape)
#print(quantity_standardized_test.shape,y_test.shape)
```

```
Mean : 16.965610354422964, Standard deviation : 26.182821919093175
(109248, 1) (109248,)
```

In [0]:

```
print(quantity_standardized_train)
```

```
[[ 0.23047132]
 [-0.60977424]
 [ 0.19227834]
 ...
 [-0.4951953 ]
 [-0.03687954]
 [-0.45700232]]
```

2.3 Make Data Model Ready: encoding eassay, and project_title

2.3.1 Bag of words on preprocessed_essays

In [0]:

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

print("="*100)


vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values) # fit has to happen only on train dat

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

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("="*100)
```

```
(109248, 19) (109248,)
============================================================================
========================
After vectorizations
(109248, 5000) (109248,)
============================================================================
========================
```

2.3.2 Bag of words on preprocessed_titles

In [0]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
print(X_train.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
#print(X_test.shape, y_test.shape)

print("="*100)


vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(X_train['preprocessed_titles'].values) # fit has to happen only on train dat

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['preprocessed_titles'].values)
#X_cv_title_bow = vectorizer.transform(X_cv['preprocessed_titles'].values)
#X_test_title_bow = vectorizer.transform(X_test['preprocessed_titles'].values)

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("="*100)
```

```
(109248, 19) (109248,)
============================================================================
========================
After vectorizations
(109248, 5000) (109248,)
============================================================================
========================
```

2.3.3. Merging all the above features

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

In [0]:

```
print(X_train_categories_ohe.shape)
print(X_train_subcategories_ohe.shape)
print(X_train_state_ohe.shape)
print(X_train_grade_ohe.shape)
print(X_train_essay_bow.shape)
print(price_standardized_train.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 51)
(109248, 4)
(109248, 5000)
(109248, 1)
```

In [0]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow, X_train_title_bow, X_train_categories_ohe, X_train_subcat
#X_cr = hstack((X_cv_essay_bow, X_cv_title_bow, X_cv_resources_bow, X_cv_categories_ohe, X_
#X_te = hstack((X_test_essay_bow, X_test_title_bow, X_test_categories_ohe, X_test_subcatego

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
#print(X_cr.shape, y_cv.shape)
#print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(109248, 10102) (109248,)
============================================================================
========================
```

2.4 Dimensionality Reduction on the selected features

In [0]:

```
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import f_classif
X_new = SelectKBest(f_classif, k=5000).fit_transform(X_tr, y_train)
X_new.shape
```

Out[106]:

```
(109248, 5000)
```

In [0]:

```
X_new = X_new[:10000]
X_new.shape
```

Out[107]:

```
(10000, 5000)
```

2.5 Apply Kmeans

In [0]:

```
# please write all the code with proper documentation, and proper titles for each subsectio
# 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 cod
# 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 [0]:

```
from sklearn.cluster import KMeans
n_clstr = [2,4,5,7,8]
inertia = []
for k in tqdm(n_clstr, position= 0, leave= True):
    #print(k)
    kmeans = KMeans(n_clusters= k, random_state=0,n_jobs= -1).fit(X_new)
    inertia.append(kmeans.inertia_)
```

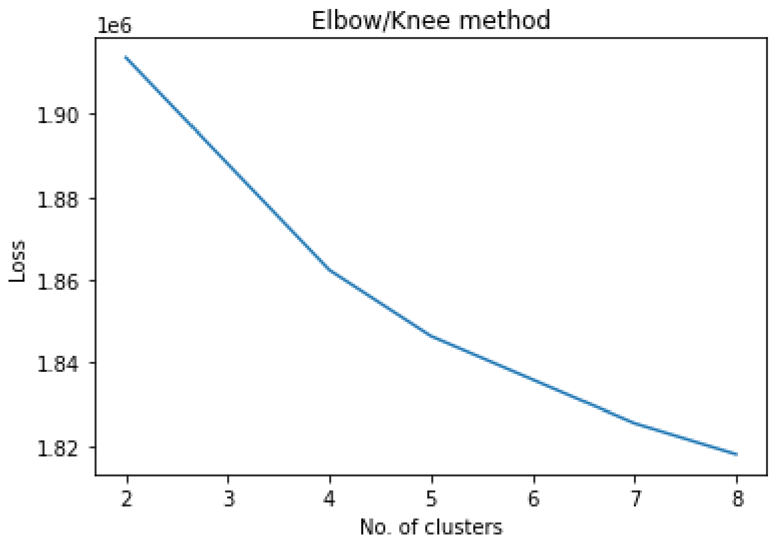
```
100%|██████████| 5/5 [1:25:03<00:00, 1020.74s/it]
```

In [0]:

```
#plot elbow-knee method
plt.plot(n_clstr,inertia)
plt.xlabel("No. of clusters")
plt.ylabel("Loss")
plt.title("Elbow/Knee method")
```

Out[110]:

```
Text(0.5, 1.0, 'Elbow/Knee method')
```



In [0]:

```
optimal_k = 5
kmeans= KMeans(n_clusters = optimal_k, random_state= 0, n_jobs= -1).fit(X_new)
```

In [0]:

```
print(kmeans.labels_)
```

```
[2 0 4 ... 1 2 0]
```

In [0]:

```
np.unique(kmeans.labels_, return_counts= True)
```

Out[114]:

```
(array([0, 1, 2, 3, 4], dtype=int32), array([1785, 3001, 2860,  958, 1396]))
```

In [0]:

```
essay = preprocessed_essays
cluster1=[]
cluster2=[]
cluster3=[]
cluster4=[]
cluster5=[]
for i in range(kmeans.labels_.shape[0]):
    if kmeans.labels_[i] == 0:
        cluster1.append(essay[i])
    elif kmeans.labels_[i]==1 :
        cluster2.append(essay[i])
    elif kmeans.labels_[i]==2 :
        cluster3.append(essay[i])
    elif kmeans.labels_[i]==3 :
        cluster4.append(essay[i])
    elif kmeans.labels_[i]==4 :
        cluster5.append(essay[i])
```

In [0]:

```
print('Length of cluster1 is', len(cluster1))
print('Length of cluster2 is', len(cluster2))
print('Length of cluster3 is', len(cluster3))
print('Length of cluster4 is', len(cluster4))
print('Length of cluster5 is', len(cluster5))
```

```
Length of cluster1 is 1785
Length of cluster2 is 3001
Length of cluster3 is 2860
Length of cluster4 is 958
Length of cluster5 is 1396
```

In [0]:

```
print(cluster2[1000])
```

```
i 26 students kindergarten classroom my class diverse i students many differ
ent levels my kindergartners full life big bright smiles they get excited sc
hool learning they intelligent always asking questions my students constantl
y learning observing exploring new skills practice experience two things kno
w important although school sets bar high kindergarten students always excee
d expectations kindergarten truly rewarding many ways i love watch students 
grow throughout year we live time technology growing advancing students surr
ounded technology every day access daily classroom the addition 3 kindle fir
e tablets classroom help students practice skills learning classroom fun int
eresting way giving important opportunity use technology learn they chance p
ractice skills fun games websites daily skills reinforced my students love w
atch educational videos play interactive games using technology i not wait a
ble use tablets classroom nannan
```

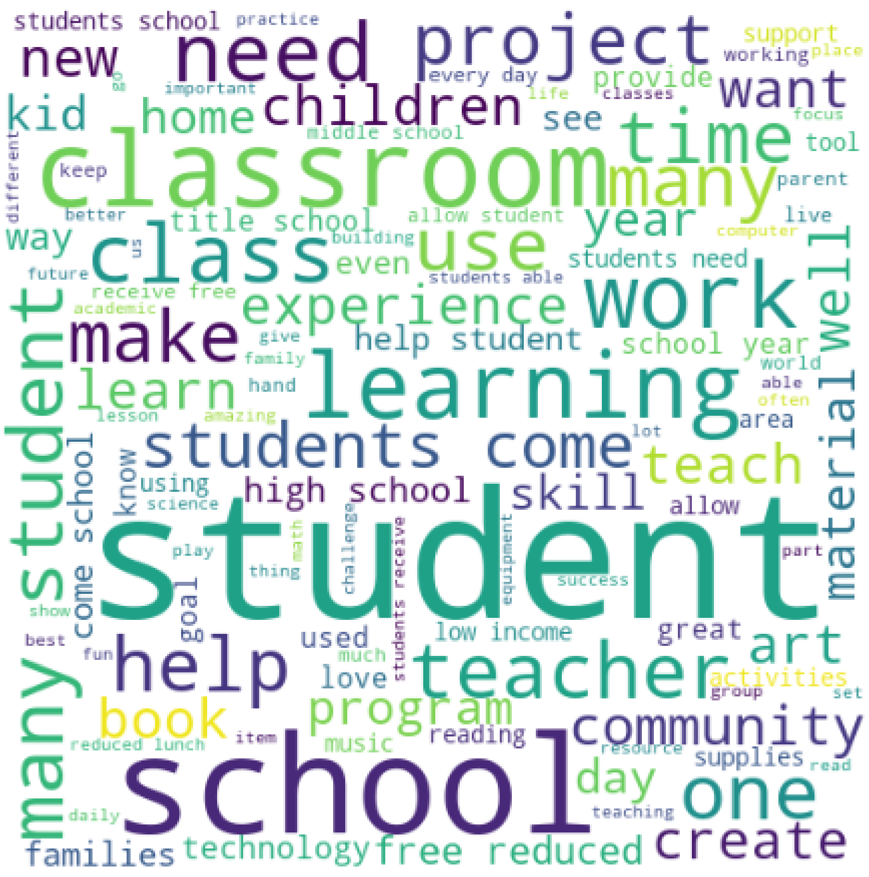
In [0]:

```
import nltk
import string
from nltk.corpus import stopwords

# Python program to generate WordCloud

# importing all necessery modules
from wordcloud import WordCloud, STOPWORDS
def wordcloud(cluster_val):
    comment_words = ' '
    stopwords = ["nannan"] + list(STOPWORDS)
    for val in cluster_val:
        val = str(val) # typecaste each val to string
        tokens = val.split()  # split the value
      # Converts each token into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            comment_words = comment_words + words + ' '
    wordcloud = WordCloud(width = 500, height = 500,
                  background_color ='white',
                  stopwords = stopwords,
                  min_font_size = 10).generate(comment_words)
  # plot the WordCloud image
    plt.figure(figsize = (6, 6), facecolor = None)
    plt.imshow(wordcloud)
    plt.axis("off")
    plt.tight_layout(pad = 0)
    plt.show()
```

In [0]:

```
print('WordCloud with essay text for cluster1 for KMeans')
wordcloud(cluster1)
```

```
WordCloud with essay text for cluster1 for KMeans
```

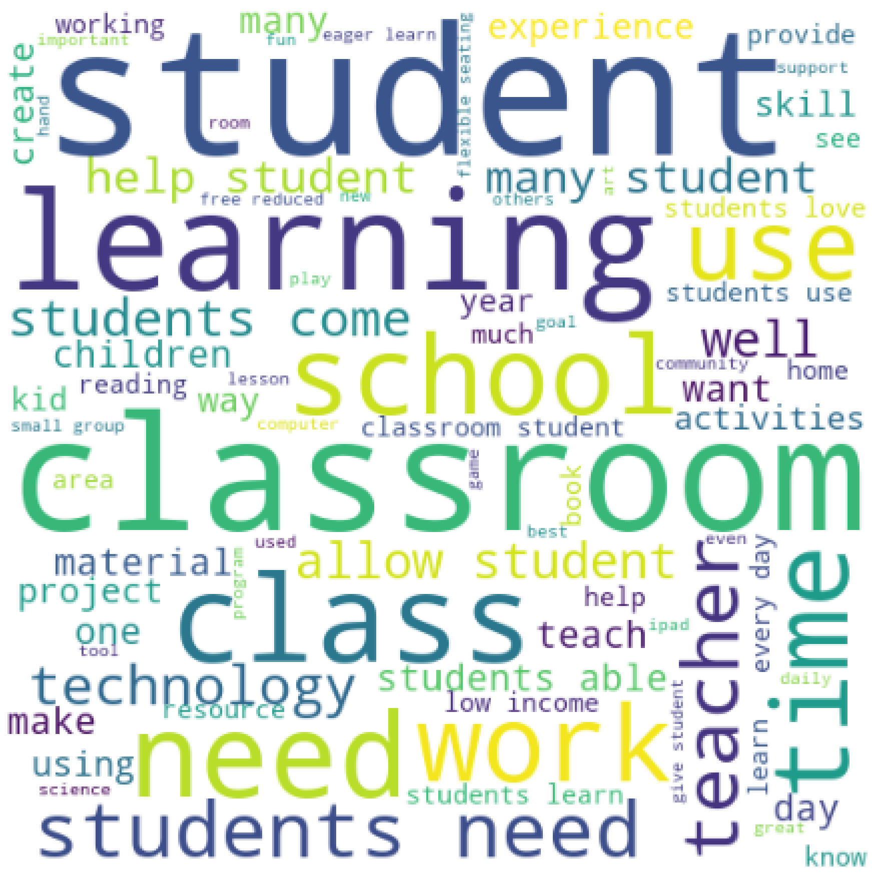


The most frequent words in cluster1 for kmeans are(in descending order): student, school, classroom, learning, work, need, help, project.

In [0]:

```
print('WordCloud with essay text for cluster2 for KMeans')
wordcloud(cluster2)
```

```
WordCloud with essay text for cluster2 for KMeans
```



The most frequent words in cluster2 for kmeans are(in descending order): classroom, student, learning, class, need, work, use.

In [0]:

```
cluster3[100]
```

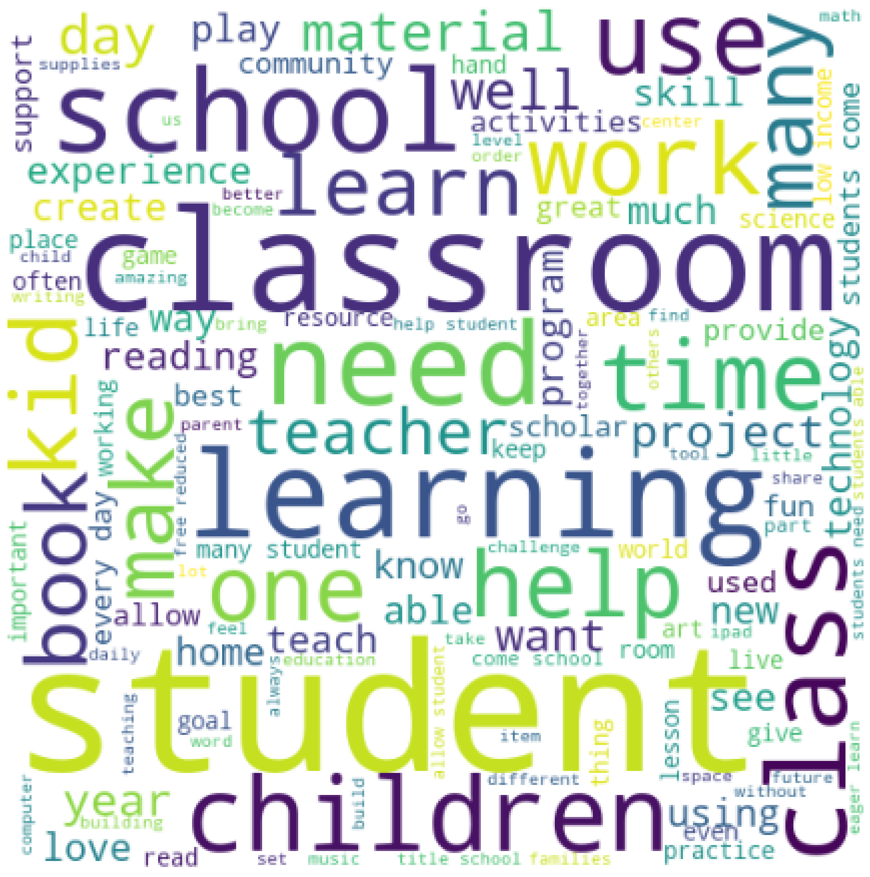
Out[121]:

```
'my 4th grade students smart creative intelligent they story many sad depres
sing working low income community children put smile try best it hard create
atmosphere fully rich materials the school i work old poor neighborhood thes
e students deserve best truly want best not cards my school lacks materials
many supplies limited a notebook create writing poetry notes a folder hold o
pinion piece wrote favorite poem pencils create inspire writer reader map fa
vorite place wish visit these basic needs student families struggle supply i
teacher struggle keep supplies stocked each subject i teach students need pl
ace write take notes research hold work i go pencils need take home night we
lack computers i still write chalk board i use many things i want students c
hildren public schools nannan'
```

In [0]:

```
print('WordCloud with essay text for cluster3 for KMeans')
wordcloud(cluster3)
```

```
WordCloud with essay text for cluster3 for KMeans
```

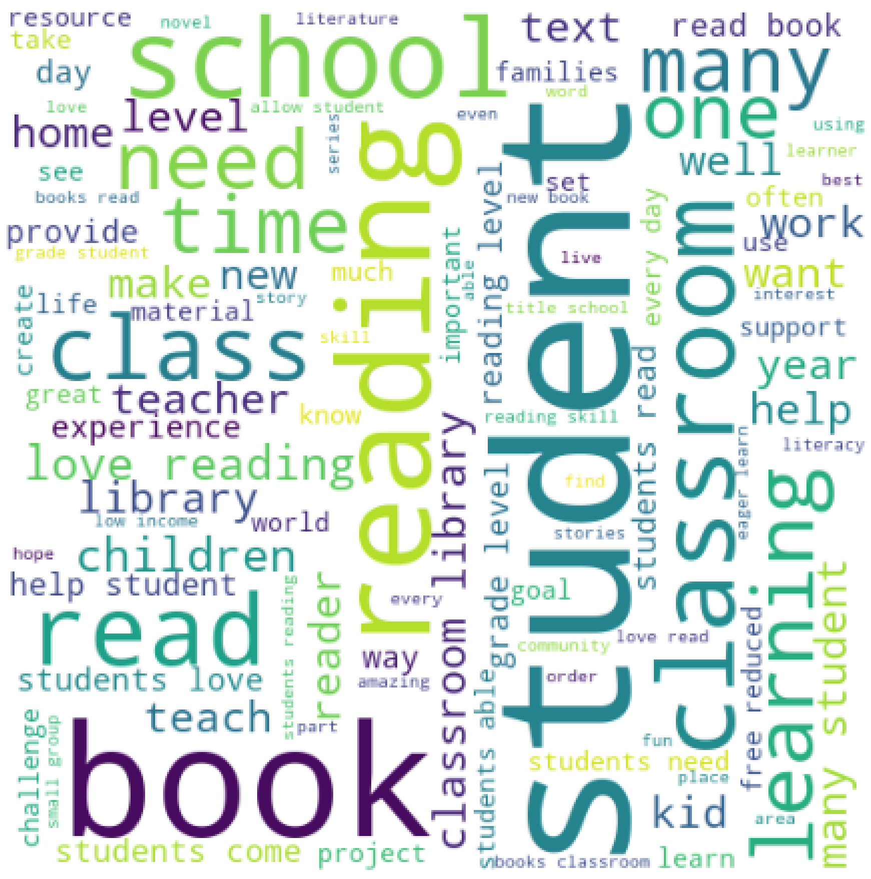


The most frequent words in cluster3 for kmeans are(in descending order): classroom, student, learning, children, school, need, time.

In [0]:

```
print('WordCloud with essay text for cluster4 for KMeans')
wordcloud(cluster4)
```

```
WordCloud with essay text for cluster4 for KMeans
```

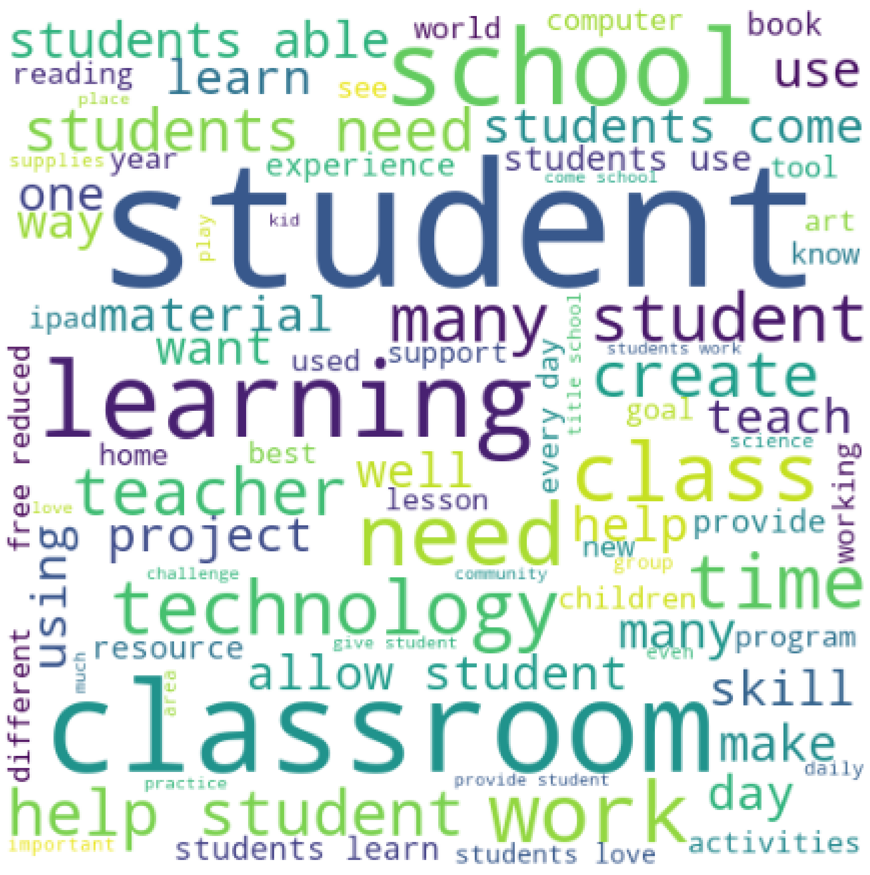


The most frequent words in cluster4 for kmeans are(in descending order): student, reading, book, classroom, school, learning, read.

In [0]:

```
print('WordCloud with essay text for cluster5 for KMeans')
wordcloud(cluster5)
```

```
WordCloud with essay text for cluster5 for KMeans
```



The most frequent words in cluster5 for kmeans are(in descending order): student, classroom, learning, school, technology, work.

2.6 Apply AgglomerativeClustering

In [0]:

```
# please write all the code with proper documentation, and proper titles for each subsectio
# 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 cod
# 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 [0]:

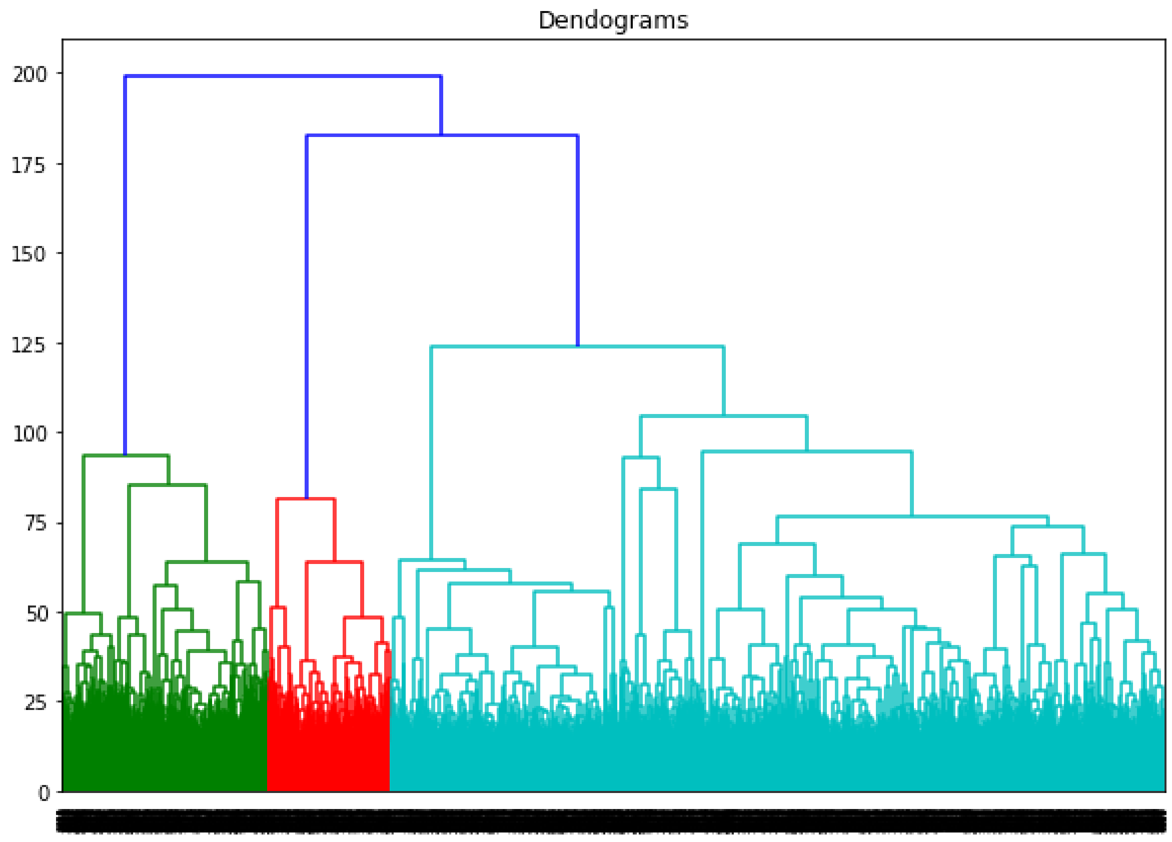
```
X_new1= X_new[:5000]
X_new1.shape
```

Out[125]:

```
(5000, 5000)
```

In [0]:

```
#https://stackabuse.com/hierarchical-clustering-with-python-and-scikit-learn/
import scipy.cluster.hierarchy as shc
data = X_new1.toarray()[:5000]
plt.figure(figsize=(10, 7))
plt.title("Dendograms")
dend = shc.dendrogram(shc.linkage(data, method='ward'))
```



If we draw a horizontal line that passes through longest distance without a horizontal line, we get 4 clusters. So from dendrogram we conclude that the number of clusters is equal to 4.

In [0]:

```
from sklearn.cluster import AgglomerativeClustering
clustering = AgglomerativeClustering(n_clusters= 4, affinity='euclidean',linkage= 'ward').f
clustering.fit_predict(data)
```

Out[164]:

```
array([0, 3, 1, ..., 0, 2, 3])
```

In [0]:

```
np.unique(clustering.labels_, return_counts= True)
```

Out[167]:

```
(array([0, 1, 2, 3]), array([2473,  940,  554, 1033]))
```

In [0]:

```
essay = preprocessed_essays
cluster1=[]
cluster2=[]
cluster3=[]
cluster4=[]
for i in range(clustering.labels_.shape[0]):
    if clustering.labels_[i] == 0:
        cluster1.append(essay[i])
    elif clustering.labels_[i]==1 :
        cluster2.append(essay[i])
    elif clustering.labels_[i]==2 :
        cluster3.append(essay[i])
    elif clustering.labels_[i]==3 :
        cluster4.append(essay[i])
```

In [0]:

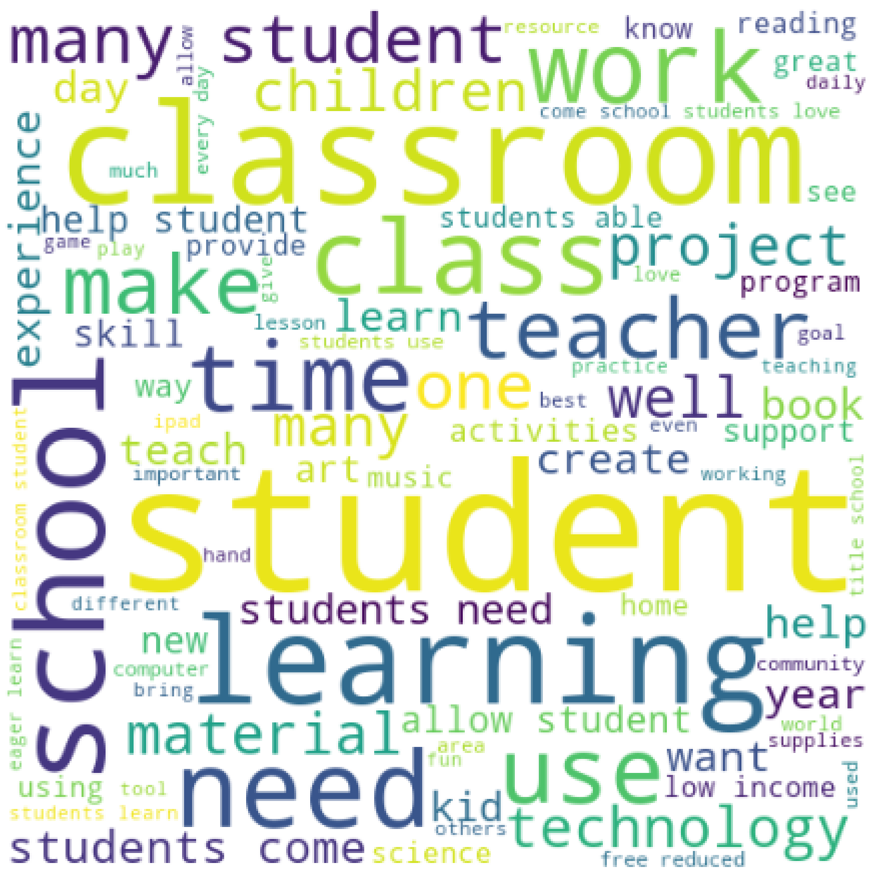
```
print('Length of cluster1 is', len(cluster1))
print('Length of cluster2 is', len(cluster2))
print('Length of cluster3 is', len(cluster3))
print('Length of cluster4 is', len(cluster4))
```

```
Length of cluster1 is 2473
Length of cluster2 is 940
Length of cluster3 is 554
Length of cluster4 is 1033
```

In [0]:

```
print('WordCloud with essay text for cluster1 for AgglomerativeClustering')
wordcloud(cluster1)
```

```
WordCloud with essay text for cluster1 for AgglomerativeClustering
```

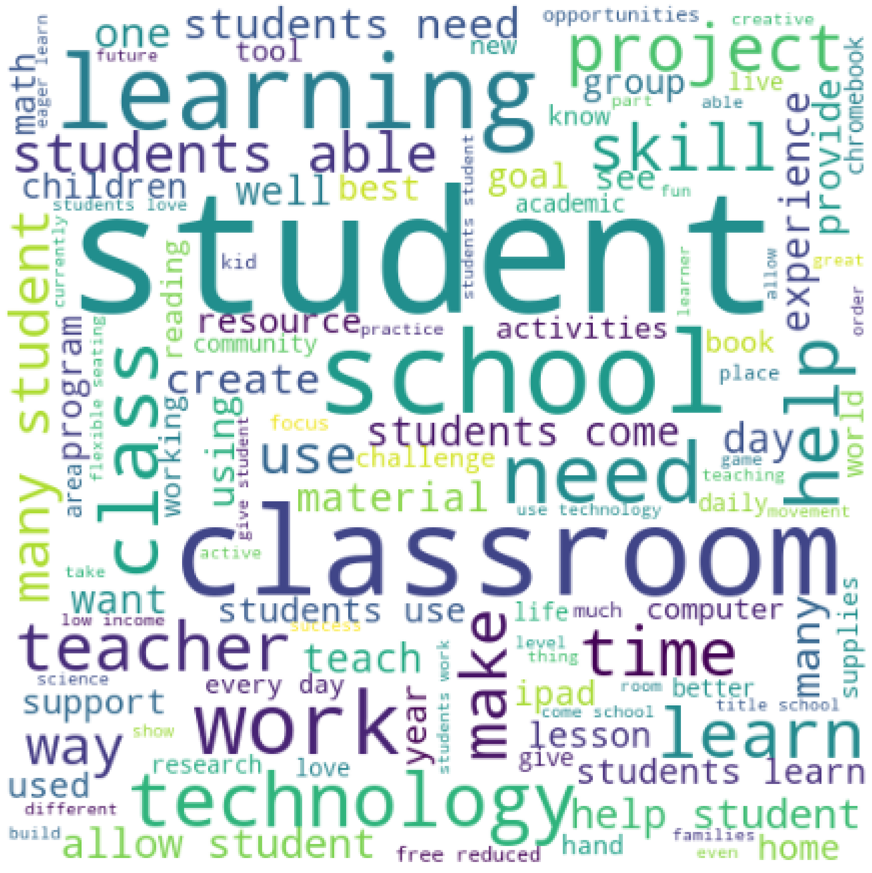


The most frequent words in cluster1 for agglomerative clustering are(in descending order): student, learning, classroom, need, school, class, teacher, time.

In [0]:

```python
print('WordCloud with essay text for cluster2 for AgglomerativeClustering')
wordcloud(cluster2)
```

```
WordCloud with essay text for cluster2 for AgglomerativeClustering
```

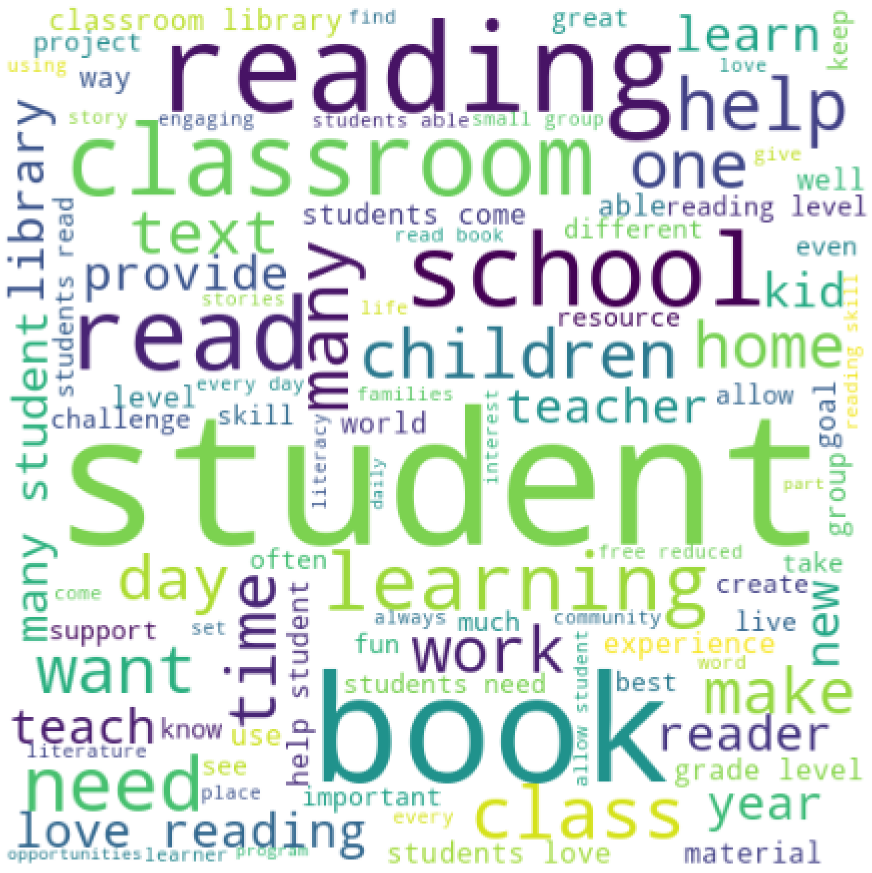


The most frequent words in cluster1 for agglomerative clustering are(in descending order): student, learning, classroom, school, technology, work.

In [0]:

```
print('WordCloud with essay text for cluster3 for AgglomerativeClustering')
wordcloud(cluster3)
```

```
WordCloud with essay text for cluster3 for AgglomerativeClustering
```

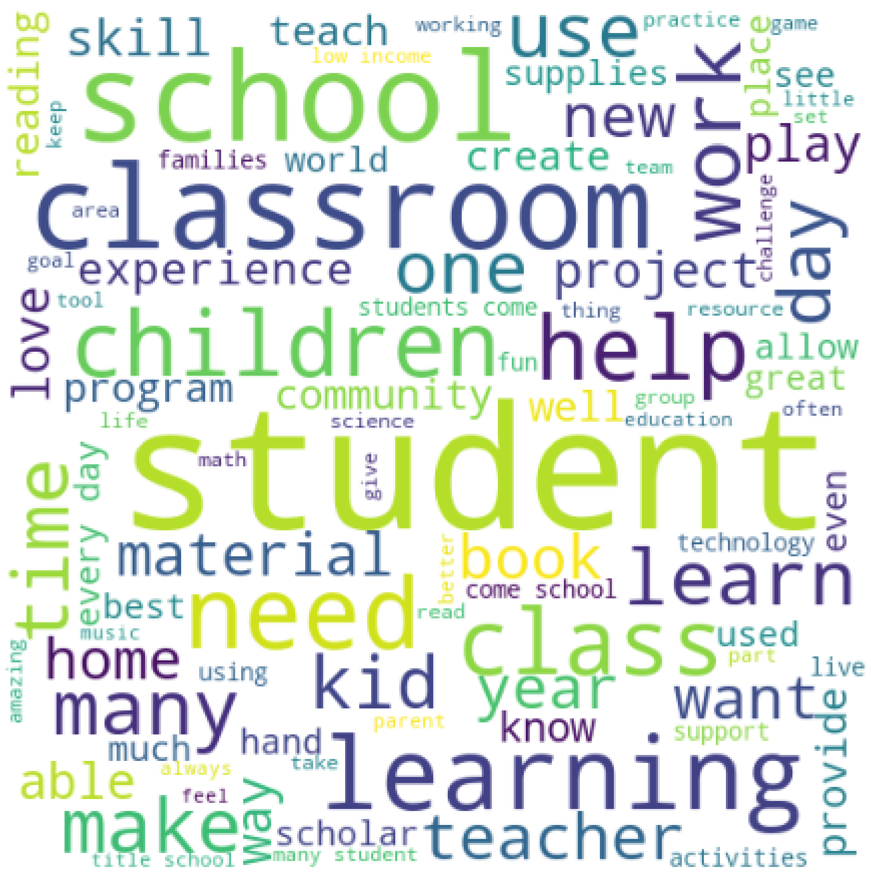


The most frequent words in cluster3 for agglomerative clustering are(in descending order): Student, book, reading, classroom, school, read.

In [0]:

```
print('WordCloud with essay text for cluster4 for AgglomerativeClustering')
wordcloud(cluster4)
```

```
WordCloud with essay text for cluster4 for AgglomerativeClustering
```



The most frequent words in cluster4 for agglomerative clustering are(in descending order): student, classroom, school, learning, children, need, help.

2.7 Apply DBSCAN

In [0]:

```
# please write all the code with proper documentation, and proper titles for each subsectic
# 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 coc
# 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 [0]:

```
from sklearn.datasets.samples_generator import make_blobs
from sklearn.neighbors import NearestNeighbors
from sklearn.cluster import DBSCAN
from matplotlib import pyplot as plt
import seaborn as sns
sns.set()
```

In [0]:

```
X_new1= X_new[:5000]
X_new1.shape
```

Out[136]:

```
(5000, 5000)
```

In [0]:

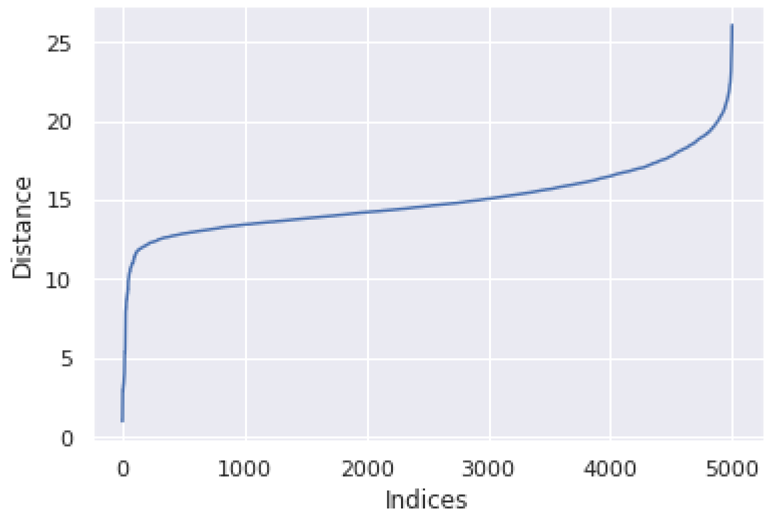
```
#Calculating the distance from each point to its closest neighbour using the NearestNeighbc
#[https://towardsdatascience.com/machine-learning-clustering-dbscan-determine-the-optimal-v
neigh = NearestNeighbors(n_neighbors=2)
nbrs = neigh.fit(X_new1)
distances, indices = nbrs.kneighbors(X_new1)
```

In [0]:

```
#we sort and plot results
distances = np.sort(distances, axis=0)
distances = distances[:,1]
plt.xlabel('Indices')
plt.ylabel('Distance')
plt.plot(distances)
```

Out[138]:

```
[<matplotlib.lines.Line2D at 0x7fca73d31438>]
```



We get maximum curvature near distance value of 19. So optimal value of epsilon chosen is 19.

Reference : https://stackoverflow.com/a/48558030 (https://stackoverflow.com/a/48558030)

MinPts is best set by a domain expert who understands the data well. Unfortunately many cases we don't know the domain knowledge, especially after data is normalized. One heuristic approach is use "ln(n)", where n is the total number of points to be clustered.

So, ln(5000) = 8.517

Hence taking Minpts = 9

In [0]:

```
from sklearn.cluster import DBSCAN
min_pts = 9
dbscan = DBSCAN(eps=19, min_samples= min_pts).fit(X_new1)
```

In [0]:

```
dbscan.labels_
```

Out[158]:

```
array([0, 0, 0, ..., 0, 0, 0])
```

```
In [0]:
```

```python
np.unique(dbscan.labels_)
```

```
Out[159]:
```

```
array([-1,  0])
```

There are two clusters. The noisy ones are indicated by -1.

```
In [0]:
```

```python
essay = preprocessed_essays
cluster1=[]
cluster2=[]

for i in range(dbscan.labels_.shape[0]):
    if dbscan.labels_[i] == 0:
        cluster1.append(essay[i])
    elif dbscan.labels_[i]== -1 :
        cluster2.append(essay[i])
```

```
In [0]:
```

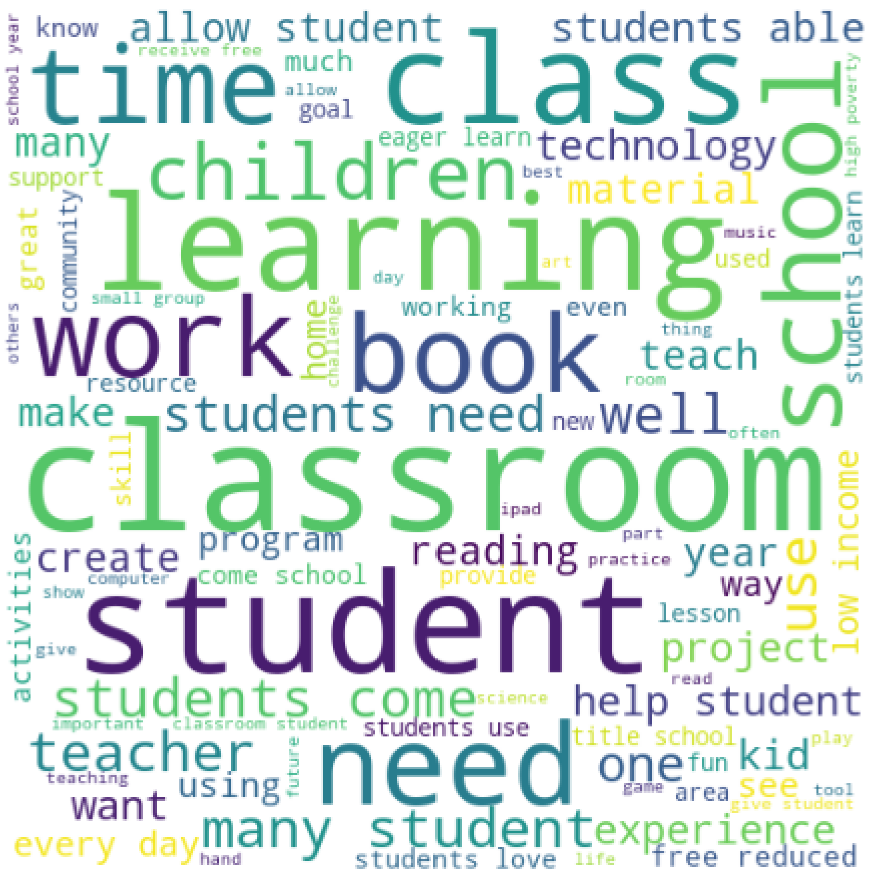
```python
print('Length of cluster1 is', len(cluster1))
print('Length of cluster2 is', len(cluster2))
```

```
Length of cluster1 is 4749
Length of cluster2 is 251
```

In [0]:

```
print('WordCloud with essay text for cluster1 for DBSCAN Clustering')
wordcloud(cluster1)
```

```
WordCloud with essay text for cluster1 for DBSCAN Clustering
```

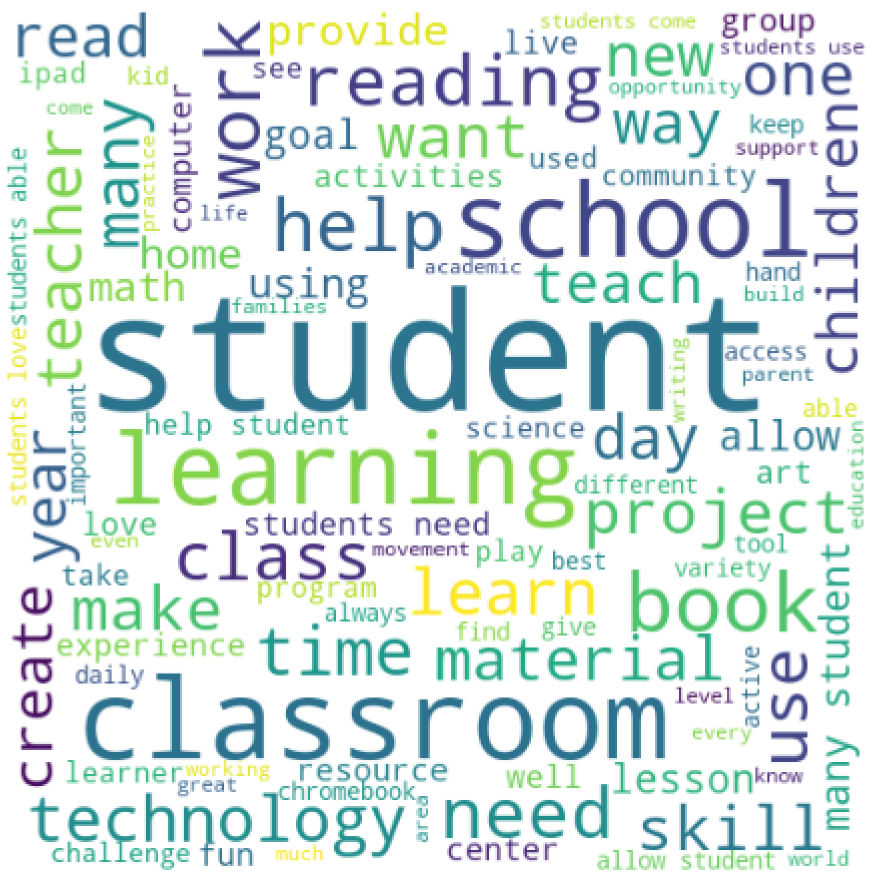


The most frequent words in cluster1 for DBSCAN clustering are(in descending order): classroom, learning, student, class, time, work, book, need, school.

In [0]:

```
print('WordCloud with essay text for cluster2 for DBSCAN Clustering')
wordcloud(cluster2)
```

```
WordCloud with essay text for cluster2 for DBSCAN Clustering
```



The most frequent words in cluster2 i.e. noise cluster for DBSCAN clustering are(in descending order): student, learning, classroom, school, reading, technology.

italicized text

3. Conclusions

Please write down few lines of your observations on this assignment.

K-Means Clustering:

The clusters are approximately similar in size. There is slight variation in the densities of clusters. Some of the most common words observed from each cluster in KMeans clustering are: student, classroom, learning, need, work.

Agglomerative Clustering:

The clusters in agglomerative clustering are slightly more variations in size. Some variations in the densties of the clusters can also be observed, probably a large cluster may have broken into smaller clusters. Some of the most common words observed from each cluster in Agglomerative clustering are: Student, learning ,classroom, school, book.

DBSCAN Clustering:

The clusters in DBSCAN clustering are completely of different sizes. The cluster with label -1 indicates the noise cluster which is small in size. And also in noise cluster there are few words that are frequently present in that cluster, most of the words are smaller in size which means these words are very less commonly used in the essay text. Some of the most common words observed from each cluster in DBSCAN clustering are: classroom, learning, student, school.