DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

your neighborhood, and your school are all helpful.

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

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

In [1]:

```
%config IPCompleter.greedy=True
%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
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
from sklearn.metrics import confusion_matrix
from scipy.sparse import hstack
import plotly.offline as offline
import plotly.graph_objs as go
```

1.1 Reading Data

In [2]:

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

In [3]:

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

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]
#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)
# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]
project_data.head(2)
```

Out[4]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
86221	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:00	Grades PreK-2
18308	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:00	Grades 3-5

In [5]:

```
# 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 [6]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
```

```
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

1.2 preprocessing of `project_subject_categories`

In [7]:

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

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

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

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

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

In [8]:

```
sorted_cat_dict
```

Out[8]:

```
{'Warmth': 1388,
 'Care_Hunger': 1388,
 'History_Civics': 5914,
 'Music_Arts': 10293,
 'AppliedLearning': 12135,
 'SpecialNeeds': 13642,
 'Health_Sports': 14223,
 'Math_Science': 41421,
 'Literacy_Language': 52239}
```

1.3 preprocessing of `project_subject_subcategories`

In [9]:

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

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

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

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

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

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

1.3 Text preprocessing

In [10]:

```
# 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 [11]:

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

Out[11]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
86221	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:00	Grades PreK-2
18308	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:00	Grades 3-5

In [12]:

```
# printing some random reviews
```

```
print(project_data['essay'].values[0])
```

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

In [13]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
len_essay=[]
# tqdm is for printing the status bar
for sentance1 in tqdm(project_data['essay'].values):
    sent= sentance1.lower()
    sent = decontracted(sent)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
    len_essay.append(len(sent.split()))
num_essay=np.array(len_essay)
```

```
100%|██████████████████████████████████| 109248/109248 [01:34<00:00, 1151.60it/s]
```

In [14]:

```
# after preprocesing
project_data['essay']=preprocessed_essays
project_data['num_essay']=num_essay
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
print(project_data['essay'].values[0])
```

```
fortunate enough use fairy tale stem kits classroom well stem journals students really enjoyed wou
ld love implement lakeshore stem kits classroom next school year provide excellent engaging stem l
essons students come variety backgrounds including language socioeconomic status many not lot expe
rience science engineering kits give materials provide exciting opportunities students month try s
everal science stem steam projects would use kits robot help guide science instruction engaging me
aningful ways adapt kits current language arts pacing guide already teach material kits like tall
tales paul bunyan johnny appleseed following units taught next school year implement kits magnets
motion sink vs float robots often get units not know teaching right way using right materials kits
give additional ideas strategies lessons prepare students science challenging develop high quality
science activities kits give materials need provide students science activities go along
curriculum classroom although things like magnets classroom not know use effectively kits provide
right amount materials show use appropriate way
```

1.4 Preprocessing of `project_title`

In [15]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_titles = []
len_project=[]
# tqdm is for printing the status bar
for sentence2 in tqdm(project_data['project_title'].values):
    sent = sentence2.lower()
    sent = decontracted(sent)
    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())
    len_project.append(len(sent.split()))
num_project=np.array(len_project)
```

```
100%|██████████████████████████████████| 109248/109248 [00:04<00:00, 26693.30it/s]
```

In [16]:

```
# after preprocesing
project_data['project_title']=preprocessed_titles
project_data['num_project']=num_project
print(project_data['project_title'][0])
```

```
not 21st century learners across ocean
```

In [17]:

```
#Preprocessing the project_grade_category
project_grade_category_cleaned=[]
for grade in tqdm(project_data['project_grade_category'].values):
    grade = grade.replace(' ', '_')
    grade = grade.replace('-', '_')
    project_grade_category_cleaned.append(grade)
project_data['Project_grade_category']=project_grade_category_cleaned
```

```
100%|██████████████████████████████████| 109248/109248 [00:00<00:00, 674296.19it/s]
```

In [18]:

```
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')
```

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/reduction algorithms 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 and try a different number of clusters like 2,5 etc.
    - You can take less data points (as this is very computationally expensive one) 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.
    - You can take a smaller sample size for this as well.
- 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.

In [19]:

In [19]:

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

Out[19]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:00	Grades PreK-2
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:00	Grades 3-5

2. Clustering

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

In [20]:

```
from sklearn.model_selection import train_test_split
# split the data set into train and test respectively 80% and 20%
y=project_data['project_is_approved']
project_data.drop(['project_is_approved'],axis=1, inplace=True)
x=project_data
X_temp,X_test,Y_temp,Y_test=train_test_split(x,y,test_size=0.33,random_state=1)
# split the data set into train and cv respectively 60% and 20%
X_train,X_cv,Y_train,Y_cv=train_test_split(X_temp,Y_temp,test_size=0.33,random_state=1)
print("Shape of Train data set X={} Y={}".format(X_train.shape,Y_train.shape))
print("Shape of Test data set X={} Y={}".format(X_test.shape,Y_test.shape))
print("Shape of CV data set X={} Y={}".format(X_cv.shape,Y_cv.shape))
```

```
Shape of Train data set X=(49041, 18) Y=(49041,)
Shape of Test data set X=(36052, 18) Y=(36052,)
Shape of CV data set X=(24155, 18) Y=(24155,)
```

In [21]:

```
X_train
```

Out[21]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_ca
22470	16301	p102862	8b996f6d87703d2630413100b590dd62	Ms.	CA	2016-08-03 16:06:00	Grades 3-5
61672	74853	p119206	058b33d511a2c806b2396ef8c27b9c72	Ms.	VA	2016-10-24 16:46:00	Grades 3-5
22765	81958	p094993	c4929600d3c4c4447404f3b8f8fb05de	Mrs.	IA	2016-08-03	Grades PreK-2

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	21:53:00 Date	project_grade_ca
91723	90360	p218593	9af2b10274f7ef464214490b41d880a2	Ms.	VA	2017-02-14 18:43:00	Grades PreK-2
46625	171921	p256636	66c62ddf88b4a969523f481c675669da	Ms.	LA	2016-09-10 13:15:00	Grades 9-12
6421	9308	p253067	7e6a71daf5ad7184212cc9d1dbc81ef2	Mrs.	AZ	2016-05-31 14:26:00	Grades 6-8
4586	160927	p158249	534ed3557240db520d31b486520aa671	Ms.	IL	2016-05-21 15:52:00	Grades 9-12
36707	138757	p151306	575a29f894b432175a39aa89d5b8eac4	Mrs.	NY	2016-08-26 09:18:00	Grades 6-8
94064	105065	p222160	2f02b02985e96ff60eef2fc454a2e583	Ms.	MO	2017-02-23 21:00:00	Grades 3-5
5793	44766	p188013	c127da422fef57b697848b51fd749a2d	Ms.	TN	2016-05-27 10:15:00	Grades PreK-2
11468	172887	p066694	9154d5a7f43daed71fd36482a219a1ba	Ms.	CA	2016-06-28 17:18:00	Grades 3-5
19487	95536	p150931	4d61b48d9fc6079b00d29f0be8ce9ebb	Mrs.	VA	2016-07-30 20:27:00	Grades 3-5
101968	43885	p183732	d7cfd2ca99a8e5cd09584066c9a652d8	Mrs.	MD	2017-03-28 19:55:00	Grades 6-8
42760	32327	p033758	24b16eab588c205e57e881507124f8ec	Mrs.	CA	2016-09-02 15:11:00	Grades 3-5
35806	71346	p052892	ab70a8377d8c3a3d39abdf07952fd5cb	Mr.	AR	2016-08-25 09:51:00	Grades 6-8
107162	138674	p039886	7880a7d016af55888fcd2e89c6c5bdb3	Teacher	TX	2017-04-20 00:35:00	Grades PreK-2

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_ca
63827	149341	p212388	0dfba10f0b472746a6f299ae1305a8b5	Mrs.	TX	2016-11-02 13:31:00	Grades 6-8
59531	158504	p078916	b17cd8bd63c8e483996a50ec3c897884	Ms.	NY	2016-10-15 20:11:00	Grades PreK-2
12236	133294	p190076	192e2297f28f215a7bb04e46976f7635	Mrs.	NY	2016-07-02 12:16:00	Grades PreK-2
100472	121019	p162414	768858c081bf21f52391d22d4a076c93	Ms.	IL	2017-03-24 02:45:00	Grades 6-8
49621	57208	p044139	e5daf8ee734e210adc46b274f80b4617	Mrs.	AL	2016-09-17 17:40:00	Grades 3-5
31746	68100	p027200	4d4a80291fba284072d7b0500b9959a5	Mrs.	TX	2016-08-17 20:05:00	Grades PreK-2
33734	29591	p232234	dafb8f8281abb69de7d7fb130cd4c094	Mrs.	CA	2016-08-21 17:25:00	Grades PreK-2
13098	8165	p049303	48420505bba11f394328af01c031146a	Mrs.	CA	2016-07-07 17:23:00	Grades 3-5
486	43970	p010063	75141e4d4e6d3528fc3ad8e41ce10507	Ms.	CA	2016-04-28 22:12:00	Grades 9-12
104741	35328	p044957	7b300390394e42d705052b0f31987847	Mrs.	OH	2017-04-05 21:14:00	Grades PreK-2
68542	50225	p229836	cb252bccc27cb4a844e0768f9028b662	Ms.	GA	2016-11-18 10:42:00	Grades 3-5
8371	77239	p186485	51c9febc13e9eee85340bab63039ea47	Mrs.	NM	2016-06-11 12:25:00	Grades PreK-2
59708	143418	p212155	8c4a1d8b60eaf7f7c51bfcc427f760fe	Mrs.	IN	2016-10-16 21:17:00	Grades 3-5

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	2016 Date	project_grade_ca
45304	54284	p076203	d5a5f5982be75de8505ef87b32065b8d	Mrs.	MI	09-07 13:54:00	Grades 9-12
...	...	...	...	...	...	...	...
17841	174589	p051075	701e372cc06523c94e9190b96193e083	Mrs.	VA	2016-07-25 19:46:00	Grades 6-8
39012	77677	p161110	c5e25a88441371d34d9f9fd192851cfe	Mrs.	NY	2016-08-30 18:14:00	Grades 6-8
95333	139210	p224245	8d76514e7e465647352e71c1164811f5	Mrs.	SC	2017-03-01 15:18:00	Grades PreK-2
93731	149816	p056613	ced23d893362685d452c288a76329490	Mrs.	TN	2017-02-22 17:20:00	Grades 3-5
47164	57474	p088604	f90538aa0f68aa2cf515b875a40ca2cd	Mrs.	MA	2016-09-11 19:28:00	Grades PreK-2
97712	170587	p250570	00e6d08a58ebd94682732ddbe2202070	Mr.	CA	2017-03-11 14:50:00	Grades 9-12
29484	69955	p089740	8f6207014defbeb6e91838a032c93000	Ms.	SC	2016-08-14 07:55:00	Grades 3-5
23731	80830	p052701	7f8cbd9fff1b0a3d801fac6e7dc11d5d	Mrs.	AL	2016-08-05 10:31:00	Grades 3-5
98627	135443	p009940	0d572366d6900c05a09343bf050dea31	Mrs.	CT	2017-03-15 14:22:00	Grades 3-5
95932	177898	p131398	296dd2635e771ab18ab1b2f1618d0c71	Mrs.	CO	2017-03-03 16:57:00	Grades 6-8
76279	132858	p179883	df2c697e6c4300c22e19fce7069241ef	Mrs.	MN	2016-12-18 22:42:00	Grades PreK-2
56123	57901	p051721	9a27a7309e856b4675f3c757fda01919	Mrs.	CA	2016-10-05 01:06:00	Grades 9-12

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_ca
92852	173593	p250144	5f66077740964356d0b343e9451baa47	Mrs.	CA	2017-02-18 21:29:00	Grades PreK-2
2949	123094	p140157	897088ead72deae7ba7b69afb22aa237	Mrs.	PA	2016-05-11 20:57:00	Grades 3-5
96600	50435	p072462	ade8ccc09f84f6307fd9168d0d51c3ff	Teacher	IL	2017-03-07 05:52:00	Grades PreK-2
28519	71186	p014116	6ff7df2e136d2d78157de3acb32f1a57	Mr.	OK	2016-08-12 15:32:00	Grades 9-12
50290	145316	p113481	29f82785e11dd7aef70b98223f5686df	Mrs.	CA	2016-09-19 17:32:00	Grades PreK-2
49997	81793	p052626	5954eb3bd8f2ae3446f3ba94bd4357d2	Mrs.	MD	2016-09-18 20:42:00	Grades 3-5
84681	124768	p040848	92577f98149cae5387b4e3bdfe76c98c	Ms.	AL	2017-01-19 19:57:00	Grades PreK-2
44906	148815	p001562	c7d204ec1f597cc13cd636630929df1f	Ms.	PA	2016-09-06 19:02:00	Grades 3-5
105236	117265	p109375	b906f09bac7529c514b74747977d4e47	Teacher	NY	2017-04-08 10:57:00	Grades 3-5
54533	86834	p220447	b84239aa53b298b290565e722a4020cf	Mrs.	NY	2016-09-30 08:42:00	Grades PreK-2
49376	59225	p141511	56af4fbf0531bae7504533e0e8bb2848	Mrs.	AZ	2016-09-16 20:55:00	Grades PreK-2
54123	181661	p192368	f53d9d71266bcdb7809a0ed20aa04a1e	Mrs.	MO	2016-09-29 10:41:00	Grades PreK-2
87768	161288	p027928	d87916ace20f067373b3b04dc5aa60bb	Mr.	NY	2017-01-31 14:24:00	Grades 3-5
56588	167751	p032112	3bce4887ad0632268b434b1d408ae20d	Mrs.	TX	2016-10-05 22:17:00	Grades 9-12

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_ca
81127	3435	p258759	a3596130909067db434e55a9a6b4fe4f	Mrs.	NC	2017-01-09 15:09:00	Grades 6-8
39902	18041	p103188	7d8badd58f0293fb40b39e0e84ebfac3	Mrs.	AL	2016-09-01 00:00:00	Grades PreK-2
108620	164031	p159933	922a9c17375092e60dc5b32fb4d10318	Ms.	NY	2017-04-27 12:27:00	Grades 6-8
47209	100495	p233789	e6281bd57845e3607c13de816a0eaafa	Mrs.	NC	2016-09-11 21:05:00	Grades 3-5

49041 rows × 18 columns

2.2 Make Data Model Ready: encoding numerical, categorical features

Vectorizing Categorical data

In [22]:

```
#Response coding

def get_prob(x_columns,x_column_name,y,all_unique_values):
    i=0
    prob_temp=0.
    prob_1=[]
    prob_0=[]
    new_column_1=x_column_name+'_approved' #if column is clean_categories then
new_column_1=clean_categories_approved
    new_column_0=x_column_name+'_not_approved'#if column is clean_categories then
new_column_0=clean_categories_not_approved
    #all_unique_values=x_columns[x_column_name].unique()
    for unique in tqdm(all_unique_values):
        total_unique=x_columns[(x_columns[x_column_name]==unique)].count()[0]#getting total count o
f  unique word in column
        unique_count=x_columns[(x_columns[x_column_name]==unique)&(y==1)].count()[0]#getting count
of  unique word in column where class label is 1
        prob_temp=round((unique_count/total_unique),3)#Calculating the probability of unique word
where class label is 1
        prob_1.append(prob_temp)
        prob_0.append(round((1-prob_temp),3))#Calculating the probability of unique word where
class label is 0
    d={'Name':all_unique_values,"Approved":prob_1,"Not_approved":prob_0}
    df = pd.DataFrame(data=d)
    print(df[0:2])
    for unique in all_unique_values:
        x_columns.loc[(x_columns[x_column_name]==unique),new_column_1]=df.loc[(df["Name"]==unique),
"Approved"][i]#Updating the probabilities to the dataset
        x_columns.loc[(x_columns[x_column_name]==unique),new_column_0]=df.loc[(df["Name"]==unique),
"Not_approved"][i]#Updating the probabilities to the dataset
        i=i+1
    return(x_columns[new_column_1],x_columns[new_column_0])
```

In [23]:

```
#Response coding
# clean_categories
all_unique_values=X_train["clean_categories"].unique()# getting all unique data from column
```

```
tr_categories_approved,tr_categories_not_approved = get_prob(X_train,"clean_categories",Y_train,al
l_unique_values)
cv_categories_approved,cv_categories_not_approved =
get_prob(X_cv,"clean_categories",Y_cv,all_unique_values)
te_categories_approved,te_categories_not_approved =
get_prob(X_test,"clean_categories",Y_test,all_unique_values)
tr_categories_approved=np.array(tr_categories_approved).reshape(-1,1)
tr_categories_not_approved=np.array(tr_categories_not_approved).reshape(-1,1)
cv_categories_approved=np.array(cv_categories_approved).reshape(-1,1)
cv_categories_not_approved=np.array(cv_categories_not_approved).reshape(-1,1)
te_categories_approved=np.array(te_categories_approved).reshape(-1,1)
te_categories_not_approved=np.array(te_categories_not_approved).reshape(-1,1)
```

```
100%|██████████████████████████████████████████| 50/50 [00:01<00:00, 36.13it/s]
```

	Name	Approved	Not_approved
0	Health_Sports	0.852	0.148
1	Math_Science	0.820	0.180

```
100%|██████████████████████████████████████████| 50/50 [00:00<00:00, 53.90it/s]
```

	Name	Approved	Not_approved
0	Health_Sports	0.843	0.157
1	Math_Science	0.812	0.188

```
100%|██████████████████████████████████████████| 50/50 [00:01<00:00, 42.06it/s]
```

	Name	Approved	Not_approved
0	Health_Sports	0.848	0.152
1	Math_Science	0.824	0.176

In [24]:

```
#Response coding
# clean_subcategories
all_unique_values=X_train["clean_subcategories"].unique()# getting all unique data from column
tr_sub_categories_approved,tr_sub_categories_not_approved = get_prob(X_train,"clean_subcategories"
,Y_train,all_unique_values)
cv_sub_categories_approved,cv_sub_categories_not_approved = get_prob(X_cv,"clean_subcategories",Y_
cv,all_unique_values)
te_sub_categories_approved,te_sub_categories_not_approved = get_prob(X_test,"clean_subcategories",
Y_test,all_unique_values)
tr_sub_categories_approved=np.array(tr_sub_categories_approved).reshape(-1,1)
tr_sub_categories_not_approved=np.array(tr_sub_categories_not_approved).reshape(-1,1)
cv_sub_categories_approved=np.array(cv_sub_categories_approved).reshape(-1,1)
cv_sub_categories_not_approved=np.array(cv_sub_categories_not_approved).reshape(-1,1)
te_sub_categories_approved=np.array(te_sub_categories_approved).reshape(-1,1)
te_sub_categories_not_approved=np.array(te_sub_categories_not_approved).reshape(-1,1)
```

```
100%|██████████████████████████████████████████| 377/377 [00:09<00:00, 40.73it/s]
```

	Name	Approved	Not_approved
0	Health_Wellness NutritionEducation	0.857	0.143
1	AppliedSciences	0.815	0.185

```
100%|██████████████████████████████████████████| 377/377 [00:05<00:00, 68.50it/s]
```

	Name	Approved	Not_approved
0	Health_Wellness NutritionEducation	0.806	0.194
1	AppliedSciences	0.819	0.181

```
100%|██████████████████████████████████████████| 377/377 [00:07<00:00, 52.48it/s]
```

	Name	Approved	Not_approved
0	Health_Wellness NutritionEducation	0.829	0.171
1	AppliedSciences	0.821	0.179

In [25]:

```
#Response coding
#teacher_prefix
all_unique_values=X_train["teacher_prefix"].unique()# getting all unique data from column
tr_teacher_prefix_approved,tr_teacher_prefix_not_approved =
get_prob(X_train,"teacher_prefix",Y_train,all_unique_values)
cv_teacher_prefix_approved,cv_teacher_prefix_not_approved = get_prob(X_cv,"teacher_prefix",Y_cv,al
l_unique_values)
te_teacher_prefix_approved,te_teacher_prefix_not_approved =
get_prob(X_test,"teacher_prefix",Y_test,all_unique_values)
tr_teacher_prefix_approved=np.array(tr_teacher_prefix_approved).reshape(-1,1)
tr_teacher_prefix_not_approved=np.array(tr_teacher_prefix_not_approved).reshape(-1,1)
cv_teacher_prefix_approved=np.array(cv_teacher_prefix_approved).reshape(-1,1)
cv_teacher_prefix_not_approved=np.array(cv_teacher_prefix_not_approved).reshape(-1,1)
te_teacher_prefix_approved=np.array(te_teacher_prefix_approved).reshape(-1,1)
te_teacher_prefix_not_approved=np.array(te_teacher_prefix_not_approved).reshape(-1,1)
```

```
100%|████████████████████████████████████████| 5/5 [00:00<00:00, 15.63it/s]
```

```
   Name  Approved  Not_approved
0   Ms.     0.843         0.157
1  Mrs.     0.855         0.145
```

```
100%|████████████████████████████████████████| 5/5 [00:00<00:00, 30.67it/s]
```

```
   Name  Approved  Not_approved
0   Ms.     0.843         0.157
1  Mrs.     0.854         0.146
```

```
100%|████████████████████████████████████████| 5/5 [00:00<00:00, 19.72it/s]
```

```
   Name  Approved  Not_approved
0   Ms.     0.844         0.156
1  Mrs.     0.857         0.143
```

In [26]:

```
#Response coding
# Project school_state
all_unique_values=X_train["school_state"].unique()# getting all unique data from column
tr_school_state_approved,tr_school_state_not_approved =
get_prob(X_train,"school_state",Y_train,all_unique_values)
cv_school_state_approved,cv_school_state_not_approved =
get_prob(X_cv,"school_state",Y_cv,all_unique_values)
te_school_state_approved,te_school_state_not_approved = get_prob(X_test,"school_state",Y_test,all_u
nique_values)
tr_school_state_approved=np.array(tr_school_state_approved).reshape(-1,1)
tr_school_state_not_approved=np.array(tr_school_state_not_approved).reshape(-1,1)
cv_school_state_approved=np.array(cv_school_state_approved).reshape(-1,1)
cv_school_state_not_approved=np.array(cv_school_state_not_approved).reshape(-1,1)
te_school_state_approved=np.array(te_school_state_approved).reshape(-1,1)
te_school_state_not_approved=np.array(te_school_state_not_approved).reshape(-1,1)
```

```
100%|████████████████████████████████████████| 51/51 [00:01<00:00, 39.68it/s]
```

```
  Name  Approved  Not_approved
0   CA     0.858         0.142
1   VA     0.843         0.157
```

```
100%|████████████████████████████████████████| 51/51 [00:00<00:00, 63.96it/s]
```

```
  Name  Approved  Not_approved
0   CA     0.858         0.142
1   VA     0.845         0.155
```

```
100%|████████████████████████████████████████| 51/51 [00:00<00:00, 51.13it/s]
```

```
  Name  Approved  Not_approved
0   CA     0.858         0.142
1   VA     0.865         0.135
```

In [27]:

```
#Response coding
# Project project_grade_category
all_unique_values=X_train["project_grade_category"].unique()# getting all unique data from column
tr_project_grade_category_approved,tr_project_grade_category_not_approved =
get_prob(X_train,"project_grade_category",Y_train,all_unique_values)
cv_project_grade_category_approved,cv_project_grade_category_not_approved =
get_prob(X_cv,"project_grade_category",Y_cv,all_unique_values)
te_project_grade_category_approved,te_project_grade_category_not_approved =
get_prob(X_test,"project_grade_category",Y_test,all_unique_values)
tr_project_grade_category_approved=np.array(tr_project_grade_category_approved).reshape(-1,1)
tr_project_grade_category_not_approved=np.array(tr_project_grade_category_not_approved).reshape(-1
,1)
cv_project_grade_category_approved=np.array(cv_project_grade_category_approved).reshape(-1,1)
cv_project_grade_category_not_approved=np.array(cv_project_grade_category_not_approved).reshape(-1
,1)
te_project_grade_category_approved=np.array(te_project_grade_category_approved).reshape(-1,1)
te_project_grade_category_not_approved=np.array(te_project_grade_category_not_approved).reshape(-1
,1)
```

```
100%|██████████████████████████████████████████| 4/4 [00:00<00:00, 14.78it/s]
```

```
             Name  Approved  Not_approved
0     Grades 3-5     0.854         0.146
1  Grades PreK-2     0.849         0.151
```

```
100%|██████████████████████████████████████████| 4/4 [00:00<00:00, 24.81it/s]
```

```
             Name  Approved  Not_approved
0     Grades 3-5     0.850         0.150
1  Grades PreK-2     0.849         0.151
```

```
100%|██████████████████████████████████████████| 4/4 [00:00<00:00, 17.99it/s]
```

```
             Name  Approved  Not_approved
0     Grades 3-5     0.858         0.142
1  Grades PreK-2     0.849         0.151
```

standardizing Numerical features

In [28]:

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

# price_standardized = standardScalar.fit(X_train['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
tr_price_standardized=price_scalar.fit_transform(X_train['price'].values.reshape(-1,1)) # finding t
he mean and standard deviation of this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
cv_price_standardized = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
te_price_standardized = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
```

```
Mean : 298.5818657857711, Standard deviation : 363.8573751232583
```

In [29]:

```
print("\nShape of matrix after column standardization for 'price'\nTrain data-{},\nCV data\t-{}\nT
est data-{}".format(tr_price_standardized.shape,cv_price_standardized.shape,te_price_standardized.s
```

```
hape))
```

```
Shape of matrix after column standardization for 'price'
Train data-(49041, 1),
CV data -(24155, 1)
Test data-(36052, 1)
```

In [30]:

```
#quantity
quantity_scalar = StandardScaler()
tr_quantity_standardized=quantity_scalar.fit_transform(X_train['quantity'].values.reshape(-1,1)) #
finding the mean and standard deviation of this data
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation :
{np.sqrt(quantity_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
cv_quantity_standardized = quantity_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
te_quantity_standardized = quantity_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
print("\nShape of matrix after column standardization for 'quantity'\nTrain data-{},\nCV data\t-{}
\nTest
data-{}".format(tr_quantity_standardized.shape,cv_quantity_standardized.shape,te_quantity_standardi
zed.shape))
```

```
Mean : 16.96853653065802, Standard deviation : 26.262737421015874

Shape of matrix after column standardization for 'quantity'
Train data-(49041, 1),
CV data -(24155, 1)
Test data-(36052, 1)
```

In [31]:

```
#teacher_number_of_previously_posted_projects
teacher_number_of_previously_posted_projects_scalar = StandardScaler()
tr_teacher_number_of_previously_posted_projects_standardized=teacher_number_of_previously_posted_pr
jects_scalar.fit_transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(
-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {teacher_number_of_previously_posted_projects_scalar.mean_[0]}, Standard deviation
: {np.sqrt(teacher_number_of_previously_posted_projects_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
cv_teacher_number_of_previously_posted_projects_standardized =
teacher_number_of_previously_posted_projects_scalar.transform(X_cv['teacher_number_of_previously_po
ted_projects'].values.reshape(-1, 1))
te_teacher_number_of_previously_posted_projects_standardized =
teacher_number_of_previously_posted_projects_scalar.transform(X_test['teacher_number_of_previously_
osted_projects'].values.reshape(-1, 1))
print("\nShape of matrix after column standardization for
'teacher_number_of_previously_posted_projects'\nTrain data-{},\nCV data\t-{}\nTest data-{}".format
(tr_teacher_number_of_previously_posted_projects_standardized.shape,cv_teacher_number_of_previously
posted_projects_standardized.shape,te_teacher_number_of_previously_posted_projects_standardized.sh
ape))
```

```
Mean : 11.03756040863767, Standard deviation : 27.38081956899988

Shape of matrix after column standardization for 'teacher_number_of_previously_posted_projects'
Train data-(49041, 1),
CV data -(24155, 1)
Test data-(36052, 1)
```

In [32]:

```
#Number of words in essay
num_essay_scalar = StandardScaler()
tr_num_essay_standardized=num_essay_scalar.fit_transform(X_train['num_essay'].values.reshape(-1,1))
# finding the mean and standard deviation of this data
print(f"Mean : {num_essay_scalar.mean_[0]}, Standard deviation :
{np.sqrt(num_essay_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
cv_num_essay_standardized = num_essay_scalar.transform(X_cv['num_essay'].values.reshape(-1, 1))
```

```
te_num_essay_standardized = num_essay_scalar.transform(X_test['num_essay'].values.reshape(-1, 1))
print("\nShape of matrix after column standardization for 'num_essay'\nTrain data-{},\nCV data\t-{
}\nTest
data-{}".format(tr_num_essay_standardized.shape,cv_num_essay_standardized.shape,te_num_essay_standa
rdized.shape))
```

```
Mean : 138.1287086315532, Standard deviation : 36.41300099141212

Shape of matrix after column standardization for 'num_essay'
Train data-(49041, 1),
CV data -(24155, 1)
Test data-(36052, 1)
```

In [33]:

```
#Number of words in essay
num_project_scalar = StandardScaler()
tr_num_project_standardized=num_project_scalar.fit_transform(X_train['num_project'].values.reshape
(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {num_project_scalar.mean_[0]}, Standard deviation :
{np.sqrt(num_project_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
cv_num_project_standardized = num_project_scalar.transform(X_cv['num_project'].values.reshape(-1, 1
))
te_num_project_standardized = num_project_scalar.transform(X_test['num_project'].values.reshape(-1,
1))
print("\nShape of matrix after column standardization for 'num_project'\nTrain data-{},\nCV data\t
-{}\nTest data-{}".format(tr_num_project_standardized.shape,cv_num_project_standardized.shape,te_n
um_project_standardized.shape))
```

```
Mean : 3.6965600212067455, Standard deviation : 1.523906739030445

Shape of matrix after column standardization for 'num_project'
Train data-(49041, 1),
CV data -(24155, 1)
Test data-(36052, 1)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

Vectorizing Text data

Bag of Words on `preprocessed_essay`

In [34]:

```
#Bag of words of Project essays
# We are considering only the words which appeared in at least 10 documents(rows or projects) and
max feature is 8000.
#Fitting train data because we need all and transforming  train ,cv and test vector shape should b
e same.
vectorizer_essays = CountVectorizer(min_df=10,max_features=5000)#max_features=8000
tr_text_bow=vectorizer_essays.fit_transform(X_train['essay']) # fitting train data

#transforming train,cv and test data

cv_text_bow = vectorizer_essays.transform(X_cv['essay'])
te_text_bow = vectorizer_essays.transform(X_test['essay'])
print("Shape of matrix after one hot encodig \nTrain data-{},\nCV data\t-{}\nTest data-{}".format(
tr_text_bow.shape,cv_text_bow.shape,te_text_bow.shape))
```

```
Shape of matrix after one hot encodig
Train data-(49041, 5000),
CV data -(24155, 5000)
Test data-(36052, 5000)
```

In [35]:

```
print('Some feature names of bag of words of the essays')
print('='*50)
print(vectorizer_essays.get_feature_names()[1000:1020])
print(tr_text_bow.toarray()[0:1])
```

```
Some feature names of bag of words of the essays
==================================================
['consistently', 'consisting', 'consists', 'constant', 'constantly', 'constraints', 'construct', '
constructing', 'construction', 'constructive', 'consumable', 'consumers', 'consuming', 'contact',
'contagious', 'contain', 'contained', 'containers', 'contains', 'contemporary']
[[0 0 0 ... 0 0 0]]
```

Bag of Words on `project_title`

In [36]:

```
#Bag of words project_title
# We are considering only the words which appeared in at least 5 documents(rows or projects) and m
ax number of feature is 5000.
#Fitting train data and transforming  train ,cv and test vector shape should be same.
vectorizer_title = CountVectorizer(min_df=10,max_features=5000)
tr_text_bow_title=vectorizer_title.fit_transform(X_train['project_title'])
cv_text_bow_title = vectorizer_title.transform(X_cv['project_title'])
te_text_bow_title = vectorizer_title.transform(X_test['project_title'])
print("Shape of matrix after one hot encodig \nTrain data-{},\nCV data\t-{}\nTest data-{}".format(
tr_text_bow_title.shape,cv_text_bow_title.shape,te_text_bow_title.shape))
```

```
Shape of matrix after one hot encodig
Train data-(49041, 1978),
CV data -(24155, 1978)
Test data-(36052, 1978)
```

In [37]:

```
print('Some feature names of bag of words of the project title')
print('='*50)
print(vectorizer_title.get_feature_names()[1000:1020])
print(tr_text_bow_title.toarray()[0:2])
```

```
Some feature names of bag of words of the project title
==================================================
['la', 'lab', 'labs', 'lakeshore', 'laminate', 'laminating', 'land', 'language', 'lap', 'laptop',
'laptops', 'large', 'last', 'lead', 'leader', 'leaders', 'leadership', 'leading', 'leads',
'league']
[[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]
```

TFIDF vectorizer

TFIDF Vectorizer on `preprocessed_essay`

In [38]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer_essays = TfidfVectorizer(min_df=10,max_features=3000)
#Fitting train data and transforming  train ,cv and test vector shape should be same.
tr_text_tfidf=tfidf_vectorizer_essays.fit_transform(X_train['essay'])
cv_text_tfidf = tfidf_vectorizer_essays.transform(X_cv['essay'])
te_text_tfidf = tfidf_vectorizer_essays.transform(X_test['essay'])
print("Shape of matrix TFIDF Vectorizer on essays \nTrain data-{},\nCV data\t-{}\nTest data-{}".fo
rmat(tr_text_tfidf.shape,cv_text_tfidf.shape,te_text_tfidf.shape))
```

```
Shape of matrix TFIDF Vectorizer on essays
Train data-(49041, 3000),
CV data -(24155, 3000)
Test data-(36052, 3000)
```

In [39]:

```
print('Sample of TFIDF Vectorizer on essays')
print('='*50)
print(tr_text_tfidf.toarray()[0:1])
print(tfidf_vectorizer_essays.get_feature_names()[300:310])
```

```
Sample of TFIDF Vectorizer on essays
==================================================
[[0. 0. 0. ... 0. 0. 0.]]
['becoming', 'began', 'begin', 'beginning', 'begins', 'begun', 'behavior', 'behavioral',
'behaviors', 'behind']
```

1.4.2.4 TFIDF Vectorizer on `project_title`

In [40]:

```
# Similarly you can vectorize for title also
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer_title = TfidfVectorizer(min_df=10)
#Fitting train data and transforming  train ,cv and test vector shape should be same.
tr_title_tfidf=tfidf_vectorizer_title.fit_transform(X_train['project_title'])

cv_title_tfidf = tfidf_vectorizer_title.transform(X_cv['project_title'])
te_title_tfidf = tfidf_vectorizer_title.transform(X_test['project_title'])

print("Shape of matrix TFIDF Vectorizer on essays \nTrain data-{},\nCV data\t-{}\nTest data-{}".fo
rmat(tr_title_tfidf.shape,cv_title_tfidf.shape,te_title_tfidf.shape))
```

```
Shape of matrix TFIDF Vectorizer on essays
Train data-(49041, 1978),
CV data -(24155, 1978)
Test data-(36052, 1978)
```

In [41]:

```
print('Sample of TFIDF Vectorizer on `project_title`')
print('='*50)
print(tr_title_tfidf.toarray()[0:1,180:200])
print(tfidf_vectorizer_title.get_feature_names()[180:200])
```

```
Sample of TFIDF Vectorizer on `project_title`
==================================================
[[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
['bookshelf', 'bookshelves', 'bookworms', 'boom', 'boost', 'boosting', 'bored', 'boredom',
'boring', 'bot', 'bots', 'bounce', 'bouncing', 'bouncy', 'bound', 'box', 'boxes', 'boys', 'brain',
'brains']
```

1.5.4 Merging all the above features

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

In [42]:

```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#categorical, numerical features + project_title(BOW)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
tr_X_BOW=
hstack((tr_categories_approved,tr_categories_not_approved,tr_sub_categories_approved,tr_sub_categor
not_approved,tr_teacher_prefix_approved,tr_teacher_prefix_not_approved,tr_school_state_approved,tr_
ol_state_not_approved,tr_project_grade_category_approved,tr_project_grade_category_not_approved,tr_
e_standardized,tr_teacher_number_of_previously_posted_projects_standardized,tr_text_bow_title,tr_te
ow)).tocsr()
cv_X_BOW=
hstack((cv_categories_approved,cv_categories_not_approved,cv_sub_categories_approved,cv_sub_categor
not_approved,cv_teacher_prefix_approved,cv_teacher_prefix_not_approved,cv_school_state_approved,cv_
ol_state_not_approved,cv_project_grade_category_approved,cv_project_grade_category_not_approved,cv_
e_standardized,cv_teacher_number_of_previously_posted_projects_standardized,cv_text_bow_title,cv_te
```

```
ow)).tocsr()
te_X_BOW=
hstack((te_categories_approved,te_categories_not_approved,te_sub_categories_approved,te_sub_categor
not_approved,te_teacher_prefix_approved,te_teacher_prefix_not_approved,te_school_state_approved,te_
ol_state_not_approved,te_project_grade_category_approved,te_project_grade_category_not_approved,te_
e_standardized,te_teacher_number_of_previously_posted_projects_standardized,te_text_bow_title,te_te
ow)).tocsr()
tr_X_BOW=tr_X_BOW.toarray()
cv_X_BOW=cv_X_BOW.toarray()
te_X_BOW=te_X_BOW.toarray()
print(tr_X_BOW.shape)
print(cv_X_BOW.shape)
print(te_X_BOW.shape)
```

```
(49041, 6990)
(24155, 6990)
(36052, 6990)
Wall time: 3.05 s
```

In [43]:

```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#categorical, numerical features + project_title(TFIDF)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
tr_X_TFIDF=
hstack((tr_categories_approved,tr_categories_not_approved,tr_sub_categories_approved,tr_sub_categor
not_approved,tr_teacher_prefix_approved,tr_teacher_prefix_not_approved,tr_school_state_approved,tr_
ol_state_not_approved,tr_project_grade_category_approved,tr_project_grade_category_not_approved,tr_
e_standardized,tr_teacher_number_of_previously_posted_projects_standardized,tr_title_tfidf,tr_text_
f))
cv_X_TFIDF=
hstack((cv_categories_approved,cv_categories_not_approved,cv_sub_categories_approved,cv_sub_categor
not_approved,cv_teacher_prefix_approved,cv_teacher_prefix_not_approved,cv_school_state_approved,cv_
ol_state_not_approved,cv_project_grade_category_approved,cv_project_grade_category_not_approved,cv_
e_standardized,cv_teacher_number_of_previously_posted_projects_standardized,cv_title_tfidf,cv_text_
f))
te_X_TFIDF=
hstack((te_categories_approved,te_categories_not_approved,te_sub_categories_approved,te_sub_categor
not_approved,te_teacher_prefix_approved,te_teacher_prefix_not_approved,te_school_state_approved,te_
ol_state_not_approved,te_project_grade_category_approved,te_project_grade_category_not_approved,te_
e_standardized,te_teacher_number_of_previously_posted_projects_standardized,te_title_tfidf,te_text_
f))
tr_X_TFIDF=tr_X_TFIDF.toarray()
cv_X_TFIDF=cv_X_TFIDF.toarray()
te_X_TFIDF=te_X_TFIDF.toarray()
print(tr_X_TFIDF.shape)
print(cv_X_TFIDF.shape)
print(te_X_TFIDF.shape)
```

```
(49041, 4990)
(24155, 4990)
(36052, 4990)
Wall time: 2.04 s
```

2.4 Dimensionality Reduction on the selected features

1. having less than 5k features for TFIDF

2.5 Apply Kmeans

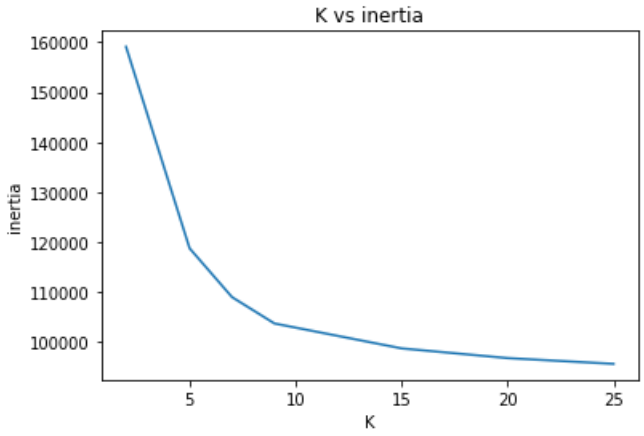
In [46]:

```
%%time
from sklearn.cluster import KMeans
inertia=[]
K=[2,5,7,9,15,20,25]
for k in tqdm(K):
    kmeans = KMeans(n_clusters=k, random_state=0,algorithm="full").fit(tr_X_TFIDF)
```

```
    inertia.append(kmeans.inertia_)
plt.plot(K,inertia,label='inertia')
plt.xlabel('K')
plt.ylabel('inertia')
plt.title('K vs inertia')
```

```
100%|██████████████████████████████████████| 7/7 [2:41:32<00:00, 1384.62s/it]
```

```
Wall time: 2h 41min 34s
```



1. From above figure we can see that inflection is at k=5.

In [132]:

```
kmeans = KMeans(n_clusters=5, random_state=0).fit(tr_X_TFIDF)
#storing cluster label of each point
X_train['cluster_label']=kmeans.labels_.reshape(-1,1)
X_train[:2]
```

Out[132]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cat
22470	16301	p102862	8b996f6d87703d2630413100b590dd62	Ms.	CA	2016-08-03 16:06:00	Grades 3-5
61672	74853	p119206	058b33d511a2c806b2396ef8c27b9c72	Ms.	VA	2016-10-24 16:46:00	Grades 3-5

2 rows × 29 columns

In [50]:

```
#Cluster distribution
X_train.cluster_label.value_counts()
```

Out[50]:

```
0    39688
1     5604
4     3093
2      550
3      106
Name: cluster_label, dtype: int64
```

In [93]:

```
#function to print Word Cloud
#https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
```

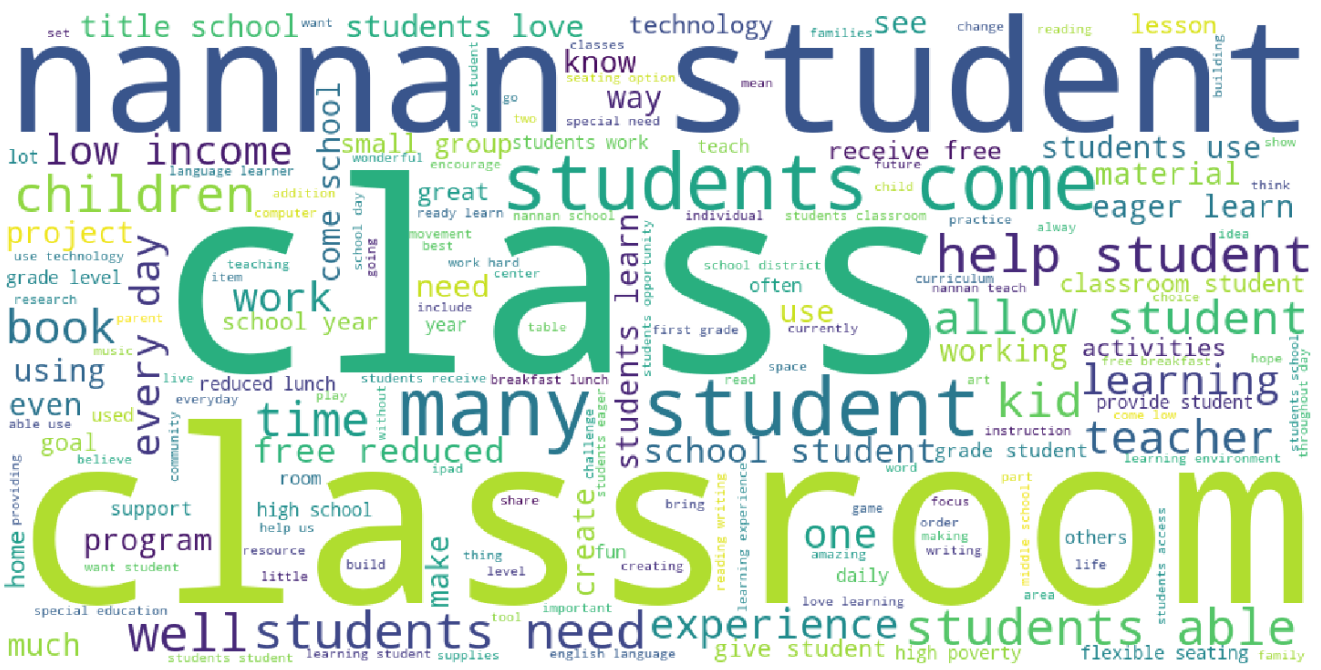
```
from wordcloud import WordCloud, STOPWORDS
def get_word_could(FP_data):
    comment_words=''
    stopwords = set(STOPWORDS)
    for val in tqdm(FP_data):

        val = str(val)
        tokens = val.split()
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()
        for words in tokens:
            comment_words = comment_words + words + ' '
    wordcloud = WordCloud(width = 1000, height = 500,background_color ='white',stopwords = stopword
s,min_font_size = 10).generate(comment_words)
    plt.figure(figsize = (25, 10), facecolor = None)
    plt.imshow(wordcloud)
    plt.axis("off")
    plt.tight_layout(pad = 0)
    plt.show()
```

Word cloud for Cluster 0

In [147]:

```
clust_0=X_train[X_train['cluster_label']==0]
get_word_could(clust_0['essay'][:10000])
```

```
100%|██████████████████████████████████| 10000/10000 [1:25:28<00:00,  1.95it/s]
```



In [124]:

```
for i in range(1,3):
    print("Essay ",i)
    print(clust_0.essay.values[i])
```

```
Essay  1
students loving hardworking happy enjoy learning love school students inner city school high pover
ty students receive free lunch speak another language home participate dual language classroom lea
rn english spanish school day despite challenges make remarkable progress throughout year students
one day change world cannot wait see far go students would love use trampolines exercise balls cla
ssroom could bounce energy would allow focus lessons students could use trampolines practice
letters sounds sight words well numbers also use exercise balls flexible seating classroom allows
students comfortable seating working trampolines exercise balls help students become healthier hap
pier classroom movement something students crave project make huge difference classroom nannan
Essay  2
school located virginia beach virginia title 1 school area located near naval base allows military
```

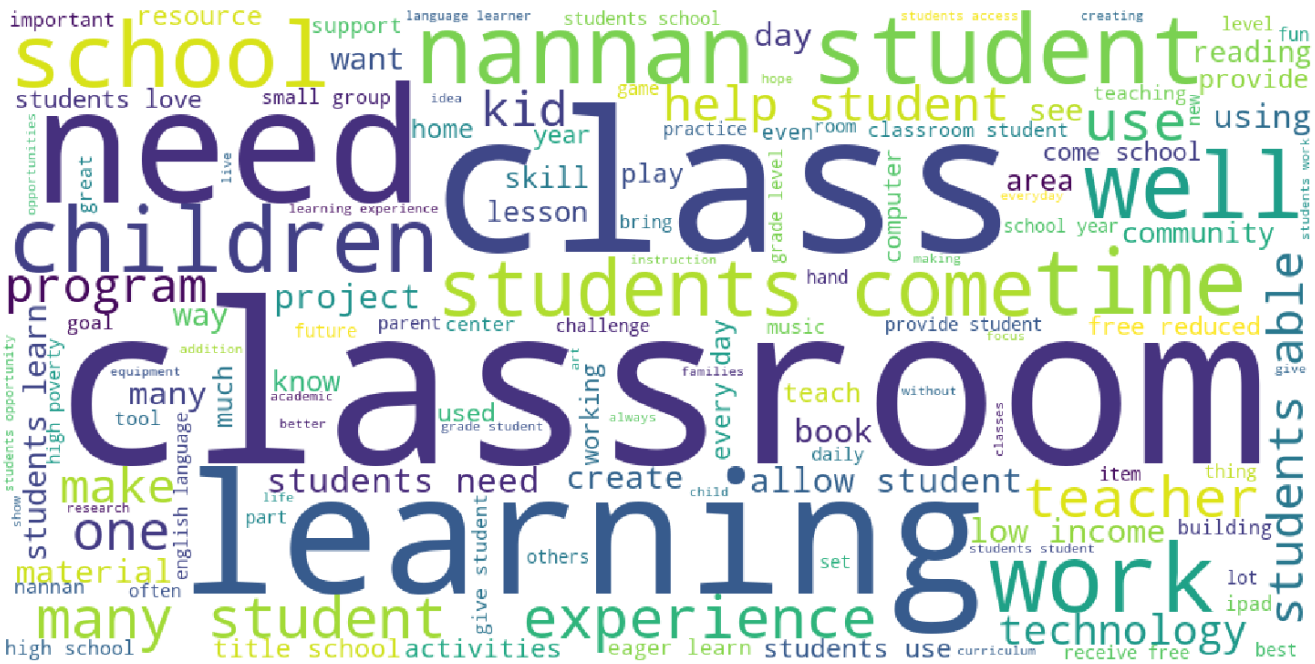
non military families attend school come different backgrounds classroom come together get teach o
ne another culture future learning key bright successful life happy healthy educated students stoo
ls schools not allow students pick want sit want sit students use seats option desks classroom cho
ose use seats build core muscles along getting work completed time students need comfy place work
order succeed everything power help make happen lovely students future great nation honor helping
achieve goals daily basis allowing choose type seat best enhances education allow need help making
dream reality nannan

Word cloud for Cluster 1

In [148]:

```
clust_1=X_train[X_train['cluster_label']==1]
get_word_could(clust_1['essay'])
```

```
100%|██████████████████████████████████| 5604/5604 [29:04<00:00,  3.21it/s]
```



In [128]:

```
for i in range(1,3):
    print("Essay ",i)
    print(clust_1.essay.values[i])
```

```
Essay  1
much fun hardest 4 points ever earn one 1st year robotics members said realized no longer last pla
ce competing mostly high school robotics teams youngest team made words even meaningful rookie tea
m competition last place never expected students come expect become leaders part life school distr
ict goals prepare students life develop leaders result consistently pushing students small charter
school towards success real world lessons opportunities cultivate leadership character charter
school campus life middle school waxahachie consists 510 seventh eighth graders almost equal amoun
t gender robotics team almost 1 4 girl boy ratio 2nd year doubled size anticipating year mindstorm
ev3 kits used support real world problems students able make use creative ideas creating robots ma
chines solve problems using critical thinking skills not students solving real world problems able
compete others similar interest expand desire stem activities added interests help increase stem h
igh schools colleges leading higher potential career area expect great things group added use kits
nannan
Essay  2
albert einstein quotes thing interferes learning education thus goal provide students low income a
frican american latino families resources challenge growth mindset academically creatively social
ills high crime rates illiteracy unemployment may plague community however not deter students lear
n provided resources experiences connect critical contexts arts allows take role engineer giving s
tudents unique opportunities learn build design problem solve create innovative ideas spite
negativity surrounds students relived daily reporting news media students inquisitive hopeful eage
r come school safe middle schoolers received special education services reading math skills four y
ears grade level yet able grasp concepts combination visual stimuli usage hands materials
individualized education plans address needs impede learning attention deficit disorder dyslexia a
```

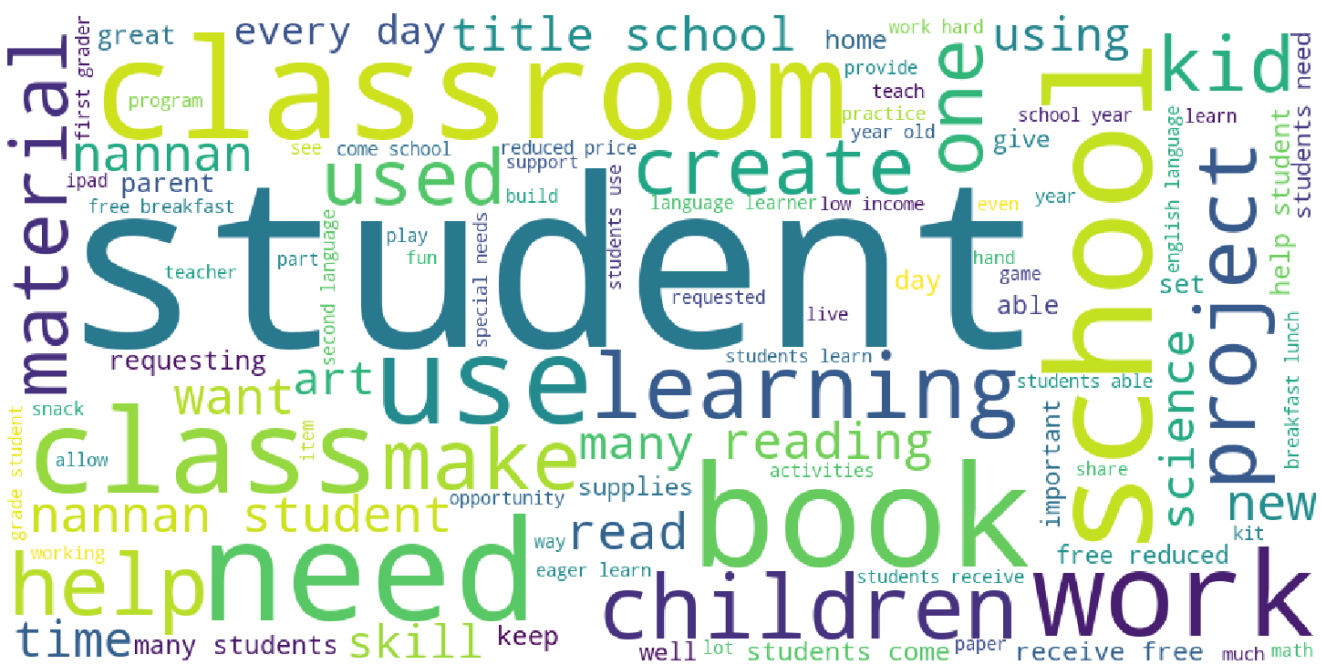
utism tend respond interactive arts infused project based learning heart breaking see middle schoo
l students struggle letter sound recognition knowledge basic sight words reading text unable
recall details answer questions relate story also difficult observe students count hands solve
equations using basic math facts not sure math operation use nevertheless role provide students fa
milies high quality instruction intervention best practices aligned diverse learning styles
learning takes place home may not reinforced school students students not able retain information
concepts not practiced experience know students growing digitized world learning interaction hands
motivates students tackle challenging activities opposed paper pencil format teaching videos provi
de auditory visual literacy students learn best interpreting meaning combination repetitious image
s sounds music families communities not computers dvd players homes therefore project allow
students check dell inspiron laptop portable dvd players practice reading math concepts
educational videos rock n learn read along stories multiplication rock writing strategies money
making change beginning fractions decimals meet sight words phonics pack fiction nonfiction single
student read alongs library gr 2 3 taken home use portable cd players already purchased read pen c
lose reading kit power pen reading comprehension quiz cards teaching geometry activity center serv
e interactive homework tools project also positively impacts social emotional health families lear
n grow together nannan

Word cloud for Cluster 2

In [149]:

```
clust_2=X_train[X_train['cluster_label']==2]
get_word_could(clust_2['essay'])
```

```
100%|██████████████████████████████████████| 550/550 [00:02<00:00, 210.12it/s]
```



In [129]:

```
for i in range(1,3):
    print("Essay ",i)
    print(clust_2.essay.values[i])
```

```
Essay  1
students wondrous group students reside poorest congressional district united states challenge sim
ply come school every day resilient not let life difficulties get way learning many first families
attend college understand value education proud teacher future owe give best opportunity succeed m
ath not 8 5 x 11 math sorts different shapes sizes scissors not cut straight scissors take forever
cutter cut perfect lines shapes sizes students use cutter cut large paper smaller paper use cut st
acks students cut paper different sizes mathematics not constricted letter size paper varying size
paper makes math fun engaging students able better utilize current paper resources not need waste
cut larger paper smaller ones individual math problems smaller sheet use index cards smaller paper
easier carry around help studies nannan
Essay  2
class loves books adore readaloud excited road independent reading families send school every day
ready learn work hard fun students english language learners families not speak english home criti
```

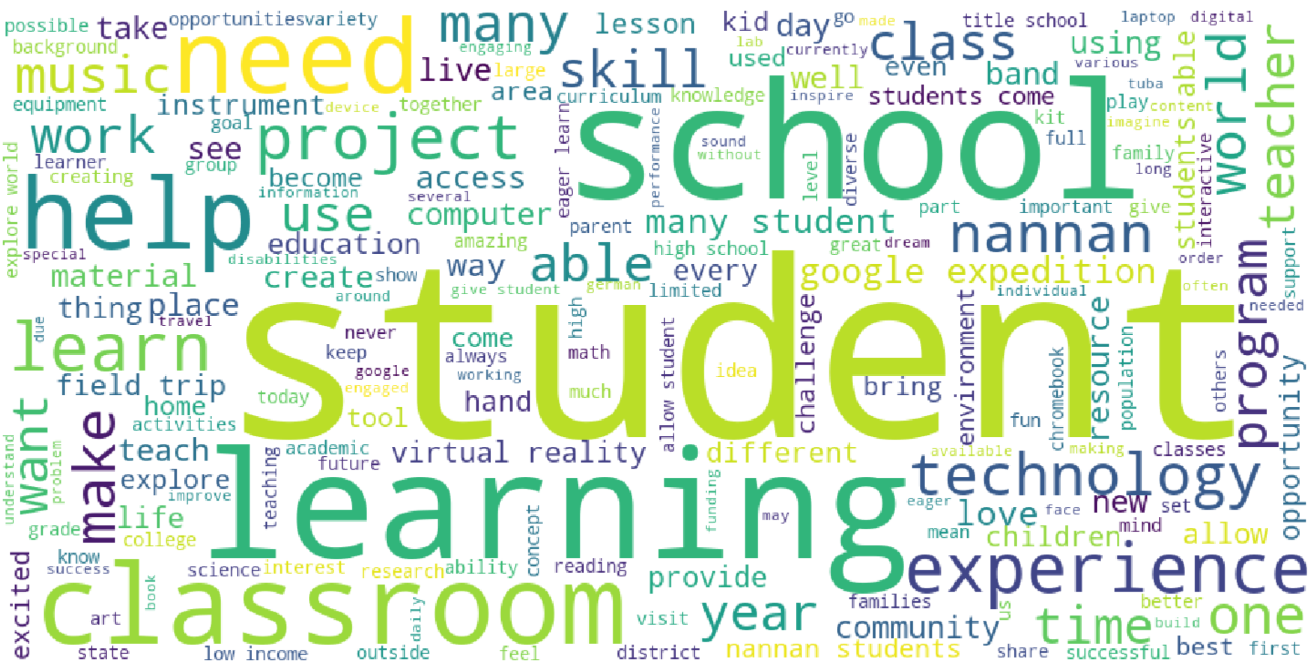
cal get lots language practice english reading practice school kindergarten students eager read ra
pidly mastering reading skills strategies want make sure plenty activities let try new skills rein
force ones already mastered independent practice requesting variety games activities students use
independently small groups whole class master reading skills many activities cover first grade
skills like contractions long vowel sounds hardworking students ready master harder skills
activities like vocabulary file folder games particularly support english language learners read e
ase pleasure phonics file folder games reinforce key kindergarten reading skills also require coop
eration turn taking sharing important early development skills word building tiles set let differe
ntiate whole group instruction students practicing phonics skills need keep growing readers games
activities provide students hours targeted hands practice level need support every one students be
coming lifelong readers reading key learning kindergarten college beyond want students ready face
learning challenges confidence resilience nannan

Word cloud for Cluster 3

In [150]:

```
clust_3=X_train[X_train['cluster_label']==3]
get_word_could(clust_3['essay'])
```

```
100%|██████████████████████████████████████| 106/106 [00:00<00:00, 1161.80it/s]
```



In [130]:

```
for i in range(1,3):
    print("Essay ",i)
    print(clust_3.essay.values[i])
```

Essay 1
imagine knowing various technological devices exist not ability exposed frequent basis moving
school advanced technology school not school urban public school services 800 students pre k 4th g
rade students come variety different economic backgrounds 80 students receiving free lunch reduced
lunch many students receive food backpacks weekend offer several clubs organizations like
girlstart sister sister brother brother dare dream g p girls achieving potential young leaders tom
orrow name extracurricular activities promote encourage academic success well fostering positive s
ocial skills building meaningful relationships school also one ethnically diverse schools houston
metro area students speak variety languages diverse students economically culturally diverse
academics well virtual reality set students really able visualize concepts taught provide meaningf
ul understanding things around us access visiting space animals national landmarks rain forest eve
n inside human body students able see close personal animal going transformation walk white house
right classroom project allow travel distant places see different things rather reading book magaz
ine would able read experience virtual reality open world many students would not able experience
places things due low socio economic status students deserve chance exposed world grander nannan
Essay 2
project serve group elementary aged students destined huge impacts world although 80 live poverty
60 english language learners nothing going stop mission achieve work toward leaving footprint worl

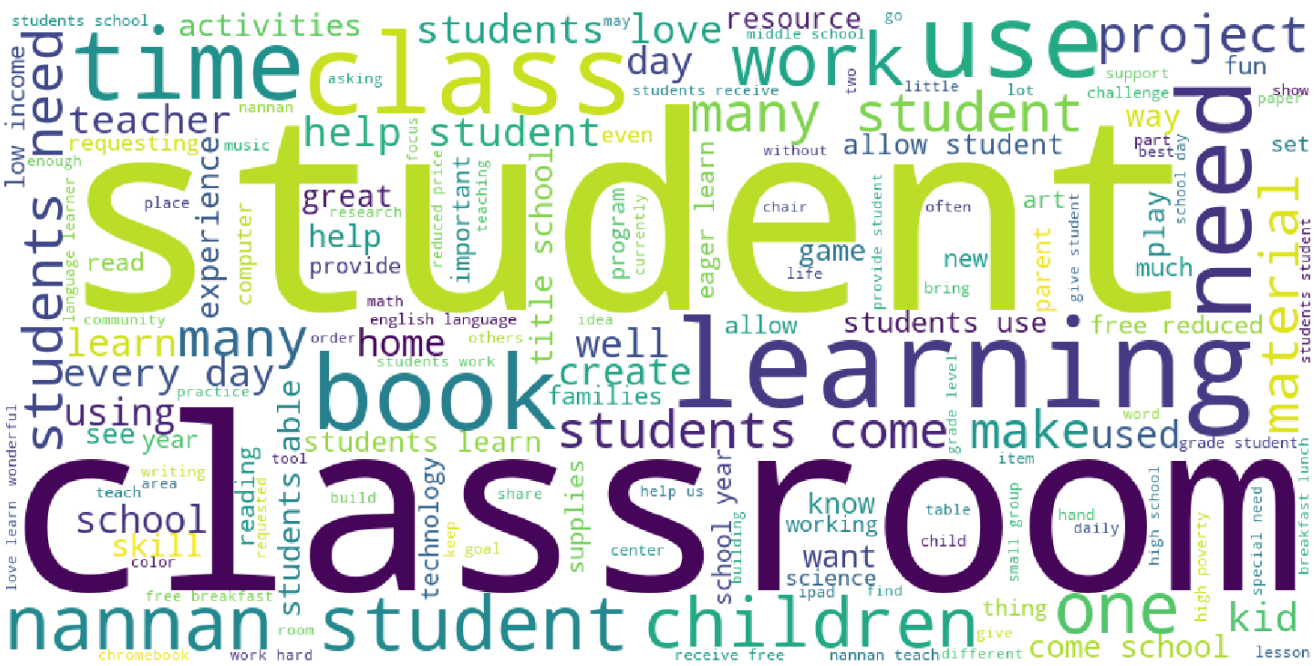
d group young boys girls overcoming language barriers learning second language many separated fami
lies live thousands miles away google expeditions hold power bring research life students field tr
ips limited cases impossible google expeditions allow students step worlds studying simply placing
headset real scientist would would able gather data collect facts reflect observations virtual
reality devices break barriers often within four walls classroom solidifying learning 360 degree v
irtual field trip experiences help us explore worlds unobtainable students whether deep space
along sea bed far across globe nannan

Word cloud for Cluster 4

In [151]:

```
clust_4=X_train[X_train['cluster_label']==4]
get_word_could(clust_4['essay'])
```

```
100%|██████████████████████████████████| 3093/3093 [07:48<00:00,  6.60it/s]
```



In [131]:

```
for i in range(1,3):
    print("Essay ",i)
    print(clust_4.essay.values[i])
```

```
Essay  1
students freshmen students signed ap environmental science give rigorous course first year high sc
hool living southeast side chicago attending neighborhood high school interested science
challenged importantly change agents environment extremely hard working motivated get 3 ap exam pr
eparing college freshmen high school apes box book book hand drawn diagrams really help students m
aster concepts learn material alternative way also great videos accompany readings give kids suppo
rt environmental topics appear test book also adapted ap material student friendly engaging still
informative allows students access information apply ap style multiple choice questions free respo
nse questions fully prepare ap exam may nannan
Essay  2
students awesome creative excited learning privileged teach music rural public school serving 900
students grades kindergarten 4th including special group children facing severe physical mental di
sabilities school high poverty strive daily provide equitable music experience students experience
includes exposing students new instruments musical cultures music history music expression self ma
ny students lack funding physical ability travel unique musical settings strive bring creative mus
ical world classroom students love read love music class want encourage reading music class
offering wonderful new books read example dem bones sunshine shoulders etc reading centers
important part music class helps much great new literature available students find books subjects
songs interested reading great fun want encourage students become best readers reading music class
nannan
```

2.6 Apply AgglomerativeClustering

In [58]:

```
%%time
from sklearn.cluster import AgglomerativeClustering
Agglomerative_n_2 = AgglomerativeClustering(n_clusters=2,linkage='ward').fit(tr_X_TFIDF[:10000])
```

```
Wall time: 7min 13s
```

In [59]:

```
#X_train.drop("cluster_label")
agglo_train=X_train[:10000]
agglo_train['cluster_label']=Agglomerative_n_2.labels_.reshape(-1,1)
print(agglo_train.cluster_label.value_counts())
agglo_train[:2]
```

```
0    9918
1      82
Name: cluster_label, dtype: int64
```

Out[59]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cat
22470	16301	p102862	8b996f6d87703d2630413100b590dd62	Ms.	CA	2016-08-03 16:06:00	Grades 3-5
61672	74853	p119206	058b33d511a2c806b2396ef8c27b9c72	Ms.	VA	2016-10-24 16:46:00	Grades 3-5

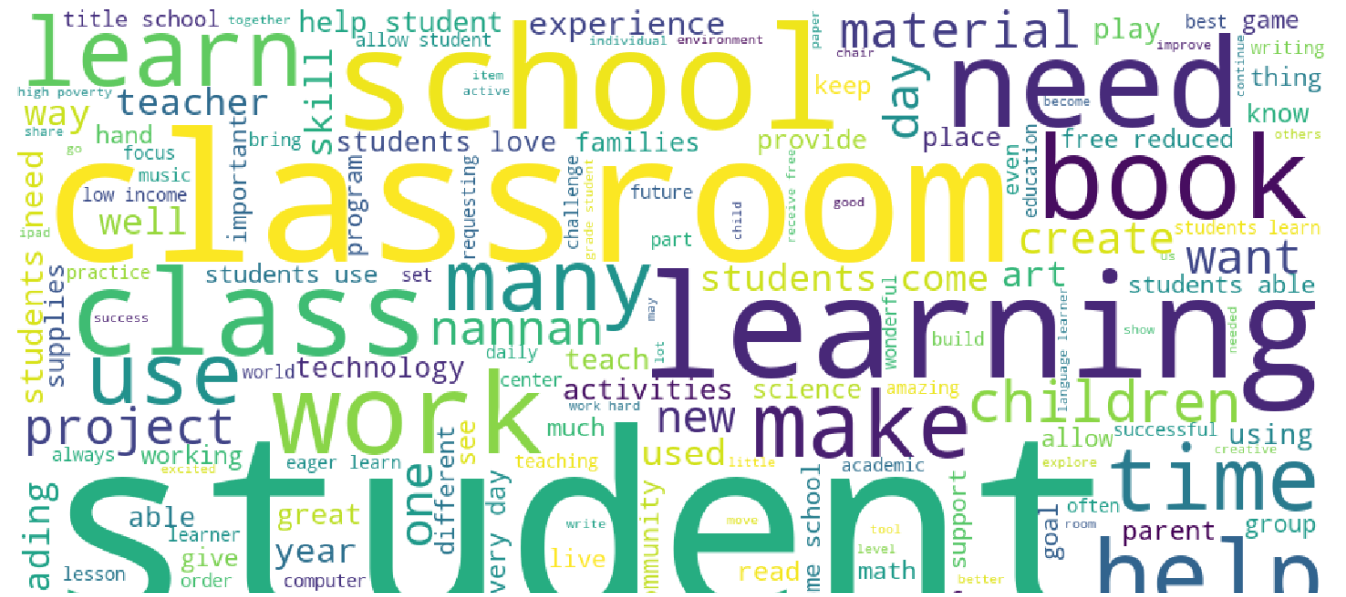
2 rows × 29 columns

Word cloud for Agglomerative Cluster 0

In [152]:

```
agglo_clust_0=agglo_train[agglo_train['cluster_label']==0]
get_word_could(agglo_clust_0['essay'])
```

```
100%|██████████████████████████████████| 1065/1065 [00:12<00:00, 83.69it/s]
```



In [137]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_0.essay.values[i])
```

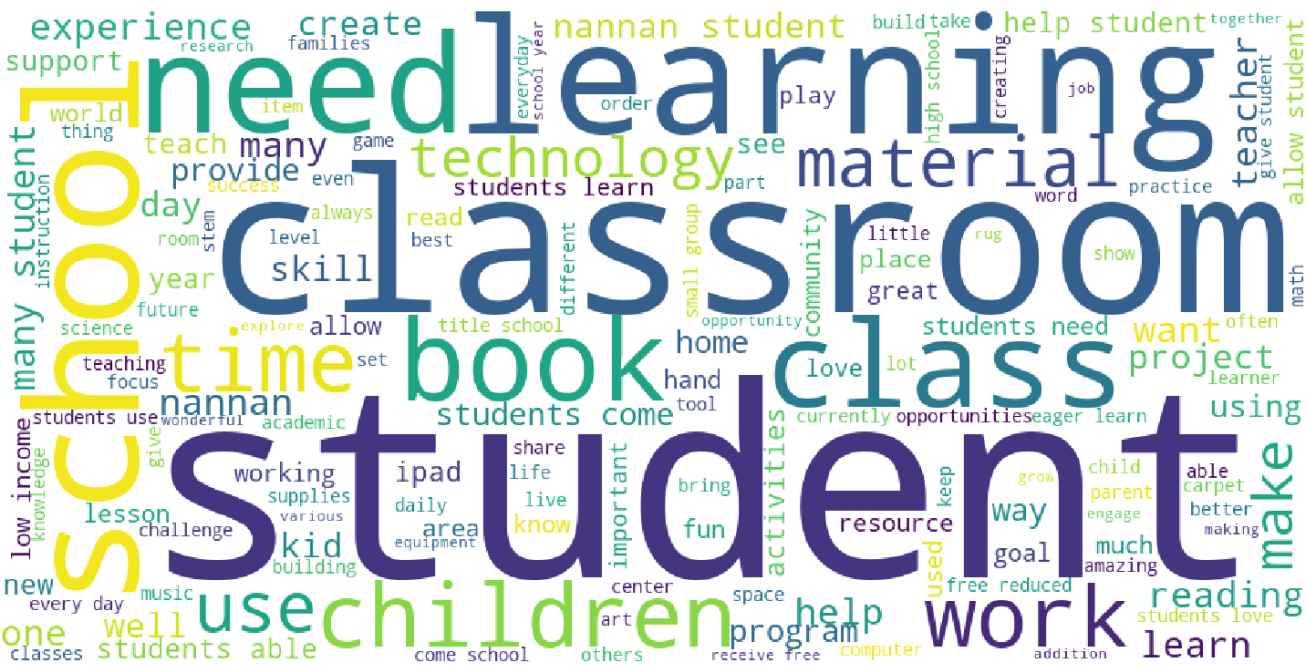
```
Essay  1
students freshmen students signed ap environmental science give rigorous course first year high sc
hool living southeast side chicago attending neighborhood high school interested science
challenged importantly change agents environment extremely hard working motivated get 3 ap exam pr
eparing college freshmen high school apes box book book hand drawn diagrams really help students m
aster concepts learn material alternative way also great videos accompany readings give kids suppo
rt environmental topics appear test book also adapted ap material student friendly engaging still
informative allows students access information apply ap style multiple choice questions free respo
nse questions fully prepare ap exam may nannan
Essay  2
target students 7th 8th grade title school high population students qualify free reduced price lun
ch incredibly bright eager learn love working inquiry driven projects require work together apply
twenty first century skills also embrace use technology project allow students varied economic bac
kgrounds work collaboratively teacher learn computer science skills prepare workforce enter coding
computer programming important stem skill students learn order prepare jobs future young students
especially girls learn coding helps something hands see results work stem skills students acquire
learning code give opportunity prepared today technology driven society great part not students le
aning computer coding blast use laptops write computer code control robots even opportunity compet
e fll first robotics competition proving grasp subject hope students especially young ladies see c
omputer science stem careers future possibility nannan
```

Word cloud for Agglomerative Cluster 1

In [153]:

```
agglo_clust_1=agglo_train[agglo_train['cluster_label']==1]
get_word_could(agglo_clust_1['essay'])
```

```
100%|██████████████████████████████████| 1943/1943 [02:39<00:00, 12.17it/s]
```



In [138]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_1.essay.values[i])
```

```
Essay  1
resource teacher service diverse group students english learners latin america egypt nepal
socioeconomically advantaged others homeless loving supportive parents others reliable adult home
common learning disability students vary age ability kindergarten 5th grade variety academic needs
including significant behaviors affect ability access regular classroom instruction youngest work
improve basic reading readiness skills like phonemic awareness phonics sight words older students
come build skills improve fluency comprehension get primary language support support students acad
emic areas greatest focus literacy impacts areas school quality life hard encounter new culture le
arn new language added disadvantage learning disability make feel odds insurmountable classroom pl
ace students come beat odds servicing diverse group students requires flexibility time
organization use space multiple groups taught simultaneously mobile learning stations make classro
om flexibility less intrusive aide supplies right sides not tied one specific wall display write a
lso listening center help reinforce literary skills learning help give students learning disabilit
ies chance beat hand dealt everyone deserves equal access education literacy learning key future q
uality life nannan
Essay  2
part leader program therefore important work bring leadership qualities students providing many op
portunities role models one another students class receive lots opportunities teach class share
ideas audience classmates diverse group students enjoy hands lessons value ideas come class
everyday ready fun filled structured lessons able find joy classroom no matter challenging
material would persistent eager discover new things everyday students adventurous always seeking l
earn dig deeper new books materials options classroom library selecting book genuinely enjoy guide
d reading noticed many students love adventure comic books reading time tailor book choices fit le
sson reinforce concepts exploring new teacher materials clipboards essential ensure students able
navigate various places classroom best help complete work meet learning goals nannan
```

6.1 Agglomerative Clustering

In [62]:

```
%%time
from sklearn.cluster import AgglomerativeClustering
Agglomerative_n_5 = AgglomerativeClustering(n_clusters=5,linkage='ward').fit(tr_X_TFIDF[:10000])
```

```
Wall time: 7min 14s
```

In [63]:

```
#agglo_train.drop("cluster_label")
agglo_train=X_train[:10000]
agglo_train['cluster_label']=Agglomerative_n_5.labels_.reshape(-1,1)
print(agglo_train.cluster_label.value_counts())
agglo_train[:2]
```

```
4    6678
1    1943
0    1065
2     232
3      82
Name: cluster_label, dtype: int64
```

Out[63]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cat
22470	16301	p102862	8b996f6d87703d2630413100b590dd62	Ms.	CA	2016-08-03 16:06:00	Grades 3-5
61672	74853	p119206	058b33d511a2c806b2396ef8c27b9c72	Ms.	VA	2016-10-24 16:46:00	Grades 3-5

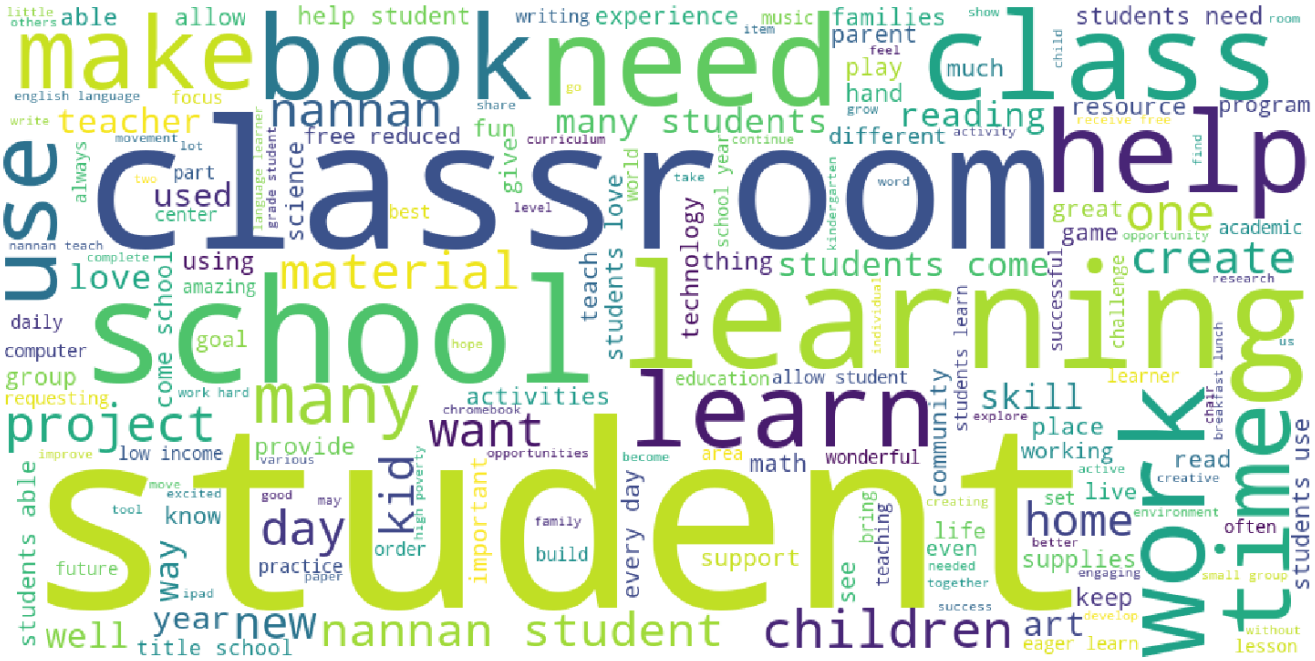
2 rows × 29 columns

Word cloud for Agglomerative Cluster 0

In [154]:

```
agglo_clust_0=agglo_train[agglo_train['cluster_label']==0]
get_word_could(agglo_clust_0['essay'])
```

```
100%|██████████████████████████████████████| 1065/1065 [00:12<00:00, 83.44it/s]
```



In [139]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_0.essay.values[i])
```

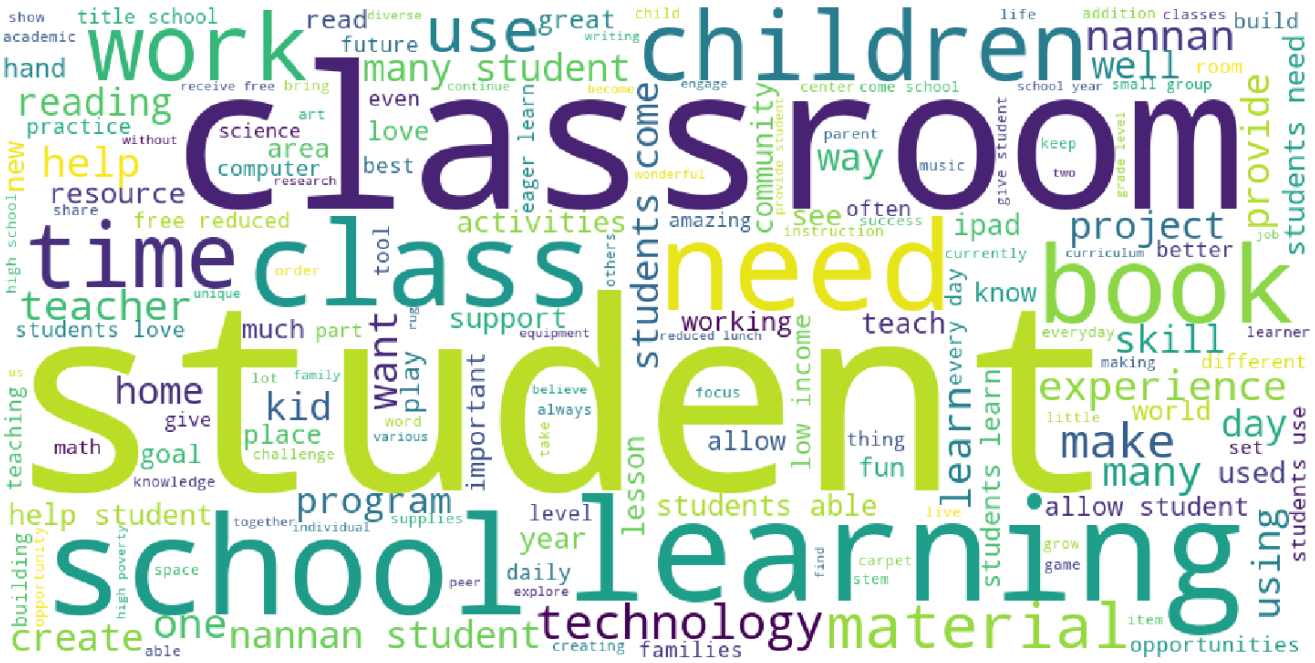
```
Essay  1
students freshmen students signed ap environmental science give rigorous course first year high sc
hool living southeast side chicago attending neighborhood high school interested science
challenged importantly change agents environment extremely hard working motivated get 3 ap exam pr
eparing college freshmen high school apes box book book hand drawn diagrams really help students m
aster concepts learn material alternative way also great videos accompany readings give kids suppo
rt environmental topics appear test book also adapted ap material student friendly engaging still
informative allows students access information apply ap style multiple choice questions free respo
nse questions fully prepare ap exam may nannan
Essay  2
target students 7th 8th grade title school high population students qualify free reduced price lun
ch incredibly bright eager learn love working inquiry driven projects require work together apply
twenty first century skills also embrace use technology project allow students varied economic bac
kgrounds work collaboratively teacher learn computer science skills prepare workforce enter coding
computer programming important stem skill students learn order prepare jobs future young students
especially girls learn coding helps something hands see results work stem skills students acquire
learning code give opportunity prepared today technology driven society great part not students le
aning computer coding blast use laptops write computer code control robots even opportunity compet
e fll first robotics competition proving grasp subject hope students especially young ladies see c
omputer science stem careers future possibility nannan
```

Word cloud for Agglomerative Cluster 1

In [155]:

```
agglo_clust_1=agglo_train[agglo_train['cluster_label']==1]
get_word_could(agglo_clust_1['essay'])
```

```
100%|██████████████████████████████████████| 1943/1943 [02:40<00:00, 12.09it/s]
```



In [140]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_1.essay.values[i])
```

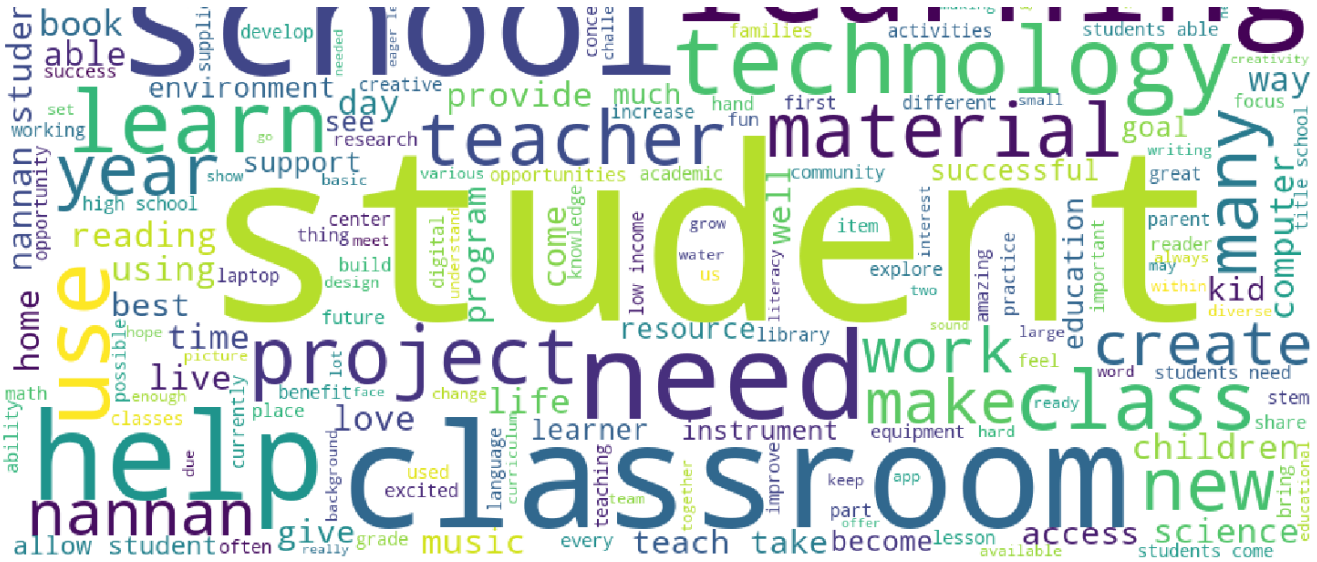
```
Essay  1
resource teacher service diverse group students english learners latin america egypt nepal
socioeconomically advantaged others homeless loving supportive parents others reliable adult home
common learning disability students vary age ability kindergarten 5th grade variety academic needs
including significant behaviors affect ability access regular classroom instruction youngest work
improve basic reading readiness skills like phonemic awareness phonics sight words older students
come build skills improve fluency comprehension get primary language support support students acad
emic areas greatest focus literacy impacts areas school quality life hard encounter new culture le
arn new language added disadvantage learning disability make feel odds insurmountable classroom pl
ace students come beat odds servicing diverse group students requires flexibility time
organization use space multiple groups taught simultaneously mobile learning stations make classro
om flexibility less intrusive aide supplies right sides not tied one specific wall display write a
lso listening center help reinforce literary skills learning help give students learning disabilit
ies chance beat hand dealt everyone deserves equal access education literacy learning key future q
uality life nannan
Essay  2
part leader program therefore important work bring leadership qualities students providing many op
portunities role models one another students class receive lots opportunities teach class share
ideas audience classmates diverse group students enjoy hands lessons value ideas come class
everyday ready fun filled structured lessons able find joy classroom no matter challenging
material would persistent eager discover new things everyday students adventurous always seeking l
earn dig deeper new books materials options classroom library selecting book genuinely enjoy guide
d reading noticed many students love adventure comic books reading time tailor book choices fit le
sson reinforce concepts exploring new teacher materials clipboards essential ensure students able
navigate various places classroom best help complete work meet learning goals nannan
```

Word cloud for Agglomerative Cluster 2

In [156]:

```
agglo_clust_2=agglo_train[agglo_train['cluster_label']==2]
get_word_could(agglo_clust_2['essay'])
```

```
100%|██████████| 232/232 [00:00<00:00, 557.37it/s]
```



In [141]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_2.essay.values[i])
```

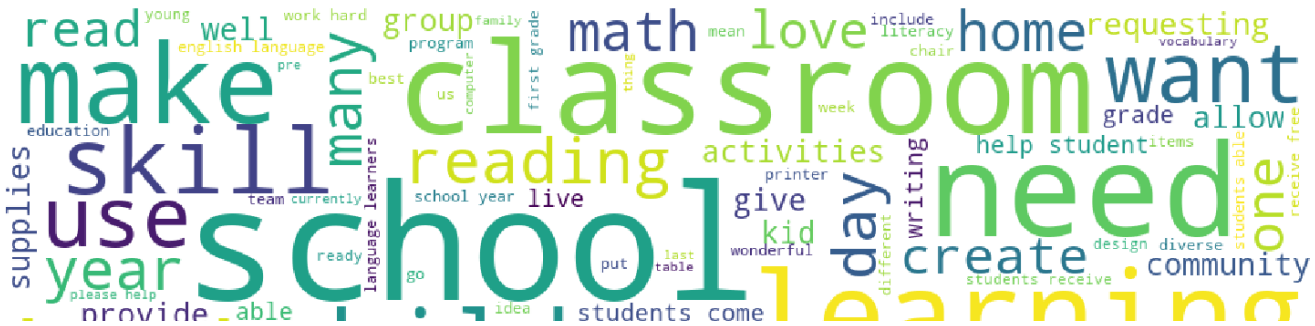
```
Essay  1
special education teacher lld1 classroom teach students language learning disabled communication i
mpairments grades k 1st 2nd grades students come school day full energy excitement day different d
ay students come low economic backgrounds often find school place gives structure need special edu
cation teacher job assess student individual level help achieve success pace students require
close assistance constant repetition redirection often perform grade level non special education p
eers students mainstreamed specials grade level try attend field trips general education peers oft
en possible students appreciate many things provided may not means enhance education home thrive m
any opportunities provide school students greatly benefit ipad mini class love stimulating
exciting ways learn often visual auditory learners students currently share one ipad class could t
ailor ipad individual needs special education class students deficits different areas able add app
s language arts literacy math science social studies needs hope help us get nannan
Essay  2
work title 1 elementary school work special needs students students classroom unique eight
students variety disabilities students communication deficits use sign language main mode
communicating incorporate lot technology movement every student requires sensory input throughout
school day make priority visit sensory room please consider helping students revamping sensory roo
m student not many sensory supplies really need lights room welcoming calming students bubble tube
students could opportunity lay beside relax able watch colors change see continuous bubbles
students would able get sensory input little bodies need use bubble tube sensory room illuminated
special needs students deserve appropriate supplies equipment throughout education hope consider f
unding project nannan
```

Word cloud for Agglomerative Cluster 3

In [157]:

```
agglo_clust_3=agglo_train[agglo_train['cluster_label']==3]
get_word_could(agglo_clust_3['essay'])
```

```
100%|██████████| 82/82 [00:00<00:00, 1318.18it/s]
```



In [142]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_3.essay.values[i])
```

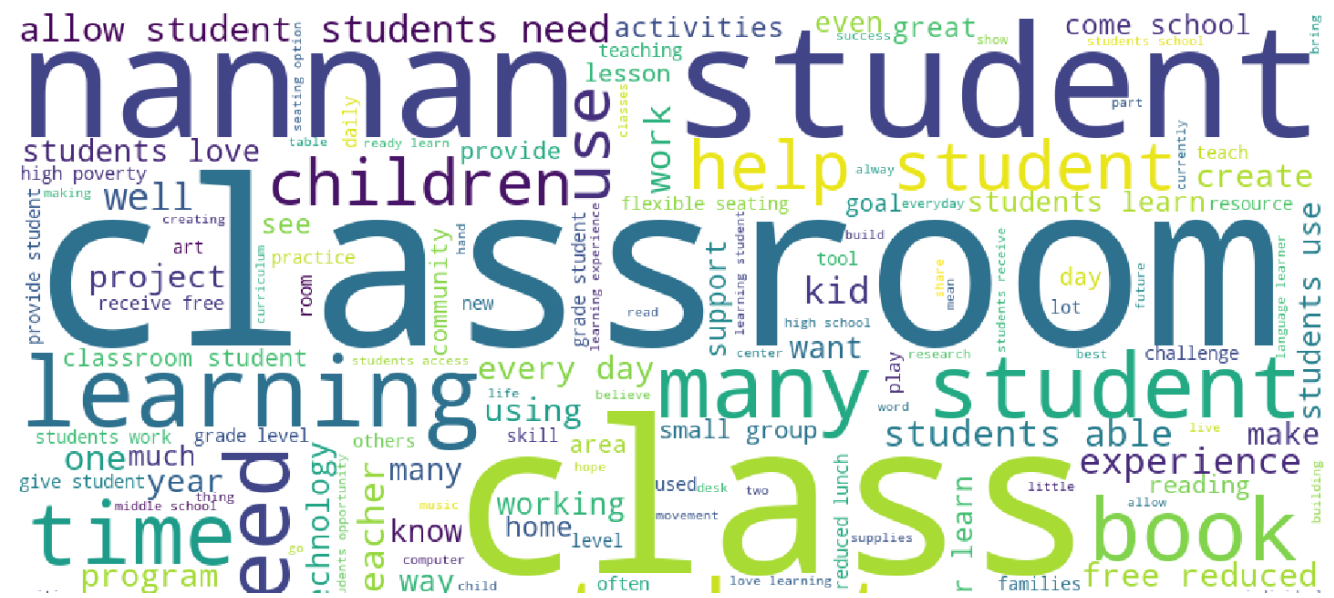
```
Essay  1
teach dynamic group fabulous kindergarten students extremely diverse school brooklyn ny students l
ove reading funny stories writing poetry creating art exploring science learning new words
building dancing singing playing math games playing puppets learning new facts class loves beloved
puppet chef lotsa words cooks sight words poems vocabulary words books day magic pot students funny
enthusiastic inquisitive compassionate sweet would love kindergarten students variety hands math m
aterials would use foam ten frame dice play counting comparing games dice help students count numb
ers zero twenty math links also help students practice counting one one correspondence button sort
ing center help students classify objects use number bond cards addition subtraction materials hel
p strengthen students mathematical thinking build critical thinking skills please consider support
ing marvelous kindergarten mathematicians nannan
Essay  2
love teaching kindergarten five year olds amazing energy infectious devour stories soak knowledge
like sponges always ask love able get close experience learning student unique point view eager sh
are days make laugh want pull hair even cry never dull moment kindergarten remember learning play
kindergarten would believe told kids not allowed play anymore school play could directed towards c
areer architecture engineering materials project help open kids minds opportunities real world
careers using critical thinking skills try build sturdy bridge 3 dimensional building even motorcy
cle play students follow blueprint look real life model try replicate using materials helping prov
ide nannan
```

Word cloud for Agglomerative Cluster 4

In [158]:

```
agglo_clust_4=agglo_train[agglo_train['cluster_label']==4]
get_word_could(agglo_clust_4['essay'])
```

```
100%|██████████████████████████████████| 6678/6678 [37:49<00:00,  2.94it/s]
```



In [143]:

```
for i in range(1,3):
    print("Essay ",i)
    print(agglo_clust_4.essay.values[i])
```

```
Essay  1
students loving hardworking happy enjoy learning love school students inner city school high pover
ty students receive free lunch speak another language home participate dual language classroom lea
rn english spanish school day despite challenges make remarkable progress throughout year students
one day change world cannot wait see far go students would love use trampolines exercise balls cla
ssroom could bounce energy would allow focus lessons students could use trampolines practice
letters sounds sight words well numbers also use exercise balls flexible seating classroom allows
students comfortable seating working trampolines exercise balls help students become healthier hap
pier classroom movement something students crave project make huge difference classroom nannan
Essay  2
school located virginia beach virginia title 1 school area located near naval base allows military
non military families attend school come different backgrounds classroom come together get teach o
ne another culture future learning key bright successful life happy healthy educated students stoo
ls schools not allow students pick want sit want sit students use seats option desks classroom cho
ose use seats build core muscles along getting work completed time students need comfy place work
order succeed everything power help make happen lovely students future great nation honor helping
achieve goals daily basis allowing choose type seat best enhances education allow need help making
dream reality nannan
```

2.7 Apply DBSCAN

In [69]:

```
import numpy as np
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 [70]:

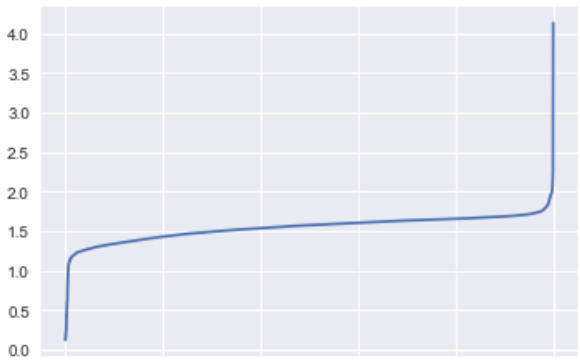
```
neigh = NearestNeighbors(n_neighbors=6000)
nbrs = neigh.fit(tr_X_TFIDF[:10000])
distances, indices = nbrs.kneighbors(tr_X_TFIDF[:10000])
```

In [71]:

```
distances = np.sort(distances, axis=0)
distances = distances[:,1]
plt.plot(distances)
```

Out[71]:

```
[<matplotlib.lines.Line2D at 0x51b0e037f0>]
```



0 2000 4000 6000 8000 10000

In [72]:

```
X = np.array([[-1, -1], [-2, -1], [-3, -2], [1, 1], [2, 1], [3, 2]])
nbrs = NearestNeighbors(n_neighbors=3).fit(X)
distances, indices = nbrs.kneighbors(X)
```

In [73]:

```
from sklearn.cluster import DBSCAN
# train data has dimension d=4990 as rule of thumb min_pts=2*d i.e min_pts=9980
clustering = DBSCAN(eps=1.8, min_samples=5000).fit(tr_X_TFIDF[:10000])
```

In [74]:

```
dbscan_train=X_train[:10000]
dbscan_train['cluster_label']=clustering.labels_.reshape(-1,1)
print(dbscan_train.cluster_label.value_counts())
agglo_train[:2]
```

```
 0     8149
-1     1851
Name: cluster_label, dtype: int64
```

Out[74]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
22470	16301	p102862	8b996f6d87703d2630413100b590dd62	Ms.	CA	2016-08-03 16:06:00	Grades 3-5
61672	74853	p119206	058b33d511a2c806b2396ef8c27b9c72	Ms.	VA	2016-10-24 16:46:00	Grades 3-5

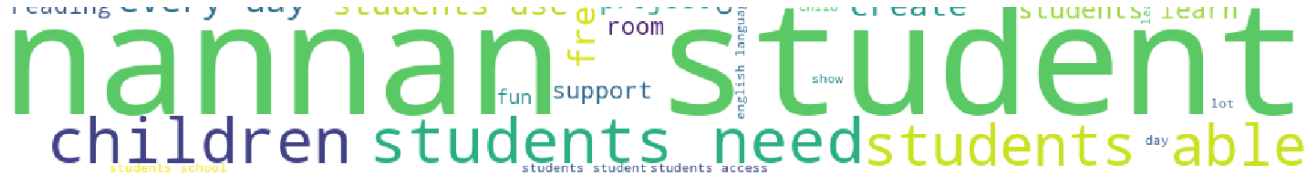
2 rows × 29 columns

Word cloud for DBSCAN Cluster 0

In [159]:

```
dbscan_clust_0=dbscan_train[dbscan_train['cluster_label']==0]
get_word_could(dbscan_clust_0['essay'])
```

```
100%|██████████| 8149/8149 [57:19<00:00,  2.37it/s]
```



In [144]:

```
for i in range(1,3):
    print("Essay ",i)
    print(dbscan_clust_0.essay.values[i])
```

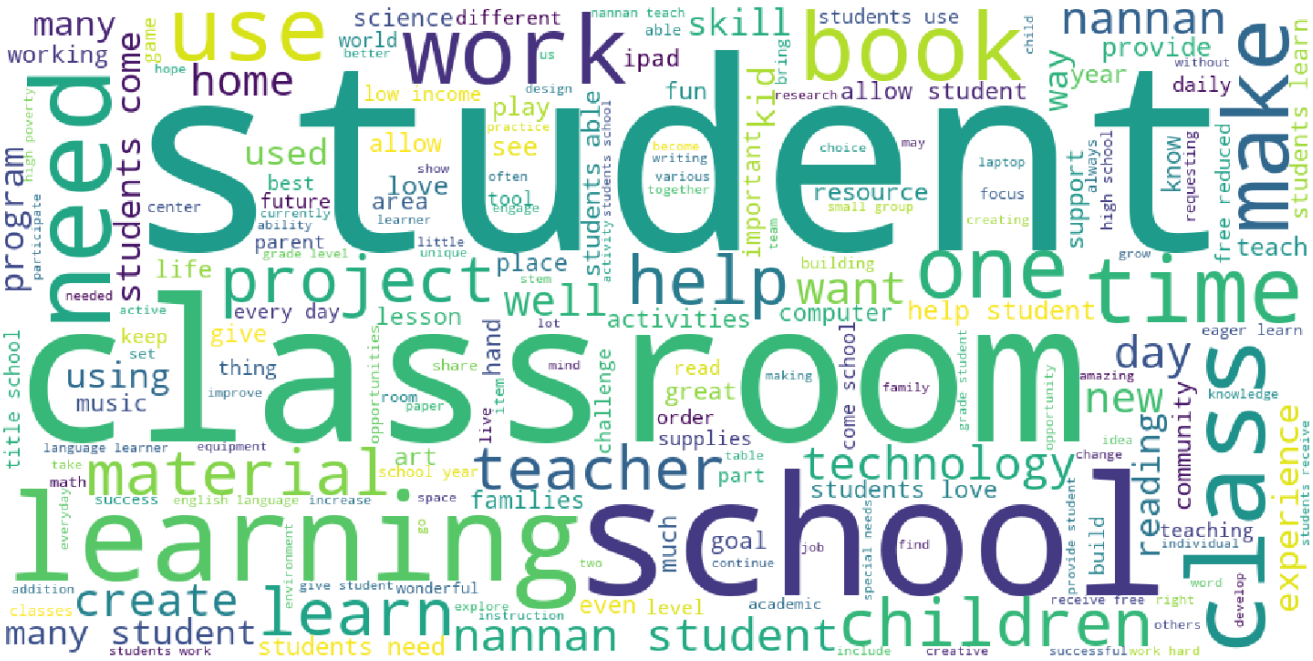
```
Essay  1
students loving hardworking happy enjoy learning love school students inner city school high pover
ty students receive free lunch speak another language home participate dual language classroom lea
rn english spanish school day despite challenges make remarkable progress throughout year students
one day change world cannot wait see far go students would love use trampolines exercise balls cla
ssroom could bounce energy would allow focus lessons students could use trampolines practice
letters sounds sight words well numbers also use exercise balls flexible seating classroom allows
students comfortable seating working trampolines exercise balls help students become healthier hap
pier classroom movement something students crave project make huge difference classroom nannan
Essay  2
school located virginia beach virginia title 1 school area located near naval base allows military
non military families attend school come different backgrounds classroom come together get teach o
ne another culture future learning key bright successful life happy healthy educated students stoo
ls schools not allow students pick want sit want sit students use seats option desks classroom cho
ose use seats build core muscles along getting work completed time students need comfy place work
order succeed everything power help make happen lovely students future great nation honor helping
achieve goals daily basis allowing choose type seat best enhances education allow need help making
dream reality nannan
```

Word cloud for DBSCAN Cluster 1

In [160]:

```
dbscan_clust_1=dbscan_train[dbscan_train['cluster_label']==-1]
get_word_could(dbscan_clust_1['essay'])
```

```
100%|██████████████████████████████████| 1851/1851 [02:26<00:00, 12.63it/s]
```



In [146]:

```
for i in range(1,3):
```

```
    print("Essay ",i)
    print(dbscan_clust_1.essay.values[i])
```

```
Essay  1
students freshmen students signed ap environmental science give rigorous course first year high sc
hool living southeast side chicago attending neighborhood high school interested science
challenged importantly change agents environment extremely hard working motivated get 3 ap exam pr
eparing college freshmen high school apes box book book hand drawn diagrams really help students m
aster concepts learn material alternative way also great videos accompany readings give kids suppo
rt environmental topics appear test book also adapted ap material student friendly engaging still
informative allows students access information apply ap style multiple choice questions free respo
nse questions fully prepare ap exam may nannan
Essay  2
resource teacher service diverse group students english learners latin america egypt nepal
socioeconomically advantaged others homeless loving supportive parents others reliable adult home
common learning disability students vary age ability kindergarten 5th grade variety academic needs
including significant behaviors affect ability access regular classroom instruction youngest work
improve basic reading readiness skills like phonemic awareness phonics sight words older students
come build skills improve fluency comprehension get primary language support support students acad
emic areas greatest focus literacy impacts areas school quality life hard encounter new culture le
arn new language added disadvantage learning disability make feel odds insurmountable classroom pl
ace students come beat odds servicing diverse group students requires flexibility time
organization use space multiple groups taught simultaneously mobile learning stations make classro
om flexibility less intrusive aide supplies right sides not tied one specific wall display write a
lso listening center help reinforce literary skills learning help give students learning disabilit
ies chance beat hand dealt everyone deserves equal access education literacy learning key future q
uality life nannan
```

In [163]:

```
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer Used", "Model", "Tried on 'n' clusters"]
x.add_row(["TFIDF", "KMeans Clustering(Optimal k = 5)", "5"])
x.add_row(["TFIDF", "Agglomerative Clustering","2 and 10"])
x.add_row(["TFIDF", "DBSCAN Clustering(eps=1.8, min_samples=5000)","2"])
print(x)
```

```
+----------------+-----------------------------------------------+-----------------------+
| Vectorizer Used |                     Model                     | Tried on 'n' clusters |
+----------------+-----------------------------------------------+-----------------------+
|      TFIDF      |       KMeans Clustering(Optimal k = 5)       |           5           |
|      TFIDF      |           Agglomerative Clustering           |        2 and 10       |
|      TFIDF      | DBSCAN Clustering(eps=1.8, min_samples=5000) |           2           |
+----------------+-----------------------------------------------+-----------------------+
```