CLUSTERING

In [1]:

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6
qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%
b&response_type=code&scope=email%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2
www.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.readonly
ttps%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/drive
```

In [0]:

```
# To enable plotly plot in Google Colab
# https://stackoverflow.com/questions/47230817/plotly-notebook-mode-with-google-
colaboratory/47230966
def configure_plotly_browser_state():
    import IPython
    display(IPython.core.display.HTML('''
        <script src="/static/components/requirejs/require.js"></script>
        <script>
          requirejs.config({
            paths: {
              base: '/static/base',
              plotly: 'https://cdn.plot.ly/plotly-1.5.1.min.js?noext',
            },
          });
        </script>
        '''))

def enable_plotly_in_cell():
    import IPython
    from plotly.offline import init_notebook_mode
    display(IPython.core.display.HTML('''<script src="/static/components/requirejs/require.js"></s
cript>'''))
    init_notebook_mode(connected=False)
```

In [3]:

```
#importing libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

from plotly.offline import init_notebook_mode, iplot
import plotly.graph_objs as go
configure_plotly_browser_state()
init_notebook_mode(connected=False)
```

In [5]:

```
data = pd.read_csv('/content/drive/My Drive/Applied AI/Datasets/New
Donors/Preprocessed_inc_others.csv')
data.head()
```

Out[5]:

	Unnamed: 0	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved
	Unnamed: 0	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved
0	0	ca	mrs	grades_prek_2	53	1
1	1	ut	ms	grades_3_5	4	1
2	2	ca	mrs	grades_prek_2	10	1
3	3	ga	mrs	grades_prek_2	2	1
4	4	wa	mrs	grades_3_5	2	1

In [6]:

```
data.describe()
```

Out[6]:

	Unnamed: 0	teacher_number_of_previously_posted_projects	project_is_approved	price	quantity	sentiment_sc
count	109248.000000	109248.000000	109248.000000	109248.000000	109248.000000	109248.000
mean	54623.500000	11.153165	0.848583	298.119343	16.965610	0.210
std	31537.325441	27.777154	0.358456	367.498030	26.182942	0.083
min	0.000000	0.000000	0.000000	0.660000	1.000000	-0.189
25%	27311.750000	0.000000	1.000000	104.310000	4.000000	0.154
50%	54623.500000	2.000000	1.000000	206.220000	9.000000	0.208
75%	81935.250000	9.000000	1.000000	379.000000	21.000000	0.264
max	109247.000000	451.000000	1.000000	9999.000000	930.000000	0.663

In [7]:

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

Out[7]:

	Unnamed: 0	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	cl
0	0	ca	mrs	grades_prek_2	53	math_science	

	Unnamed: 0	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_categories	cl
1	1	ut	ms	grades_3_5	4	specialneeds	

In [8]:

```
y = y.reshape(-1,1)
print(y.shape)
```

```
(109248, 1)
```

Splitting the data

In [0]:

```
from sklearn.model_selection import train_test_split
data_train, data_test, label_train, label_test = train_test_split(X, y, test_size=0.33, stratify=y,
random_state=42)
```

In [10]:

```
print(data_train.shape)
print(data_test.shape)
print(label_train.shape)
print(label_test.shape)
```

```
(73196, 14)
(36052, 14)
(73196, 1)
(36052, 1)
```

In [0]:

```
X_train = data_train
X_test = data_test
y_train = label_train
y_test = label_test
```

In [12]:

```
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(73196, 14)
(36052, 14)
(73196, 1)
(36052, 1)
```

1.Vectorizing Features

1.1 School State

In [0]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_1 = CountVectorizer(list(X_train['school_state'].values), lowercase=False, binary=True)
```

In [0]:

```
X_train_Sstate = vectorizer_1.fit_transform(X_train['school_state'].values)
X_test_Sstate = vectorizer_1.transform(X_test['school_state'].values)
```

```
X_test_Sstate = vectorizer_1.transform(X_test['school_state'].values)
```

In [15]:

```
print(X_train_Sstate.shape)
print(X_test_Sstate.shape)
```

```
(73196, 51)
(36052, 51)
```

1.2 Clean Categories

In [0]:

```
vectorizer_2 = CountVectorizer(list(X_train['clean_categories'].values), lowercase=False,
binary=True)
```

In [0]:

```
X_train_cat = vectorizer_2.fit_transform(X_train['clean_categories'].values)
X_test_cat = vectorizer_2.transform(X_test['clean_categories'].values)
```

In [18]:

```
print(X_train_cat.shape)
print(X_test_cat.shape)
```

```
(73196, 9)
(36052, 9)
```

1.3 Clean sub categories

In [0]:

```
vectorizer_3 = CountVectorizer(list(X_train['clean_subcategories'].values), lowercase=False,
binary=True)
```

In [0]:

```
X_train_subcat = vectorizer_3.fit_transform(X_train['clean_subcategories'].values)
X_test_subcat = vectorizer_3.transform(X_test['clean_subcategories'].values)
```

In [21]:

```
print(X_train_subcat.shape)
print(X_test_subcat.shape)
```

```
(73196, 30)
(36052, 30)
```

1.4 Project Grade Category

In [0]:

```
vectorizer_4 = CountVectorizer(list(X_train['project_grade_category'].values), lowercase=False,
binary=True)
```

In [0]:

```
X_train_grade = vectorizer_4.fit_transform(X_train['project_grade_category'].values)
X_test_grade = vectorizer_4.transform(X_test['project_grade_category'].values)
```

In [24]:

```
print(X_train_grade.shape)
print(X_test_grade.shape)
```

```
(73196, 4)
(36052, 4)
```

1.5 Teacher Prefix

In [0]:

```
vectorizer_5 = CountVectorizer(list(X_train['teacher_prefix'].values), lowercase=False,
binary=True)
```

In [0]:

```
X_train_prefix = vectorizer_5.fit_transform(X_train['teacher_prefix'].values)
X_test_prefix = vectorizer_5.transform(X_test['teacher_prefix'].values)
```

In [27]:

```
print(X_train_prefix.shape)
print(X_test_prefix.shape)
```

```
(73196, 5)
(36052, 5)
```

Step -1:

```
- Choosing the 'TFIDF vectorizer' for Essay and Title Text
```

1.6 Essay

1.6.1 TFIDF

In [0]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_7 = TfidfVectorizer(list(X_train['essay'].values), min_df=10)
```

In [0]:

```
X_train_essay_tfidf = vectorizer_7.fit_transform(X_train['essay'].values)
X_test_essay_tfidf = vectorizer_7.transform(X_test['essay'].values)
```

In [78]:

```
print(X_train_essay_tfidf.shape)
print(X_test_essay_tfidf.shape)
```

```
(73196, 14266)
(36052, 14266)
```

1.7 Title

1.7.1 TFIDF

In [0]:

In [0]:

```
vectorizer_9 = TfidfVectorizer(list(X_train['title'].values), min_df=10)
```

In [0]:

```
X_train_title_tfidf = vectorizer_9.fit_transform(X_train['title'].values)
X_test_title_tfidf = vectorizer_9.transform(X_test['title'].values)
```

In [33]:

```
print(X_train_title_tfidf.shape)
print(X_test_title_tfidf.shape)
```

```
(73196, 2617)
(36052, 2617)
```

1.8 Price

1.8.1 Unstandardized

In [0]:

```
X_train_price_unstandardized = X_train['price'].values.reshape(-1,1)
X_test_price_unstandardized = X_test['price'].values.reshape(-1,1)
```

In [35]:

```
print(X_train_price_unstandardized.shape)
print(X_test_price_unstandardized.shape)
```

```
(73196, 1)
(36052, 1)
```

1.8.2 Standardized

In [0]:

```
from sklearn.preprocessing import StandardScaler
sc_price = StandardScaler()
X_train_price = sc_price.fit_transform(X_train['price'].values.reshape(-1,1))
X_test_price = sc_price.transform(X_test['price'].values.reshape(-1,1))
```

In [37]:

```
print(X_train_price.shape)
print(X_test_price.shape)
```

```
(73196, 1)
(36052, 1)
```

1.9 Previously Posted projects

1.9.1 Unstandardized

In [0]:

```
X_train_previous_unstandardized = X_train['teacher_number_of_previously_posted_projects'].values.r
eshape(-1,1)
X_test_previous_unstandardized =
X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
```

In [39]:

```
print(X_train_previous_unstandardized.shape)
print(X_test_previous_unstandardized.shape)
```

```
(73196, 1)
(36052, 1)
```

1.9.2 Standardized

In [0]:

```
from sklearn.preprocessing import StandardScaler
sc_previous = StandardScaler()
X_train_previous =
sc_previous.fit_transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-
1,1))
X_test_previous =
sc_previous.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
```

In [0]:

```
print(X_train_previous.shape)
print(X_test_previous.shape)
```

In [42]:

```
print(X_train_Sstate.shape)
print(X_train_cat.shape)
print(X_train_subcat.shape)
print(X_train_grade.shape)
print(X_train_prefix.shape)
print(X_train_price.shape)
print(X_train_previous.shape)
print(X_train_essay_tfidf.shape)
print(X_train_title_tfidf.shape)

print('='*50)
print(X_test_Sstate.shape)
print(X_test_cat.shape)
print(X_test_subcat.shape)
print(X_test_grade.shape)
print(X_test_prefix.shape)
print(X_test_price.shape)
print(X_test_previous.shape)
print(X_test_essay_tfidf.shape)
print(X_test_title_tfidf.shape)
```

```
(73196, 51)
(73196, 9)
(73196, 30)
(73196, 4)
(73196, 5)
(73196, 1)
(73196, 1)
(73196, 14266)
(73196, 2617)
==================================================
(36052, 51)
(36052, 9)
(36052, 30)
(36052, 4)
(36052, 5)
(36052, 1)
(36052, 1)
(36052, 14266)
(36052, 2617)
```

Step -2 : Getting top 5000 features using selectKbest

Step -2 : Getting top 5000 features using SelectKBest

2.1 Merging all the features

In [0]:

```
from scipy.sparse import hstack
X_train_KB = hstack((X_train_Sstate, X_train_cat, X_train_subcat, X_train_grade, X_train_prefix, X_
train_previous_unstandardized,
                       X_train_price_unstandardized, X_train_essay_tfidf,
X_train_title_tfidf)).tocsr()

X_test_KB = hstack((X_test_Sstate, X_test_cat, X_test_subcat, X_test_grade, X_test_prefix, X_test_p
revious_unstandardized,
                     X_test_price_unstandardized, X_test_essay_tfidf, X_test_title_tfidf)).tocsr()
```

In [0]:

```
from sklearn.feature_selection import SelectKBest, chi2
selector = SelectKBest(chi2, k =5000)
X_train = selector.fit_transform(X_train_KB, y_train)
X_test = selector.transform(X_test_KB)
```

In [81]:

```
print(X_train.shape)
print(X_test.shape)
```

```
(73196, 5000)
(36052, 5000)
```

Step -3: Applying Clustering

3.1 K-Means

Note:

- Since the KMeans algorithm is computationally Expensive i will take 30k points for computation

In [0]:

```
X_train_1 = X_train[0:30000, :]
```

In [0]:

```
y_train_1 = y_train[0:30000, :]
```

In [0]:

```
from sklearn.cluster import KMeans
```

3.1.1 Elbow Method

In [0]:

```
ss = []
for i in range(1,8):
    kmeans = KMeans(n_clusters=i, init='k-means++', random_state=42)
    kmeans.fit(X_train_1)
    ss.append(kmeans.inertia_)
```

In [0]:

In [0]:

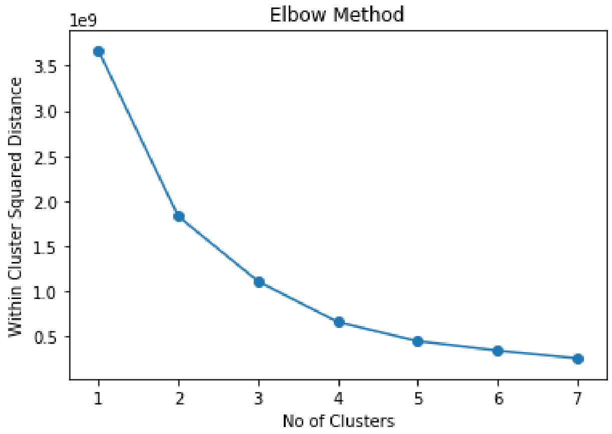
```
ss
```

Out[0]:

```
[3664288500.6005983,
 1831370800.2786806,
 1111414794.3491583,
 660980249.8632902,
 448651448.41384536,
 345766077.6683432,
 259129655.58727992]
```

In [0]:

```
plt.plot(range(1,8), ss)
plt.scatter(range(1,8), ss)
plt.title('Elbow Method')
plt.xlabel('No of Clusters')
plt.ylabel('Within Cluster Squared Distance')
plt.show()
```



Summary:

- It shows that the cluster distance have elbow shaped at No of clusters = 2

3.1.2 Modelling with n_clusters

In [0]:

```
kmeans = KMeans(n_clusters=2, init='k-means++', random_state=42)
y_kmeans = kmeans.fit_predict(X_train_1)
```

3.1.3 Manually Looking at the clusters

In [0]:

```
print(y_kmeans)
print(y_kmeans.shape)
```

```
[0 1 0 ... 1 1 1]
(30000,)
```

In [0]:

```
y_kmeans = y_kmeans.reshape(-1,1)
print(y_kmeans.shape)
print(type(y_kmeans))
print(y_train_1.shape)
print(type(y_train_1))
```

```
print(type(y_train_1))
```

```
(30000, 1)
<class 'numpy.ndarray'>
(30000, 1)
<class 'numpy.ndarray'>
```

In [0]:

```
#checking how many values are same in both the arrays
#https://stackoverflow.com/questions/25490641/check-how-many-elements-are-equal-in-two-numpy-array
s-python/25490691
(y_train_1 == y_kmeans).sum()
```

Out[0]:

```
23795
```

Summary:

- We can see that the out of 30000 data 23795 data are clustered correctly.

In [0]:

```
print(np.where(kmeans.labels_ == 0)[0])
print(len(np.where(kmeans.labels_ == 0)[0]))
```

```
[    0     2    10 ... 29970 29986 29991]
3019
```

In [0]:

```
print(np.where(kmeans.labels_ == 1)[0])
print(len(np.where(kmeans.labels_ == 1)[0]))
```

```
[    1     3     4 ... 29997 29998 29999]
26981
```

In [0]:

```
# Data points belong the each cluster
#https://stackoverflow.com/questions/32232067/cluster-points-after-kmeans-clustering-scikit-learn
my_dict = {i : np.where(kmeans.labels_== i)[0] for i in range(kmeans.n_clusters)}
```

In [0]:

```
len(my_dict[0])
```

Out[0]:

```
3019
```

In [0]:

```
len(my_dict[1])
```

Out[0]:

```
26981
```

Summary:

- It shows that out of 30k data points 26981 are clustered as one and remaining are clustered to form another

3.1.4 Plotting the Word Cloud for each cluster

In [0]:

```
X_train_essay_tfidf_1 = X_train_essay_tfidf[0:30000, :]
print(X_train_essay_tfidf_1.shape)
```

```
(30000, 14266)
```

In [0]:

```
#https://andrew47.github.io/scikitlearn-cluster.html
essay_kmeans = KMeans(n_clusters=2 , n_jobs=-1).fit(X_train_essay_tfidf_1)
```

In [0]:

```
centroids = pd.DataFrame(essay_kmeans.cluster_centers_)
centroids.columns = vectorizer_7.get_feature_names()
centroids.head(3)
```

Out[0]:

	00	000	03	10	100	1000	100th	101	102	103	104	105	107	
0	0.000104	0.000995	0.000000	0.002128	0.004715	0.000274	0.000000	0.000077	0.000036	0.000097	0.00000	0.000000	0.000083	0.
1	0.000326	0.000845	0.000039	0.002549	0.004323	0.000229	0.000063	0.000043	0.000016	0.000041	0.00002	0.000011	0.000010	0.

2 rows × 14266 columns

In [0]:

```
#look at the top 10 words in each cluster
for i in range(0, len(centroids)):
    print(centroids.iloc[i,:].sort_values(ascending=False)[0:10])
    print('='*50)
```

```
books        0.148911
reading      0.141218
students     0.134350
read         0.092631
book         0.056547
library      0.051495
school       0.046745
love         0.044425
readers      0.043976
my           0.042409
Name: 0, dtype: float64
==================================================
students      0.128708
school        0.047591
learning      0.042019
classroom     0.039006
my            0.037525
they          0.032351
the           0.031454
learn         0.031333
help          0.030540
not           0.030237
Name: 1, dtype: float64
==================================================
```

Note:

- To plot the word cloud for each cluster, we need to find which words are belongs to which clusters. So, here we need to find which words belong cluster_0 and which words belongs to cluster_1.

In [0]:

```
pd.DataFrame(centroids.iloc[0].sort_values(ascending=False).reset_index(level=0)).head()
```

Out[0]:

	index	0
0	books	0.148911
1	reading	0.141218
2	students	0.134350
3	read	0.092631
4	book	0.056547

In [0]:

```
#https://andrew47.github.io/scikitlearn-cluster.html
cluster_0 = pd.DataFrame(centroids.iloc[0].sort_values(ascending=False).reset_index()) # here i
reset index because words are in index and we want it as a column in dataframe
cluster_1 = pd.DataFrame(centroids.iloc[1].sort_values(ascending=False).reset_index())
```

In [0]:

```
cluster_0.head(2)
```

Out[0]:

	index	0
0	books	0.148911
1	reading	0.141218

In [0]:

```
cluster_0_words = []
for i in cluster_0['index']:
    cluster_0_words.append(i)

cluster_1_words = []
for i in cluster_1['index']:
    cluster_1_words.append(i)
```

3.1.4.1 Cluster 0 word cloud

In [0]:

```
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
stopwords = set(STOPWORDS)
comment_words_0 = ' '
for word in cluster_0_words:
    comment_words_0 = comment_words_0 + word + ' '
```

In [0]:

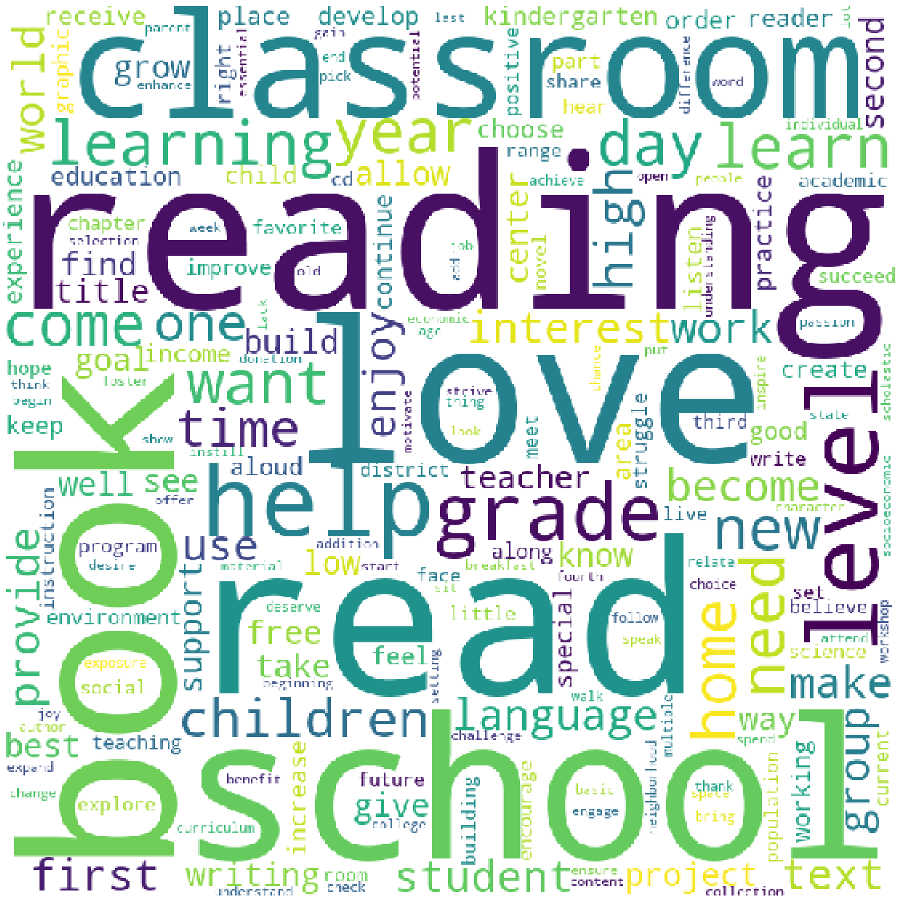
```
#Generating Word Cloud for cluster_0_words
wordcloud_0_km = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords, mi
n_font_size=10).generate(comment_words_0)
```

In [0]:

```
#plotting the Word Cloud
plt.figure(figsize=(8,8), facecolor=None)
plt.title('Cluster 0 words')
plt.imshow(wordcloud_0_km)
plt.axis('off')
```

```
plt.tight_layout(pad=0)
plt.show()
```

Cluster 0 words



3.1.4.2 Cluster_1 word cloud

In [0]:

```
comment_words_1 = ' '
for word in cluster_1_words:
    comment_words_1 = comment_words_1 + word + ' '
```

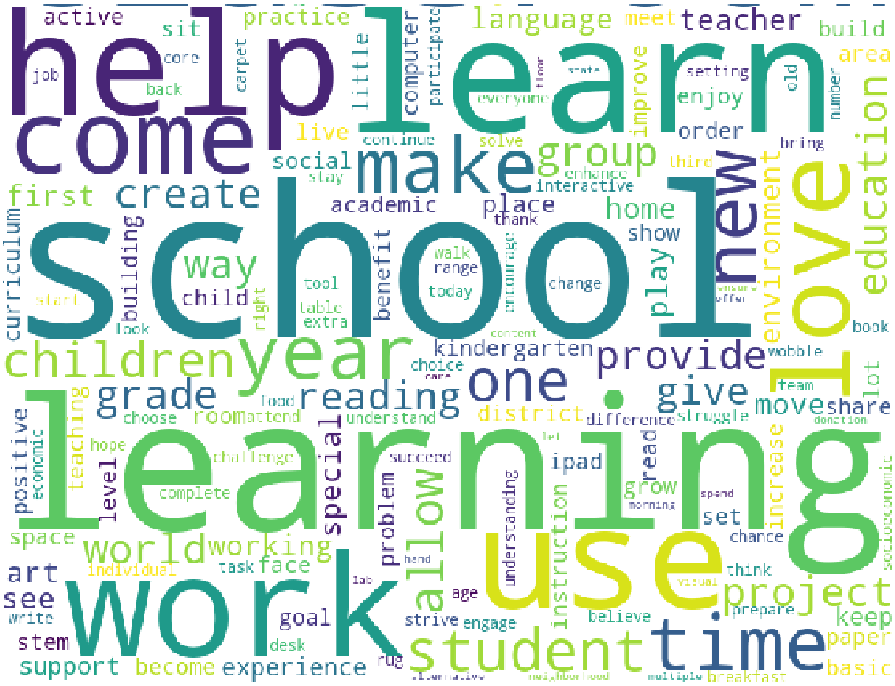
In [0]:

```
#Generating Word Cloud for cluster_0_words
wordcloud_1_km = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords, mi
n_font_size=10).generate(comment_words_1)
```

In [0]:

```
#plotting the Word Cloud
plt.figure(figsize=(8,8), facecolor=None)
plt.title('Cluster 1 words')
plt.imshow(wordcloud_1_km)
plt.axis('off')
plt.tight_layout(pad=0)
plt.show()
```

Cluster 1 words



4. Hierarchical Clustering

In [0]:

```
# Taking only 5k points as per instructions
X_train_2 = X_train[0:5000, :]
X_test_2 = X_test[0:5000, :]
y_train_2 = y_train[0:5000, :]
```

In [0]:

```
print(X_train_2.shape)
print(X_test_2.shape)
print(y_train_2.shape)
```

```
(5000, 5000)
(5000, 5000)
(5000, 1)
```

4.1 Finding Dendrogram to find the number of clusters

In [0]:

```
type(X_train_2)
```

Out[0]:

```
scipy.sparse.csr.csr_matrix
```

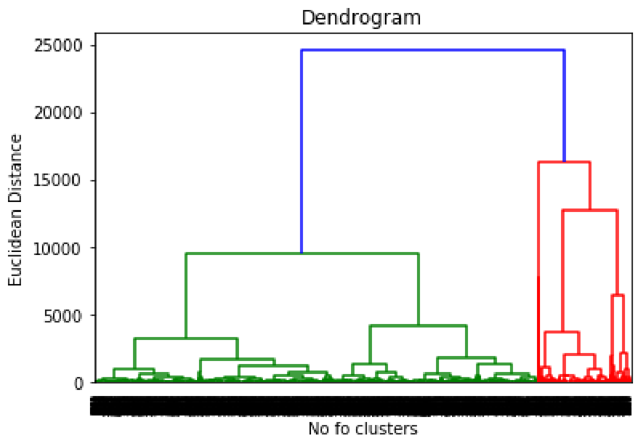
Note:

- Since it is a csr matrix we can't plot the dendrogram and we need to convert it into array as used in https://stackoverflow.com/questions/44660848/hierarchical-clustering-on-sparse-observation-matrix

In [0]:

```
#https://stackabuse.com/hierarchical-clustering-with-python-and-scikit-learn/
from scipy.cluster.hierarchy import dendrogram, linkage
linked = linkage(X_train_2.toarray(), method = 'ward')
dendrogram = dendrogram(linked)
```

```
plt.title('Dendrogram')
plt.xlabel('No fo clusters')
plt.ylabel('Euclidean Distance')
plt.show()
```



Summary:

- We can see that the number of longest vertical distance without any horizontal intersection in this dendrogram is 2. So we take the n_clusters = 2

4.2 Modelling with n_clusters

In [0]:

```
n_clusters = 2
```

In [0]:

```
from sklearn.cluster import AgglomerativeClustering
hc = AgglomerativeClustering(n_clusters = n_clusters, affinity='euclidean', linkage='ward')
y_hc = hc.fit_predict(X_train_2.toarray())
```

4.3 Manually looking at the clusters

In [0]:

```
y_hc.shape
```

Out[0]:

```
(5000,)
```

In [0]:

```
y_hc = y_hc.reshape(-1,1)
print(y_hc.shape)
print(type(y_hc))
print(y_train_2.shape)
print(type(y_train))
```

```
(5000, 1)
<class 'numpy.ndarray'>
(5000, 1)
<class 'numpy.ndarray'>
```

In [0]:

```
#checking how many values are same in both the arrays
```

```
#https://stackoverflow.com/questions/25490641/check-how-many-elements-are-equal-in-two-numpy-array
s-python/25490691
(y_train_2 == y_hc).sum()
```

Out[0]:

```
3720
```

Note:

- We can see that out of 5000 , 3720 are clustered correctly

In [0]:

```
# Data points belong the each cluster
#https://stackoverflow.com/questions/32232067/cluster-points-after-kmeans-clustering-scikit-learn
my_dict_2 = {i : np.where(hc.labels_== i)[0] for i in range(hc.n_clusters)}
```

In [0]:

```
len(my_dict_2[0])
```

Out[0]:

```
858
```

In [0]:

```
len(my_dict_2[1])
```

Out[0]:

```
4142
```

Summary:

- We can see that 858 points are clustered into one cluster and remaining 4142 cluster clustered to form another

4.4 Finding words for Essay text on each cluster

In [0]:

```
X_train_essay_tfidf_2 = X_train_essay_tfidf[0:5000, :]
print(X_train_essay_tfidf_2.shape)
```

```
(5000, 14266)
```

In [0]:

```
#https://andrew47.github.io/scikitlearn-cluster.html
from sklearn.cluster import AgglomerativeClustering
essay_hc = AgglomerativeClustering(n_clusters = n_clusters, linkage='ward', affinity='euclidean').f
it(X_train_essay_tfidf_2.toarray())
```

In [0]:

```
cluster_0_hc =  X_train_essay_tfidf_2[np.where(essay_hc.labels_ ==0)]
```

In [0]:

```
cluster_1_hc =  X_train_essay_tfidf_2[np.where(essay_hc.labels_ ==1)]
```

In [0]:

```
print(cluster_0_hc.shape)
print(cluster_1_hc.shape)
```

```
(4446, 14266)
(554, 14266)
```

Note:

- We can see that the out of 5k points 4446 points are clustered into one category and remaining 554 are clustered into another

In [0]:

```
type(cluster_0_hc)
```

Out[0]:

```
scipy.sparse.csr.csr_matrix
```

In [0]:

```
#convert csr matrix to dataframe
cluster_0_hc = pd.DataFrame(cluster_0_hc.toarray(), columns=vectorizer_7.get_feature_names())
cluster_0_hc.head(2)
```

Out[0]:

	00	000	03	10	100	1000	100th	101	102	103	104	105	107	10th	11	110	1100	112	115	11th	12	120	1200	123	12
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.

2 rows × 14266 columns

In [0]:

```
cluster_1_hc = pd.DataFrame(cluster_1_hc.toarray(), columns=vectorizer_7.get_feature_names())
cluster_1_hc.head(2)
```

Out[0]:

	00	000	03	10	100	1000	100th	101	102	103	104	105	107	10th	11	110	1100	112	115	11th	12	120	1200	123	12
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.

2 rows × 14266 columns

In [0]:

```
#looking at the sample data point and its essay words
cluster_0_hc.iloc[0,:].sort_values(ascending=False)[0:10].reset_index()
```

Out[0]:

	index	0
0	avid	0.281376
1	chromebooks	0.279620
2	college	0.179109
3	computers	0.178794
4	pulled	0.166316
5	we	0.162115

	index	0
6	hand	0.161101
7	paced	0.148754
8	skills	0.147422
9	students	0.142786

In [0]:

```
yyy = []
for i in range(0, cluster_1_hc.shape[0]):
    j = cluster_1_hc.iloc[i, :].sort_values(ascending=False).reset_index()
    yyy.append(j['index'].tolist())
```

In [0]:

```
#making cluster_1_words as a one flat list
cluster_1_words = []
for sublist in yyy:
    for item in sublist:
        cluster_1_words.append(item)
```

In [0]:

```
zzz = []
for i in range(0, cluster_0_hc.shape[0]):
    j = cluster_0_hc.iloc[i, :].sort_values(ascending=False).reset_index()
    zzz.append(j['index'].tolist())
```

In [0]:

```
#making cluster_1_words as a one flat list
cluster_0_words = []
for sublist in zzz:
    for item in sublist:
        cluster_0_words.append(item)
```

In [0]:

```
#to get the unique words in the list
cluster_0_words = list(set(cluster_0_words))
cluster_1_words = list(set(cluster_1_words))
```

In [0]:

```
print(len(cluster_0_words))
print(len(cluster_1_words))
```

```
14266
14266
```

4.6 Plotting word cloud

4.6.1 Cluster 0 words

In [0]:

```
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
stopwords = set(STOPWORDS)
comment_words_0 = ' '
for word in cluster_0_words:
    comment_words_0 = comment_words_0 + word + ' '
```

In [0]:

```
#Generating Word Cloud for cluster_0_words

wordcloud_0_hc = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords, mi
n_font_size=10).generate(comment_words_0)
```

In [0]:

```
#plotting the Word Cloud
plt.figure(figsize=(8,8), facecolor=None)
plt.title('Cluster 0 words')
plt.imshow(wordcloud_0_hc)
plt.axis('off')
plt.tight_layout(pad=0)
plt.show()
```

Cluster 0 words

4.6.2 Cluster 1 words

In [0]:

```
comment_words_1 = ' '
for word in cluster_1_words:
    comment_words_1 = comment_words_1 + word + ' '
```

In [0]:

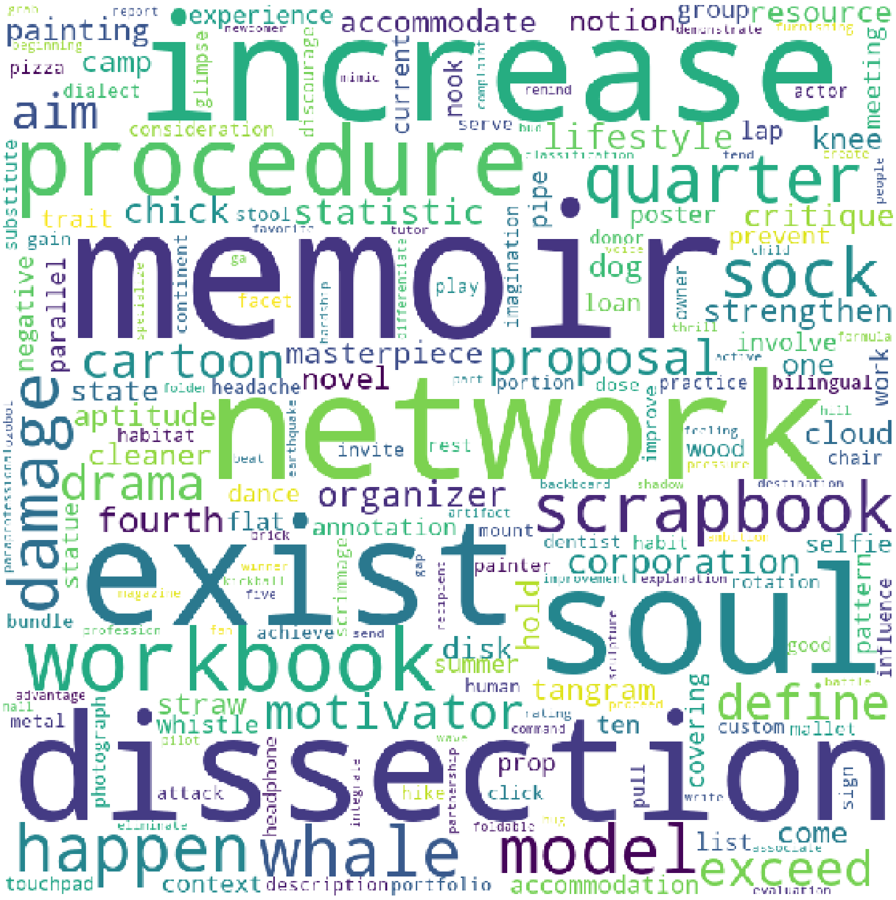
```
#Generating Word Cloud for cluster_0_words
wordcloud_1_hc = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords, mi
n_font_size=10).generate(comment_words_1)
```

In [0]:

```
#plotting the Word Cloud
plt.figure(figsize=(8,8), facecolor=None)
plt.title('Cluster 1 words')
```

```
plt.imshow(wordcloud_1_nc)
plt.axis('off')
plt.tight_layout(pad=0)
plt.show()
```

Cluster 1 words



5. DBSCAN

In [0]:

```python
from sklearn.cluster import DBSCAN
```

In [45]:

```python
X_train.shape
```

Out[45]:

```
(73196, 14)
```

In [53]:

```python
X_train_3 = X_train[0:15000, :]
y_train_3 = y_train[0:15000, :]
print(X_train_3.shape)
print(y_train_3.shape)
```

```
(15000, 5000)
(15000, 1)
```

5.1 Elbow method to find eps

Note:

- As dimension is 5000 and the min_pts should be around 2*d. So, i am going to take min_pts as 10000

In [54]:

```
# Finding nearest neighbour distance from min_pts
#to get the 100 nearest neighbor of each data points we should train with the method mentioned in link below
#https://scikit-learn.org/stable/modules/generated/sklearn.neighbors.NearestNeighbors.html
min_pts = 10000
from sklearn.neighbors import NearestNeighbors
neigh = NearestNeighbors(n_neighbors=min_pts, algorithm='auto', n_jobs=-1)
neigh.fit(X_train_3)
```

Out[54]:

```
NearestNeighbors(algorithm='auto', leaf_size=30, metric='minkowski',
                 metric_params=None, n_jobs=-1, n_neighbors=10000, p=2,
                 radius=1.0)
```

Note:

- Once we got the nearest neighbors with the n_neighbors=min_pts , we should do with "neigh.kneighbors" to get the 10000 neighbor distance from each points as it returns the tuple of (distances, index of points) and we need only the first item in tuple and from that first item, the 100th column represents the distance from the point to 10000th neighbor as mentioned in https://scikit-learn.org/stable/modules/generated/sklearn.neighbors.NearestNeighbors.html

In [55]:

```
# as mentioned above the neigh.kneighbors returns the tuple of (distance of 10000 neighbors, index of data points)
neigh.kneighbors(X_train_3)
```

Out[55]:

```
(array([[  0.        ,   4.26118444,   5.09211808, ..., 612.23987853,
         612.2467039 , 612.26383596],
        [  0.        ,   2.66705629,   2.91805014, ..., 307.63432143,
         307.63561732, 307.67179708],
        [  0.        ,   2.3686349 ,   2.4646736 , ..., 520.59357963,
         520.63979871, 520.64468002],
        ...,
        [  0.        ,   2.34817695,   2.44119171, ..., 233.88279146,
         233.89206397, 233.89741496],
        [  0.        ,   3.61697841,   4.82789578, ..., 522.66264938,
         522.66591022, 522.6774651 ],
        [  0.        ,   2.66831236,   2.6923055 , ..., 305.78602823,
         306.04776049, 306.0602724 ]]),
 array([[    0, 10087,  4199, ..., 12580,  1686,  9280],
        [    1,  1283,  6856, ..., 12517,  2003,  8707],
        [    2,  2984,  8155, ..., 12745, 11808,  1107],
        ...,
        [14997, 13364,  5756, ..., 11658,  6859,  7403],
        [14998,  2551,  7392, ...,  2876,  2268,   120],
        [14999,  7160,  7743, ...,   105, 13404, 11770]]))
```

In [56]:

```
distance = pd.DataFrame(neigh.kneighbors(X_train_3)[0])
distance.head(5)
```

Out[56]:

	0	1	2	3	4	5	6	7	8	9	10	11	12	
0	0.0	4.261184	5.092118	5.397230	5.583272	6.815528	6.829385	6.914648	7.110555	7.251853	7.509093	8.187137	8.252110	8.5412
1	0.0	2.667056	2.918050	3.229012	3.233668	3.279749	3.432496	3.576544	3.686693	3.769418	3.847985	3.886664	3.927638	3.9637
2	0.0	2.368635	2.464674	2.613090	2.971544	3.190590	3.231828	3.265269	3.274330	3.392119	3.427837	3.617337	3.618053	3.6665
3	0.0	2.846323	2.911831	2.994461	3.035966	3.111997	3.118456	3.135570	3.218536	3.282914	3.288636	3.298813	3.306224	3.3199
4	0.0	2.318865	2.708542	2.813861	2.860198	2.912357	2.914918	2.922909	2.933845	2.989036	3.068062	3.076595	3.078355	3.1471

0	1	2	3	4	5	6	7	8	9	10	11	12

5 rows × 10000 columns

Note:

- Since we need the 10000th neighbor distance, so we need only 10000th column

In [0]:

```
distance  = distance[9999]
```

In [58]:

```
distance
```

Out[58]:

```
0        612.263836
1        307.671797
2        520.644680
3        175.110670
4        273.223647
            ...
14995    279.192288
14996    291.540325
14997    233.897415
14998    522.677465
14999    306.060272
Name: 9999, Length: 15000, dtype: float64
```

In [59]:

```
pd.DataFrame(distance).describe()
```

Out[59]:

	9999
count	15000.000000
mean	311.261241
std	286.690325
min	157.852610
25%	190.148375
50%	238.259953
75%	303.531436
max	9859.842924

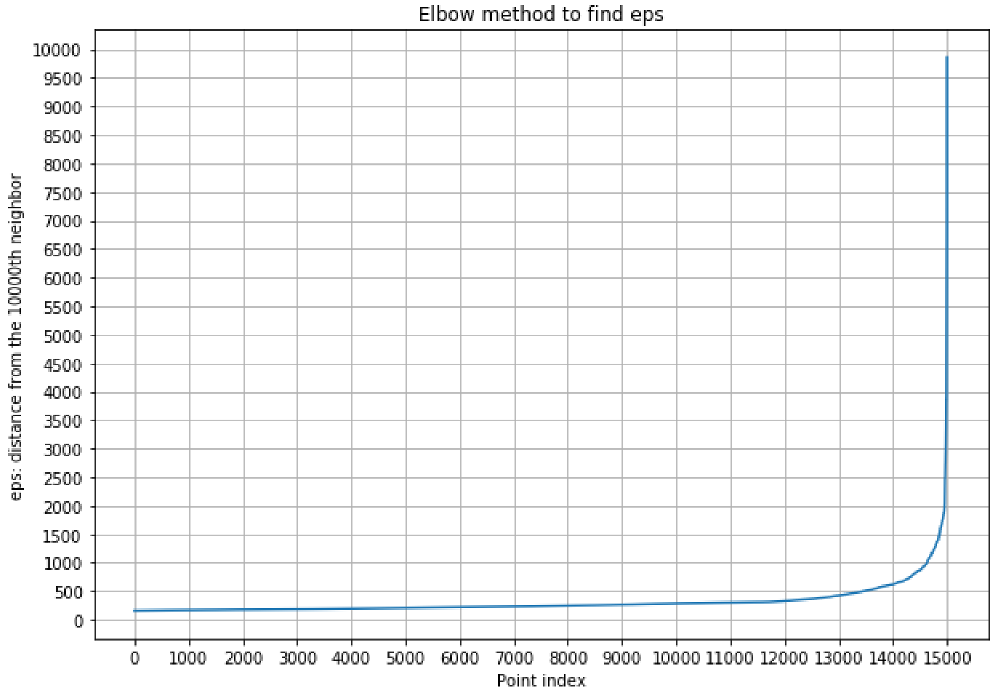
In [0]:

```
#Sort the distance in ascending order
distance = distance.sort_values(ascending=True)
```

In [66]:

```
plt.figure(figsize=(10,7))
plt.plot(range(1,15001), distance)

plt.yticks(range(0,10001,500))
plt.xticks(range(0,15001, 1000))
plt.title('Elbow method to find eps')
#plt.margins(x=0, y=-0.25)
plt.xlabel('Point index')
plt.ylabel('eps: distance from the 10000th neighbor')
plt.grid()
plt.show()
```



Note:

- It shows that the distance point around 14500 the distances start to increase over 1000 and it increases rapidly. So the distance should be taken as 1000

5.2 Modelling with parameters

In [0]:

```
dbscan = DBSCAN(eps = 1000 , min_samples=10000)
y_dbscan = dbscan.fit_predict(X_train_3)
```

In [68]:

```
dbscan.labels_
```

Out[68]:

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

In [69]:

```
y_dbscan = y_dbscan.reshape(-1,1)
print(y_dbscan.shape)
```

```
(15000, 1)
```

In [70]:

```
(y_dbscan == y_train_3).sum()
```

Out[70]:

```
2301
```

Summary:

- It shows that our model only clustered only 2301 correctly

5.3 Finding words for Essay text on each cluster

In [82]:

```
X_train_essay_tfidf_3 = X_train_essay_tfidf[0:15000, :]
print(X_train_essay_tfidf_3.shape)
```

```
(15000, 14266)
```

In [0]:

```
from sklearn.cluster import DBSCAN
dbscan = DBSCAN(eps = 1000 , min_samples=10000)
```

In [0]:

```
essay_db = dbscan.fit(X_train_essay_tfidf_3)
```

In [85]:

```
dbscan.labels_
```

Out[85]:

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

In [107]:

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

Out[107]:

```
array([0])
```

Note:

- It shows that DBSCAN plot all the points in one single cluster.

In [0]:

```
cluster_0_db =  X_train_essay_tfidf_3[np.where(essay_db.labels_ ==0)]
```

In [0]:

```
#cluster_1_db =  X_train_essay_tfidf_3[np.where(essay_db.labels_ ==1)]
```

In [113]:

```
print(cluster_0_db.shape)
#print(cluster_1_db.shape)
```

```
(15000, 14266)
```

In [0]:

```
type(cluster_0_hc)
```

Out[0]:

```
pandas.core.frame.DataFrame
```

In [91]:

```
#convert csr matrix to dataframe
cluster_0_db = pd.DataFrame(cluster_0_db.toarray(), columns=vectorizer_7.get_feature_names())
cluster_0_db.head(2)
```

Out[91]:

	00	000	03	10	100	1000	100th	101	102	103	104	105	107	10th	11	110	1100	112	115	11th	12	120	1200	123	12
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.

2 rows × 14266 columns

In [0]:

```
#cluster_1_db = pd.DataFrame(cluster_1_db.toarray(), columns=vectorizer_7.get_feature_names())
#cluster_1_db.head(2)
```

In [93]:

```
#looking at the sample data point and its essay words
cluster_0_db.iloc[0,:].sort_values(ascending=False).reset_index()
```

Out[93]:

	index	0
0	avid	0.281376
1	chromebooks	0.279620
2	college	0.179109
3	computers	0.178794
4	pulled	0.166316
...	...	...
14261	plugged	0.000000
14262	plug	0.000000
14263	pltw	0.000000
14264	plots	0.000000
14265	00	0.000000

14266 rows × 2 columns

In [0]:

```
#www = []
#for i in range(0, cluster_1_db.shape[0]):
#     j = cluster_1_db.iloc[i, :].sort_values(ascending=False).reset_index()
#    www.append(j['index'].tolist())
```

In [0]:

```
#making cluster_1_words as a one flat list
#cluster_1_words = []
#for sublist in www:
#     for item in sublist:
#         cluster_1_words.append(item)
```

In [0]:

```
xxx = []
for i in range(0, cluster_0_db.shape[0]):
    j = cluster_0_db.iloc[i, :].sort_values(ascending=False).reset_index()
    xxx.append(j['index'].tolist())
```

In [0]:

```
#making cluster_1_words as a one flat list
cluster_0_words = []
for sublist in xxx:
    for item in sublist:
        cluster_0_words.append(item)
```

In [0]:

```
#to get the unique words in the list
cluster_0_words = list(set(cluster_0_words))
#cluster_1_words = list(set(cluster_1_words))
```

5.4 Plotting word cloud

5.4.1 Cluster 0 words

In [0]:

```
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
stopwords = set(STOPWORDS)
comment_words_0_db = ' '
for word in cluster_0_words:
    comment_words_0_db = comment_words_0_db + word + ' '
```

In [0]:

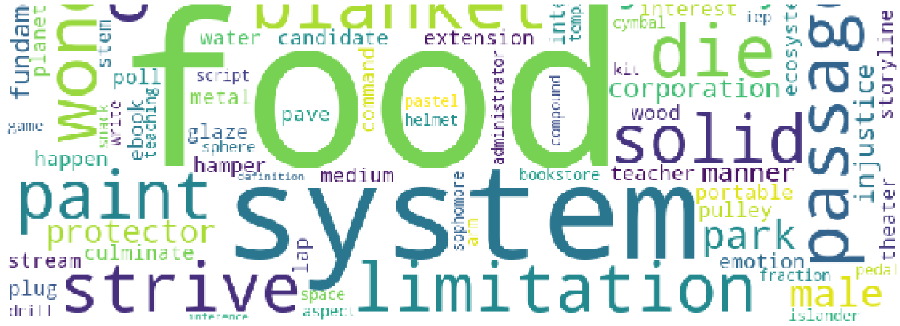
```
#Generating Word Cloud for cluster_0_words

wordcloud_0_db = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords, mi
n_font_size=10).generate(comment_words_0_db)
```

In [110]:

```
#plotting the Word Cloud
plt.figure(figsize=(8,8), facecolor=None)
plt.title('Cluster 0 words')
plt.imshow(wordcloud_0_db)
plt.axis('off')
plt.tight_layout(pad=0)
plt.show()
```

Cluster 0 words



5.4.2 Cluster 1 words

In [0]:

```
#comment_words_1_db = ' '
#for word in cluster_1_words:
#    comment_words_1_db = comment_words_1 + word + ' '
```

In [0]:

```
#Generating Word Cloud for cluster_0_words
#wordcloud_1_db = WordCloud(width=800, height=800, background_color='white', stopwords=stopwords,
min_font_size=10).generate(comment_words_1_db)
```

In [0]:

```
#plotting the Word Cloud
#plt.figure(figsize=(8,8), facecolor=None)
#plt.imshow(wordcloud_1_db)
#plt.axis('off')
#plt.tight_layout(pad=0)
#plt.show()
```

Summary:

In [117]:

```
from prettytable import PrettyTable
x = PrettyTable()

x.field_names = ['Model Number', 'Vectorizer', 'Model', 'Hyperparameter: n_clusters']
x.add_row(['1', 'TFIDF', 'K-Means', str(2)])
x.add_row(['2', 'TFIDF', 'Hierarchical', str(2)])
x.add_row(['3', 'TFIDF', 'DBSCAN', str(1)])

print(x)
```

```
+--------------+------------+--------------+----------------------------+
| Model Number | Vectorizer |    Model     | Hyperparameter: n_clusters |
+--------------+------------+--------------+----------------------------+
|      1       |   TFIDF    |   K-Means    |             2              |
|      2       |   TFIDF    | Hierarchical |             2              |
|      3       |   TFIDF    |    DBSCAN    |             1              |
+--------------+------------+--------------+----------------------------+
```

That's the end of the code