Clustering

In [1]:

```
# from google.colab import drive
# drive.mount('/gdrive')
# %cd /gdrive
```

Importing the data and necessary libraries

In [2]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
import seaborn as sns; sns.set()
import matplotlib.pyplot as plt

import warnings
warnings.filterwarnings('ignore')

```

In [3]:

```
path = 'After_BERT(Embedded_Data).csv'
df = pd.read_csv(path, index_col = 0, keep_default_na=False)
df.head()
```

Out[3]:

	Industry	Company Location	New Job (90 Days)	Year Started	Profile Headline	Profile Summary	School	Degr
0	Mechanical or Industrial Engineering	Dublin, Ohio, United States	False	2020.0	Mechanical Design Engineer, System Integration...	In the ever-growing technological world where ...	Chalmers University of Technology	
1	Information Technology and Services	New York City Metropolitan Area	False	2018.0	Digital DevOps Engineer at HSBC	AWS Certified Cloud Engineer holding 3 AWS Ass...	Binghamton University	
2	Information Technology and Services	Chicago, Illinois, United States	False	2018.0	Leading Product + UX at Remedy (Two Point Conv...	http://aroonmathai.com	Carnegie Mellon University	
3	Information Technology and Services	Bangalore Urban, Karnataka, India	False	2018.0	Product Designer at udaan		Vellore Institute of Technology	
4	Information Technology and Services	Jaipur, Rajasthan, India	True	2021.0	Digital Technology Intern at General Electric ...		Vellore Institute of Technology	

5 rows × 30 columns

In [4]:

```
coords = pd.read_csv('Coordinates.csv')
coords.head()
```

Out[4]:

	latitude	longitude
0	40.099229	-83.114077
1	44.870970	-0.547490
2	41.875562	-87.624421
3	12.945142	77.553645
4	26.915458	75.818982

In [5]:

```
df['latitude'] = coords['latitude']
df['longitude'] = coords['longitude']
```

In [6]:

```
1 df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4910 entries, 0 to 4909
Data columns (total 32 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   Industry                    4910 non-null   object 
 1   Company Location            4910 non-null   object 
 2   New Job (90 Days)           4910 non-null   bool   
 3   Year Started                4910 non-null   float64
 4   Profile Headline            4910 non-null   object 
 5   Profile Summary             4910 non-null   object 
 6   School                      4910 non-null   object 
 7   Degree                      4910 non-null   object 
 8   Education End               4910 non-null   object 
 9   Domain                      4910 non-null   object 
 10  CompanyName                 4910 non-null   object 
 11  JobTitle                    4910 non-null   object 
 12  My Network                  4910 non-null   object 
 13  Country                     4910 non-null   object 
 14  Continent                   4910 non-null   object 
 15  FieldOfStudy                4910 non-null   object 
 16  Industry_embedding          4910 non-null   float64
 17  Company Location_embedding  4910 non-null   float64
 18  Profile Headline_embedding  4910 non-null   float64
 19  Profile Summary_embedding   4910 non-null   float64
 20  School_embedding            4910 non-null   float64
 21  Degree_embedding            4910 non-null   float64
 22  Education End_embedding     4910 non-null   float64
 23  Domain_embedding            4910 non-null   float64
 24  CompanyName_embedding       4910 non-null   float64
 25  JobTitle_embedding          4910 non-null   float64
 26  My Network_embedding        4910 non-null   float64
 27  Country_embedding           4910 non-null   float64
 28  Continent_embedding         4910 non-null   float64
 29  FieldOfStudy_embedding      4910 non-null   float64
 30  latitude                    4910 non-null   float64
 31  longitude                   4910 non-null   float64
dtypes: bool(1), float64(17), object(14)
memory usage: 1.2+ MB
```

In [7]:

```
df.columns
```

Out[7]:

```
Index(['Industry', 'Company Location', 'New Job (90 Days)', 'Year Started',
       'Profile Headline', 'Profile Summary', 'School', 'Degree',
       'Education End', 'Domain', 'CompanyName', 'JobTitle', 'My Network',
       'Country', 'Continent', 'FieldOfStudy', 'Industry_embedding',
       'Company Location_embedding', 'Profile Headline_embedding',
       'Profile Summary_embedding', 'School_embedding', 'Degree_embedding',
       'Education End_embedding', 'Domain_embedding', 'CompanyName_embeddin
g',
       'JobTitle_embedding', 'My Network_embedding', 'Country_embedding',
       'Continent_embedding', 'FieldOfStudy_embedding', 'latitude',
       'longitude'],
      dtype='object')
```

In [8]:

```
df1 = df[['Country_embedding',
          'Continent_embedding',
          'Domain_embedding',
          'Industry_embedding',
          'FieldOfStudy_embedding',
          'latitude', 'longitude']]
```

Standardisation and Normalisation of Data

In [9]:

```
# Standardize data
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaled_df = scaler.fit_transform(df1)
```

In [10]:

```
# Normalizing the Data
from sklearn.preprocessing import normalize
normalized_df = normalize(scaled_df)
```

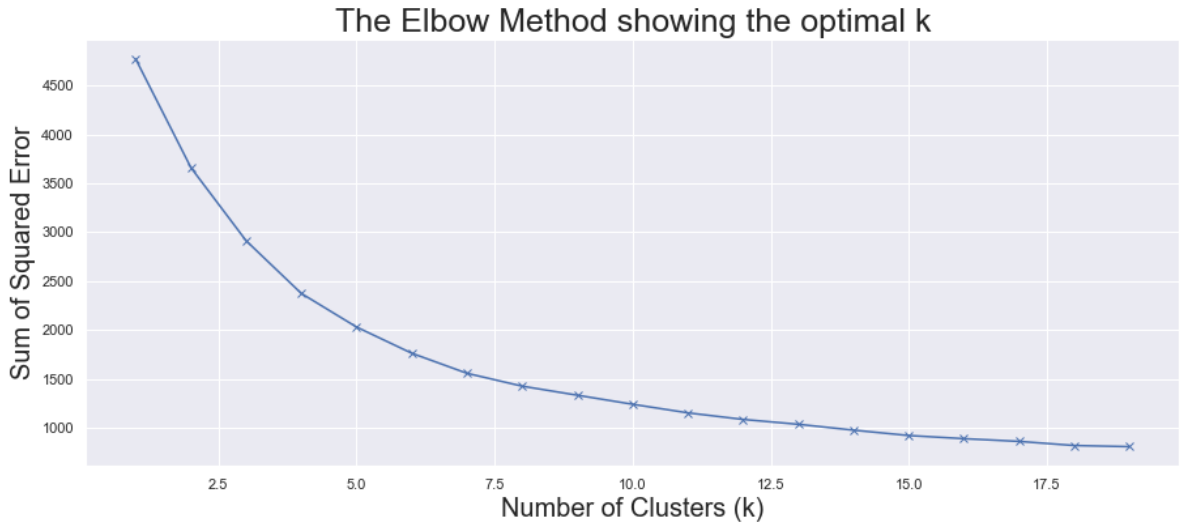
In [11]:

```
# Converting the numpy array into a pandas DataFrame
normalized_df = pd.DataFrame(normalized_df)
```

Using Elbow Method to determine the best value of k in KMeans clustering

In [12]:

```
from sklearn.cluster import KMeans

sse = []
K = range(1,20)
for k in K:
    kmeanModel = KMeans(n_clusters=k)
    kmeanModel.fit(normalized_df)
    sse.append(kmeanModel.inertia_)
plt.figure(figsize=(15,6))
plt.plot(K, sse, 'bx-')
plt.xlabel('Number of Clusters (k)', fontsize = 20)
plt.ylabel('Sum of Squared Error', fontsize = 20)
plt.title('The Elbow Method showing the optimal k', fontsize = 25)
plt.show()
```



Here we see that there is no appropriate value of k. Thus we use DBSCAN method to cluster data.

Visualising the data using PCA

In [13]:

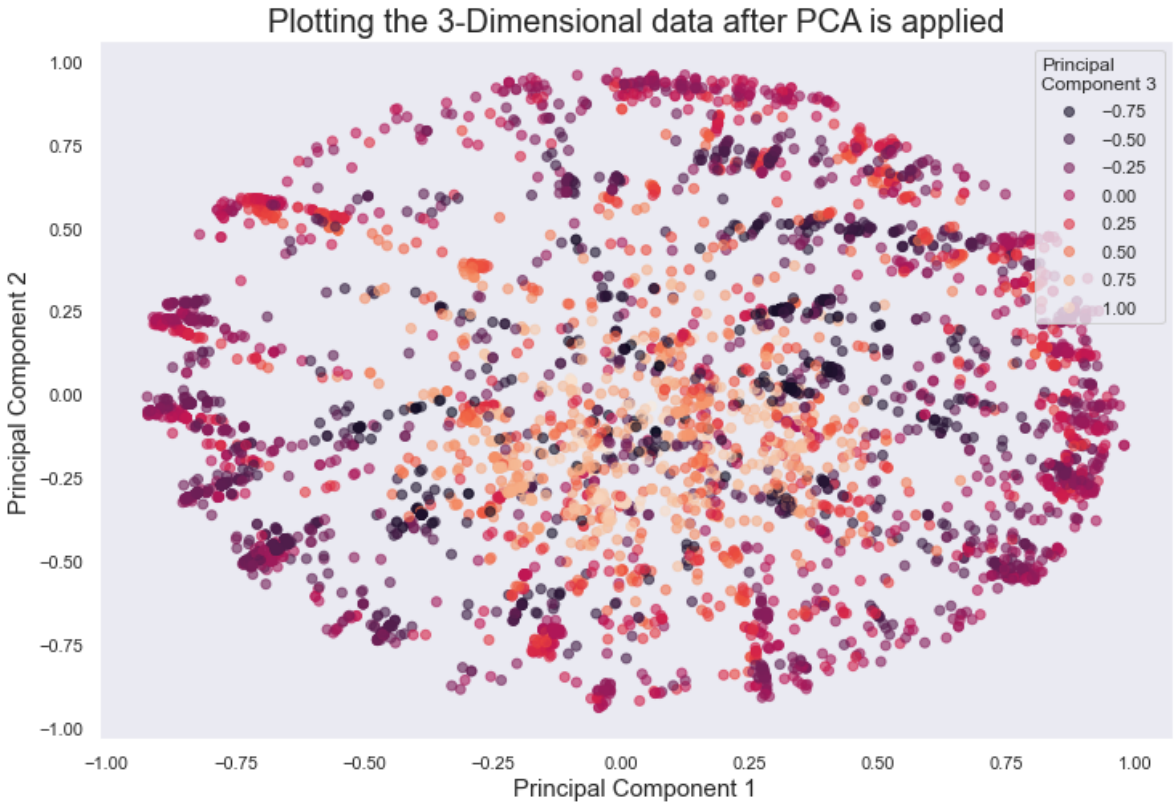
```
# Reducing the dimensions of the data
from sklearn.decomposition import PCA
pca = PCA(n_components = 3)
pcadf = pca.fit_transform(normalized_df)
pcadf = pd.DataFrame(pcadf)
pcadf.columns = ['Principal Component 1', 'Principal Component 2', 'Principal Componen

pcadf.head(10)
```

Out[13]:

	Principal Component 1	Principal Component 2	Principal Component 3
0	0.375353	-0.061732	0.885181
1	-0.285591	-0.137249	0.815803
2	-0.244175	-0.140513	0.851572
3	-0.840738	-0.028420	-0.292160
4	-0.872485	-0.068228	0.046006
5	0.373151	0.525823	-0.481568
6	-0.840738	-0.028420	-0.292160
7	0.297989	-0.033309	0.666742
8	0.820311	0.211774	-0.202186
9	0.871196	0.125964	-0.024124

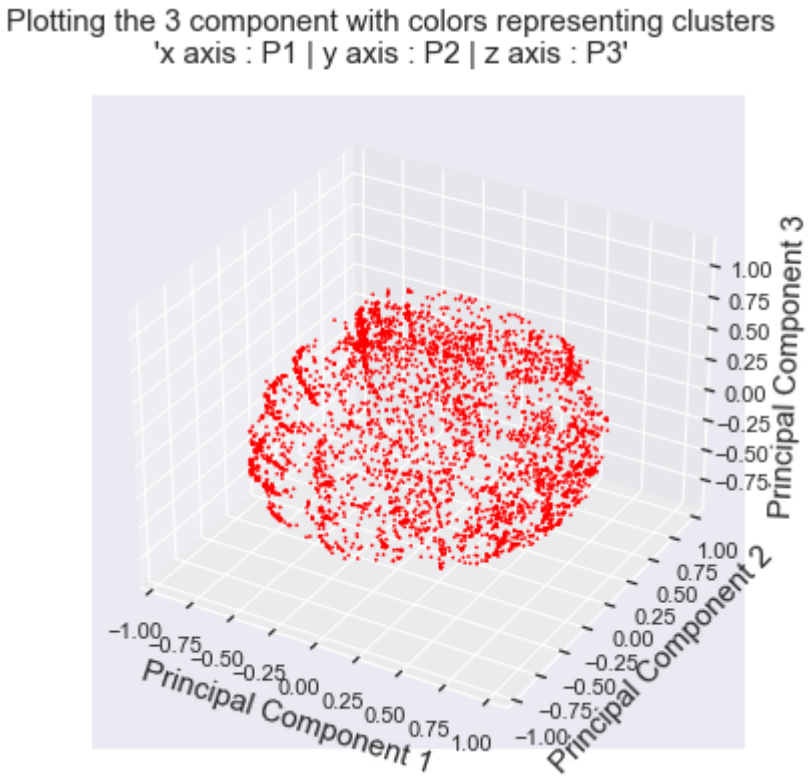
In [14]:

```
fig, ax = plt.subplots(figsize=(12, 8))
scatter = ax.scatter(pcadf['Principal Component 1'],
                     pcadf['Principal Component 2'],
                     c = pcadf['Principal Component 3'],
                     alpha=0.6)
plt.title('Plotting the 3-Dimensional data after PCA is applied', fontsize = 20)
plt.xlabel('Principal Component 1', fontsize = 15)
plt.ylabel('Principal Component 2', fontsize = 15)
plt.legend(*scatter.legend_elements(), loc="best", title="Principal\nComponent 3")
ax.plot([])
ax.grid()
plt.show()
```



In [15]:

```
fig = plt.figure(figsize = (15, 6))
plt.suptitle("Plotting the 3 component with colors representing clusters\n'x axis : P1

x, s1 = pcadf['Principal Component 1'], "Principal Component 1"
y, s2 = pcadf['Principal Component 2'], "Principal Component 2"
z, s3 = pcadf['Principal Component 3'], "Principal Component 3"

ax = fig.add_subplot(111, projection = '3d')
ax.scatter(x, y, z, c = "red", s=0.5, alpha = 1)
ax.set_xlabel(s1, fontsize = 15)
ax.set_ylabel(s2, fontsize = 15)
ax.set_zlabel(s3, fontsize = 15)

plt.show()
```



In [16]:

```
import plotly as py
import plotly.graph_objs as go
import numpy as np
import pandas as pd

trace = go.Scatter3d(
    x=pcadf['Principal Component 1'],
    y=pcadf['Principal Component 2'],
    z=pcadf['Principal Component 3'],

    mode='markers',
    marker=dict(
        size=5,
        color=pcadf['Principal Component 3'],
        colorscale='Viridis',
    ),
    name= 'PCA Visualization',

    # list comprehension to add text on hover
    text= [f"PCA 1: {a}<br>PCA 2: {b}<br>PCA 3: {c}" for a,b,c in list(zip(pcadf['Princ
    # if you do not want to display x,y,z
    hoverinfo='text'
)


layout = dict(title = 'PCA Visualization',)

data = [trace]
fig = dict(data=data, layout=layout)

py.offline.plot(fig, filename = 'Test.html')
```

Out[16]:

```
'Test.html'
```

Since there are no distinguishable clusters, we go for DBSCAN clustering and Heirarchial Clustering algorithms

DBSCAN Clustering (World)

In [17]:

```
# df1 = df[['Country_embedding',
#           'Continent_embedding',
#           'Domain_embedding',
#           'Industry_embedding',
#           'FieldOfStudy_embedding',
#           'latitude', 'longitude']]
```

In [18]:

```
from sklearn.cluster import DBSCAN

db = DBSCAN(eps=0.3, min_samples=10).fit(df1.drop(['latitude', 'longitude'], axis = 1))
labels = db.labels_
print(labels, len(labels))
```

```
[0 1 1 ... 2 2 2] 4910
```

In [19]:

```
df1['label'] = labels
df1['label'].value_counts()
```

Out[19]:

```
 2    4341
 1     204
 0     204
-1     118
 3      17
 4      16
 5      10
Name: label, dtype: int64
```

In [20]:

```
print("Cluster types: ",set(labels))
```

```
Cluster types:  {0, 1, 2, 3, 4, 5, -1}
```

In [21]:

```
df1.sample(5)
```

Out[21]:

	Country_embedding	Continent_embedding	Domain_embedding	Industry_embedding	Field
1161	-0.156677	-0.227953	-0.112251	0.394512	
206	-0.156677	-0.227953	0.195954	0.026966	
3847	0.812406	-0.227953	0.116207	0.389670	
2046	-0.156677	-0.227953	0.484690	-0.245237	
3864	-0.156677	-0.227953	0.116207	-0.245237	

Evaluation Metrics

Silhouette Score

In [22]:

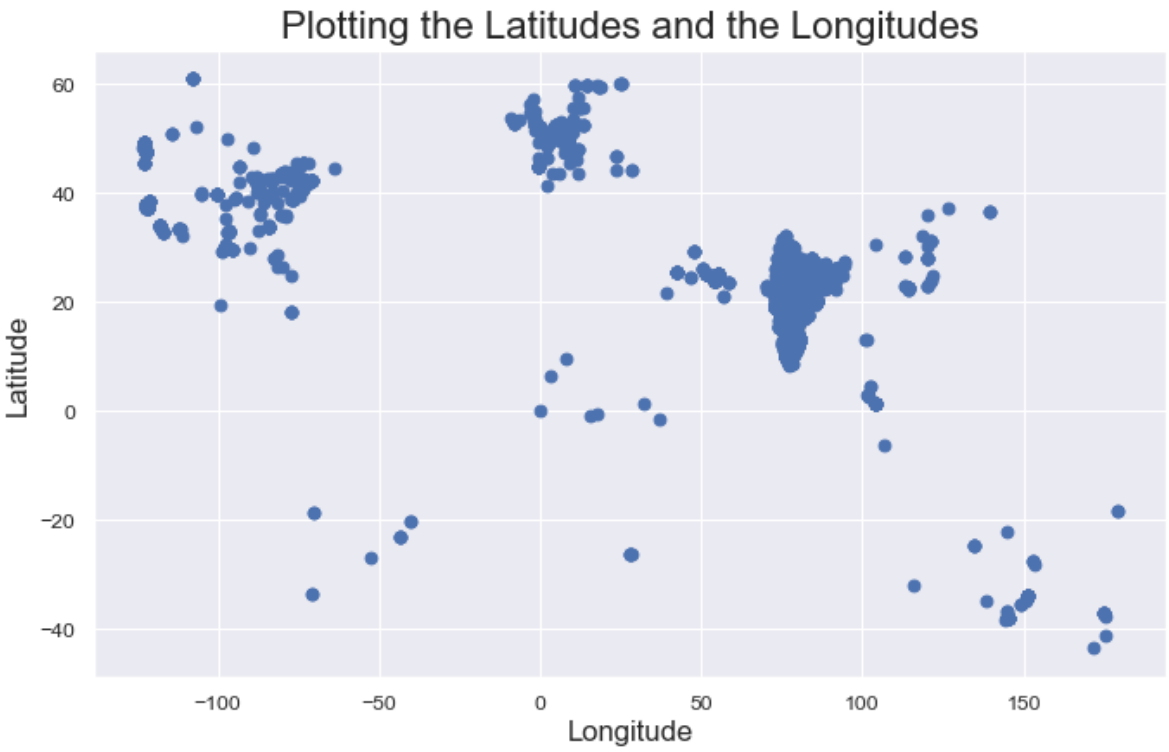
```
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score

sil_coeff = silhouette_score(df1, labels, metric='euclidean')
print("Silhoutte Score: ", sil_coeff)
```

```
Silhoutte Score:  0.6633363585442195
```

Plotting the world-wide profile clusters

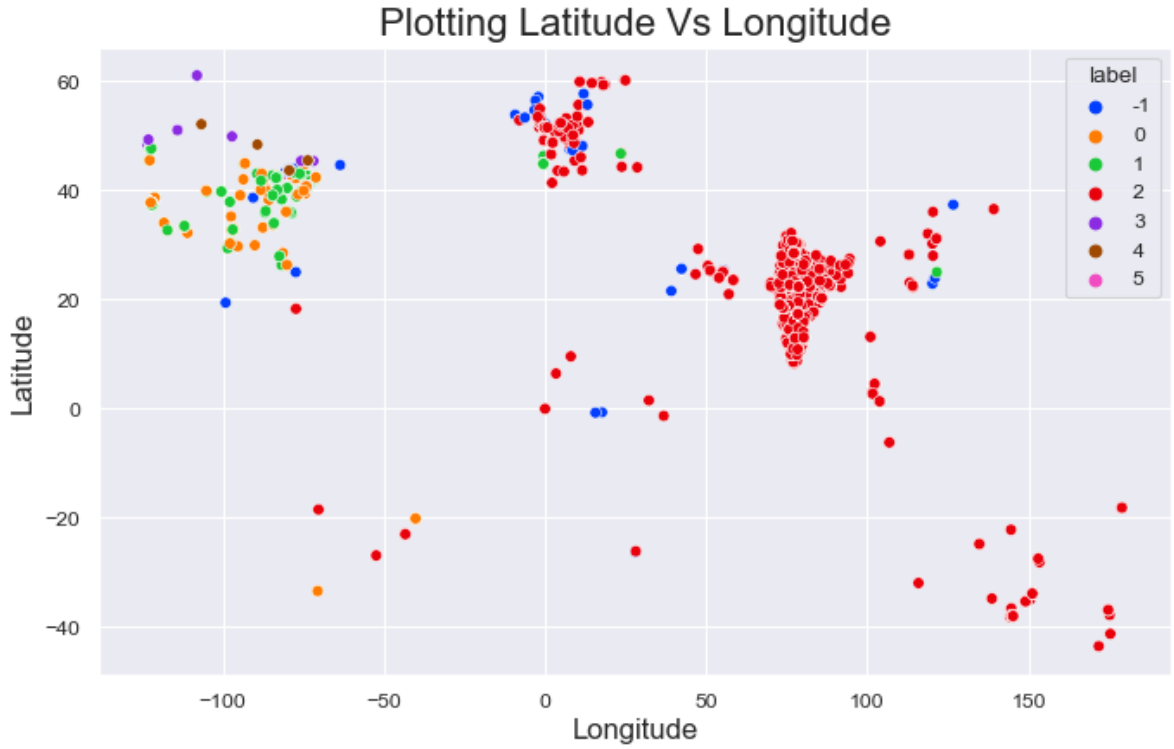
In [25]:

```
import matplotlib.pyplot as plt
from matplotlib.pyplot import figure

plt.figure(figsize=(10, 6), dpi=80)
plt.scatter(x=df1['longitude'], y=df1['latitude'])
plt.title('Plotting the Latitudes and the Longitudes', fontsize = 20)
plt.xlabel('Longitude', fontsize = 15)
plt.ylabel('Latitude', fontsize = 15)
plt.show()
```



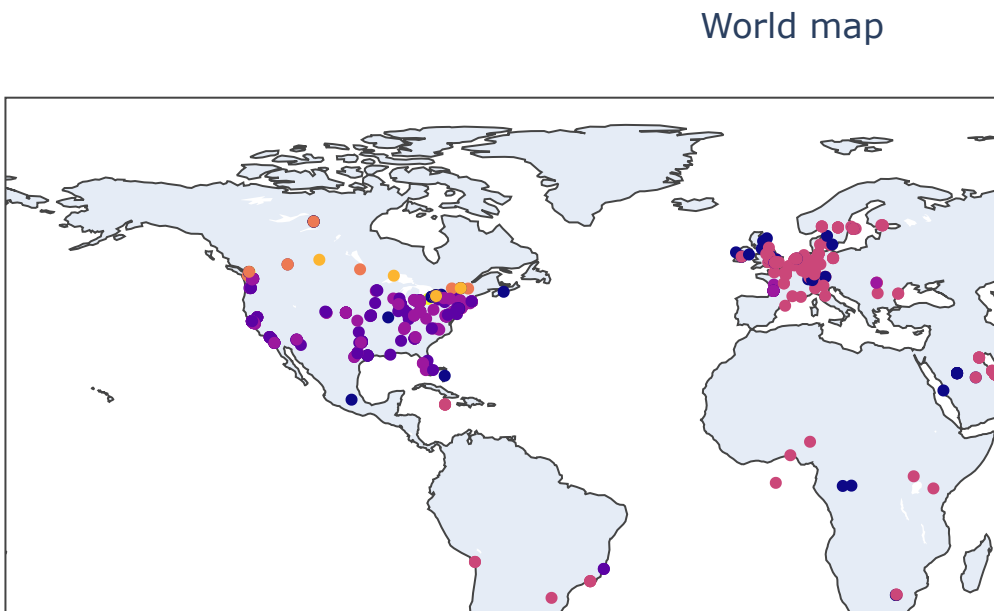
In [26]:

```
#markers=['.',',','o','v','^','<','>','1','2','3','4','8']
import seaborn as sns
sns.set_theme(color_codes=True)
fig, ax = plt.subplots(figsize = (10, 6),dpi=80)
markers=['o','v','^','<', 'x', '.', ',']
sns.scatterplot(ax = ax , x = "longitude" , y = "latitude" , data = df1, hue = "label"
ax.set_xlabel( "Longitude" , size = 15)
ax.set_ylabel( "Latitude" , size = 15)
ax.set_title( "Plotting Latitude Vs Longitude" , size = 20)
plt.show()
```



In [27]:

```
import plotly.io as pio; pio.renderers.default='notebook'
import plotly.express as px
import pandas as pd
fig = px.scatter_geo(df1,lat='latitude',lon='longitude', hover_name="label", color = d
fig.update_layout(title = 'World map', title_x=0.5)
fig.show()
```



In [52]:

```
import pandas as pd
from shapely.geometry import Point
import geopandas as gpd
from geopandas import GeoDataFrame

geometry = [Point(xy) for xy in zip(india_df['longitude'], df['latitude'])]
gdf = GeoDataFrame(india_df, geometry=geometry)

#this is a simple map that goes with geopandas
world = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))
gdf.plot(ax=world.plot(figsize=(10, 6)), marker='o', color='red', markersize=15)
```

```

```

In [ ]:

```

```

Word Clouds

In [29]:

```
df.columns
```

Out[29]:

```
Index(['Industry', 'Company Location', 'New Job (90 Days)', 'Year Started',
       'Profile Headline', 'Profile Summary', 'School', 'Degree',
       'Education End', 'Domain', 'CompanyName', 'JobTitle', 'My Network',
       'Country', 'Continent', 'FieldOfStudy', 'Industry_embedding',
       'Company Location_embedding', 'Profile Headline_embedding',
       'Profile Summary_embedding', 'School_embedding', 'Degree_embedding',
       'Education End_embedding', 'Domain_embedding', 'CompanyName_embeddin
g',
       'JobTitle_embedding', 'My Network_embedding', 'Country_embedding',
       'Continent_embedding', 'FieldOfStudy_embedding', 'latitude',
       'longitude'],
      dtype='object')
```

In [30]:

```
word_cloud_df = df[['Industry',
        'Degree',
        'Domain',
        'CompanyName',
        'JobTitle',
        'FieldOfStudy']]
```

In [31]:

```
word_cloud_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4910 entries, 0 to 4909
Data columns (total 6 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Industry      4910 non-null   object
 1   Degree        4910 non-null   object
 2   Domain        4910 non-null   object
 3   CompanyName   4910 non-null   object
 4   JobTitle      4910 non-null   object
 5   FieldOfStudy  4910 non-null   object
dtypes: object(6)
memory usage: 268.5+ KB
```

In [32]:

```
def join_text(df):
    k = ""
    for col in df.columns:
        try:
            k = (' '.join(df[col].str.lower()))
        except:
            print(col)
    return k
```

In [33]:

```
word_cloud_df['label'] = labels
word_cloud_df['label'].value_counts()
```

Out[33]:

```
 2    4341
 1     204
 0     204
-1     118
 3      17
 4      16
 5      10
Name: label, dtype: int64
```

In [34]:

```
clus1_df = word_cloud_df[word_cloud_df['label'] == -1]
```

In [35]:

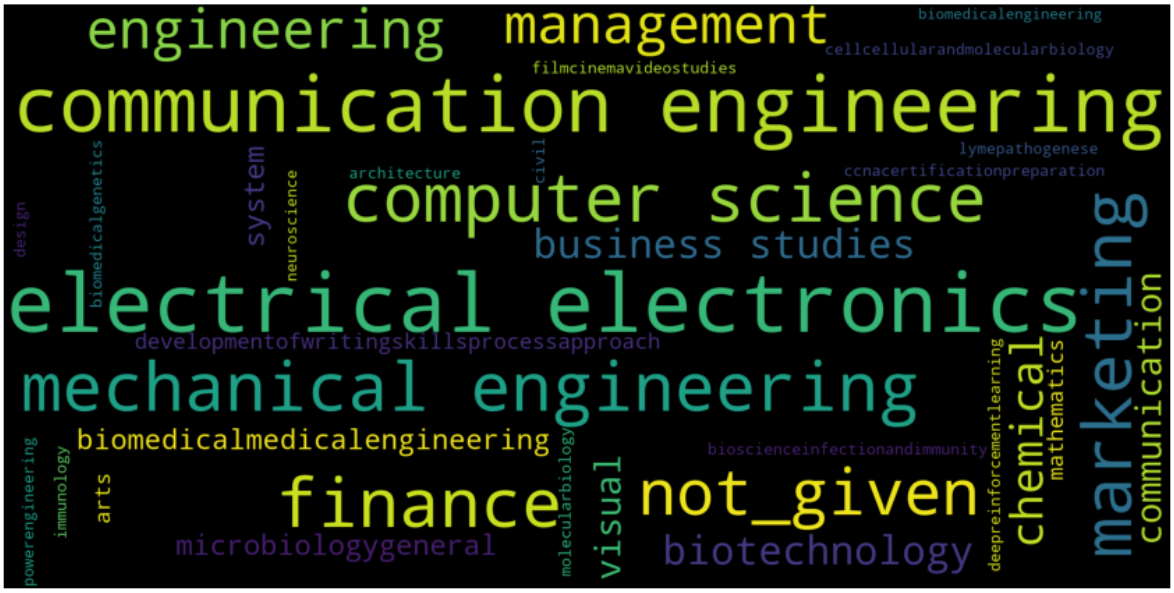
```
def plot_wordCloud(df):
    from textblob import TextBlob
    from collections import Counter
    from wordcloud import WordCloud, STOPWORDS
    import matplotlib.pyplot as plt

    k = join_text(df.drop(['label'], axis = 1))
    wordcloud = WordCloud(width = 2000, height = 1000, prefer_horizontal = 0.3).generat
    plt.figure(figsize=(15,15))
    plt.imshow(wordcloud)
    plt.axis('off')
```

In [36]:

```
import collections
import numpy as np
import pandas as pd
import matplotlib.cm as cm
import matplotlib.pyplot as plt
from matplotlib import rcParams
from wordcloud import WordCloud, STOPWORDS
%matplotlib inline
stopwords = STOPWORDS
stopwords.add('&')
stopwords.add('-')

def analyse_word_cloud(df, num):
    all_words = join_text(df)

    filtered_words = [word for word in all_words.split() if word not in stopwords]
    counted_words = collections.Counter(filtered_words)

    words = []
    counts = []
    for letter, count in counted_words.most_common(10):
        words.append(letter)
        counts.append(count)

    colors = cm.rainbow(np.linspace(0, 1, 10))
    rcParams['figure.figsize'] = 20, 10
    plt.title('Top words in the cluster (' + str(num) + ') vs their count', fontsize =
    plt.xlabel('Count', fontsize = 20)
    plt.ylabel('Words', fontsize = 20)
    plt.xticks(fontsize = 20)
    plt.yticks(fontsize = 20)
    plt.barh(words, counts, color=colors)
    plt.show()
```

In [37]:

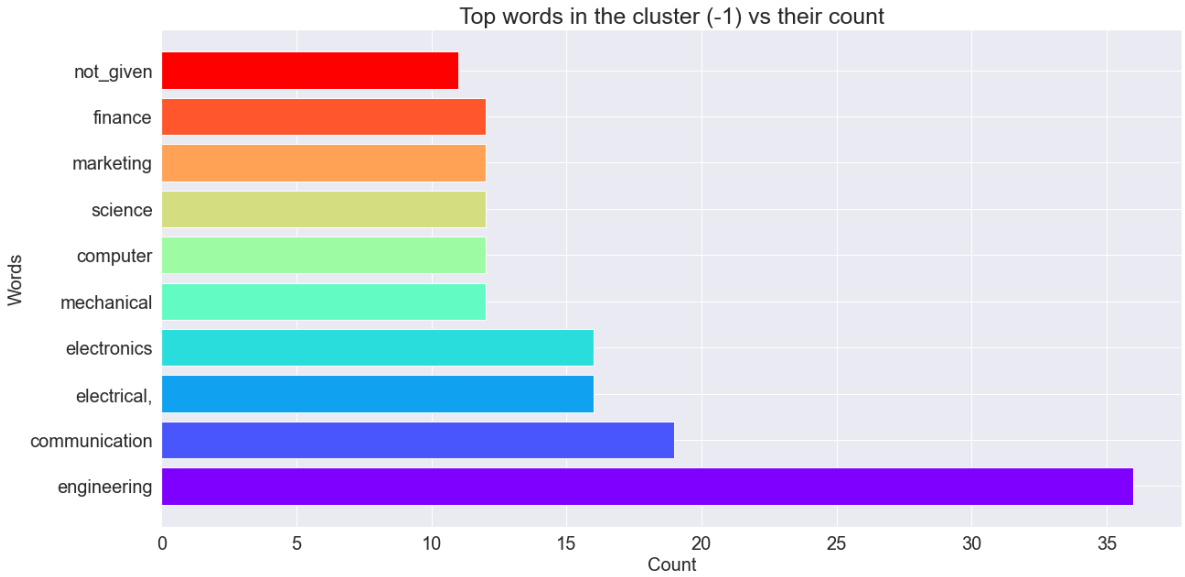
```
plot_wordCloud(clus1_df)
```



In [38]:

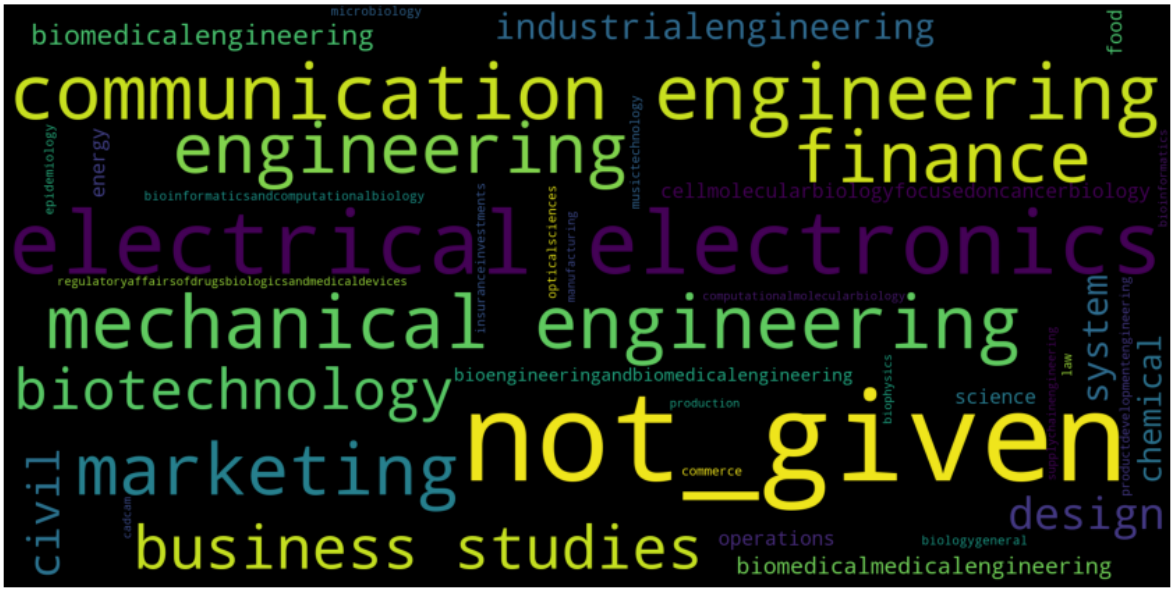
```
1 analyse_word_cloud(clus1_df, -1)
```

```
label
```



In [39]:

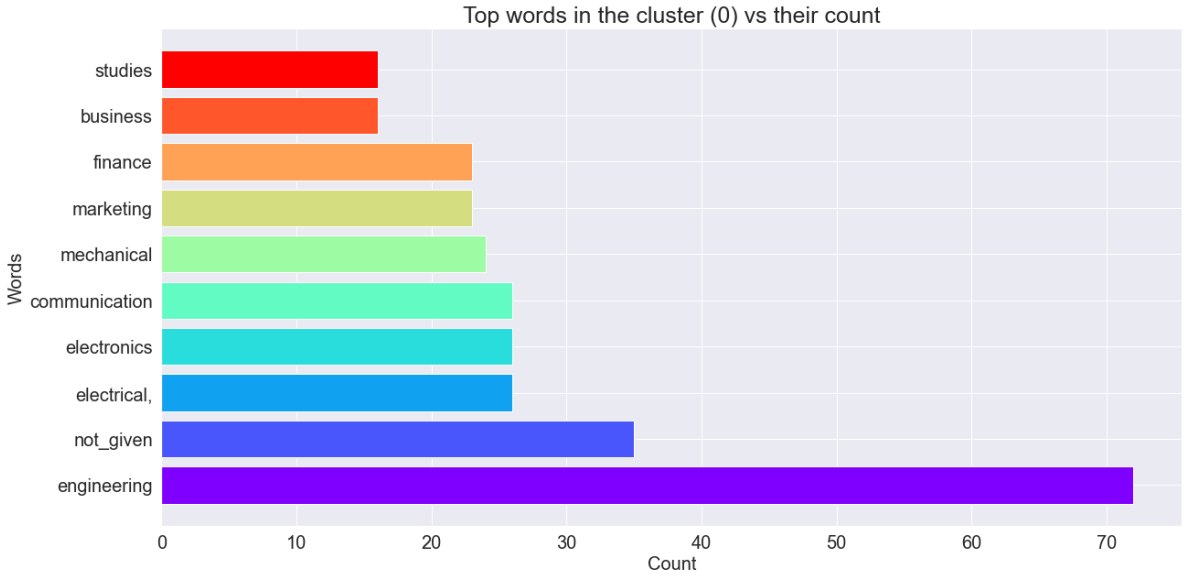
```
1 clus2_df = word_cloud_df[word_cloud_df['label'] == 0]
2 plot_wordCloud(clus2_df)
```



In [40]:

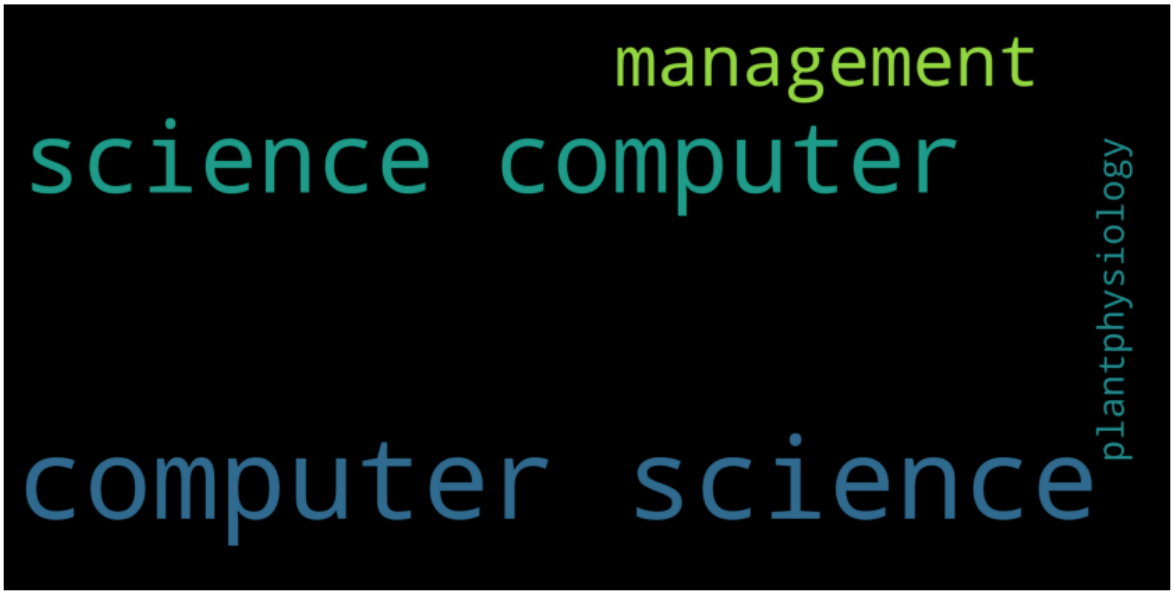
```
1 analyse_word_cloud(clus2_df, 0)
```

```
label
```



In [41]:

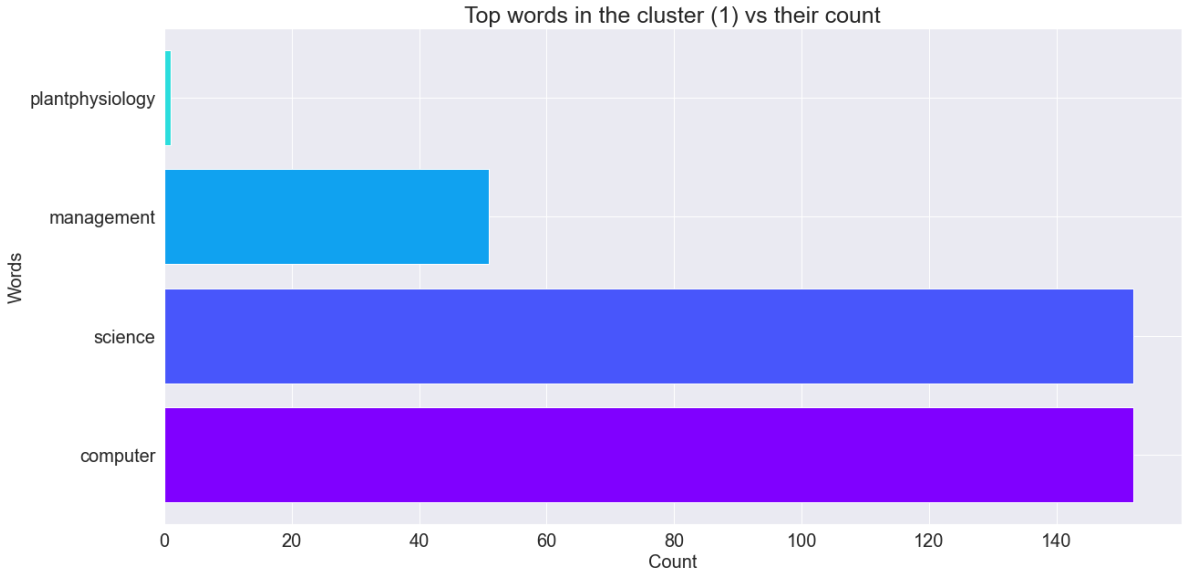
```
1 clus3_df = word_cloud_df[word_cloud_df['label'] == 1]
2 plot_wordCloud(clus3_df)
```



In [42]:

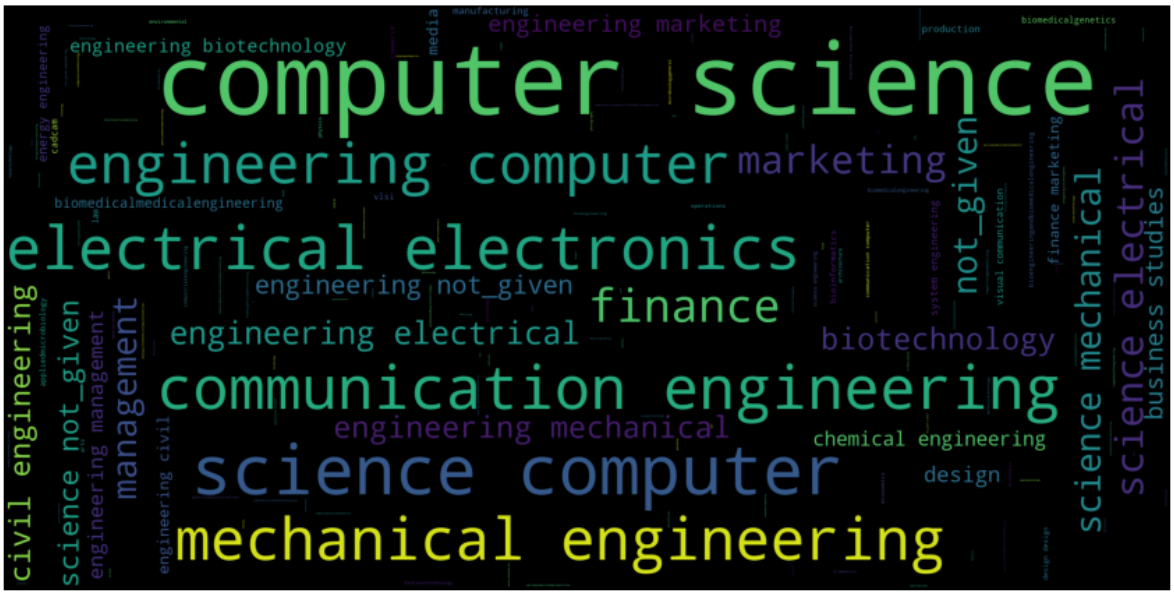
```
1 analyse_word_cloud(clus3_df, 1)
```

```
label
```



In [43]:

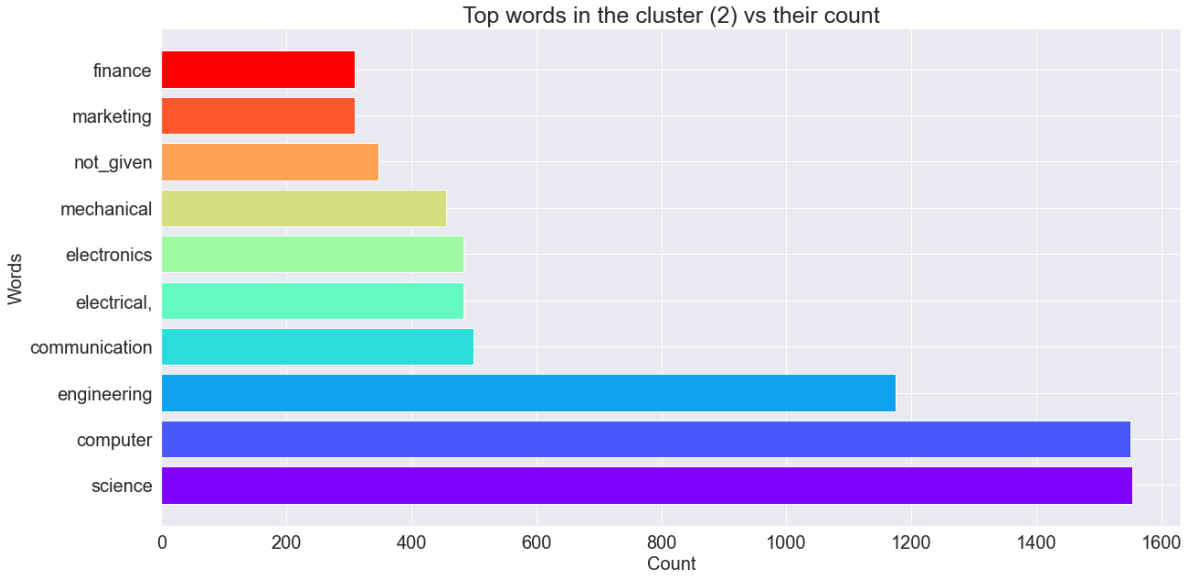
```
1 clus4_df = word_cloud_df[word_cloud_df['label'] == 2]
2 plot_wordCloud(clus4_df)
```



In [44]:

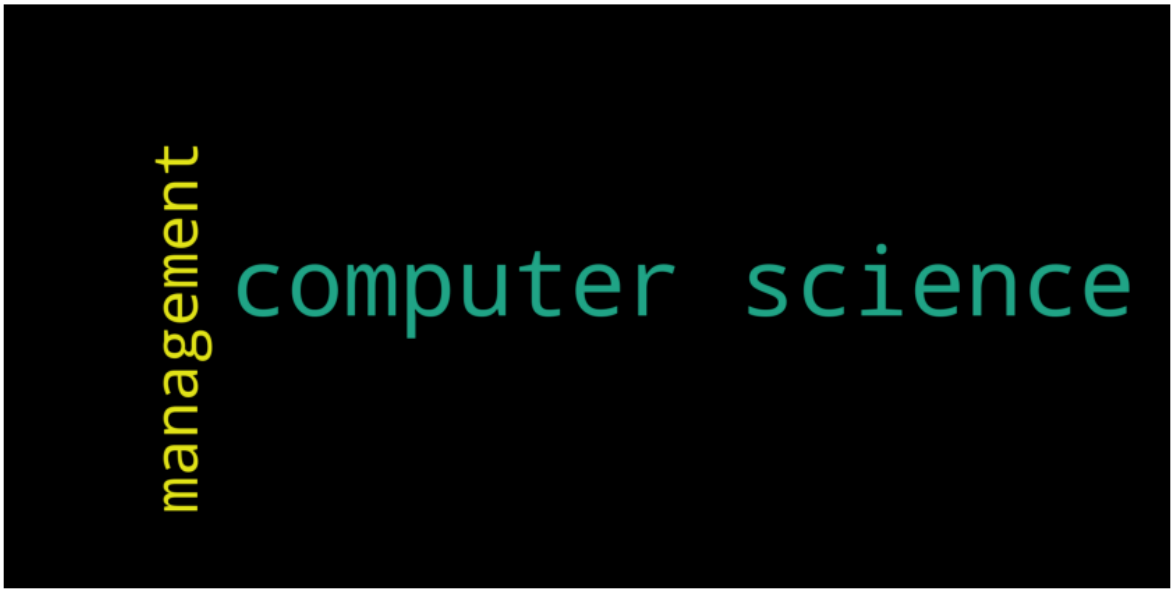
```
1 analyse_word_cloud(clus4_df, 2)
```

```
label
```



In [45]:

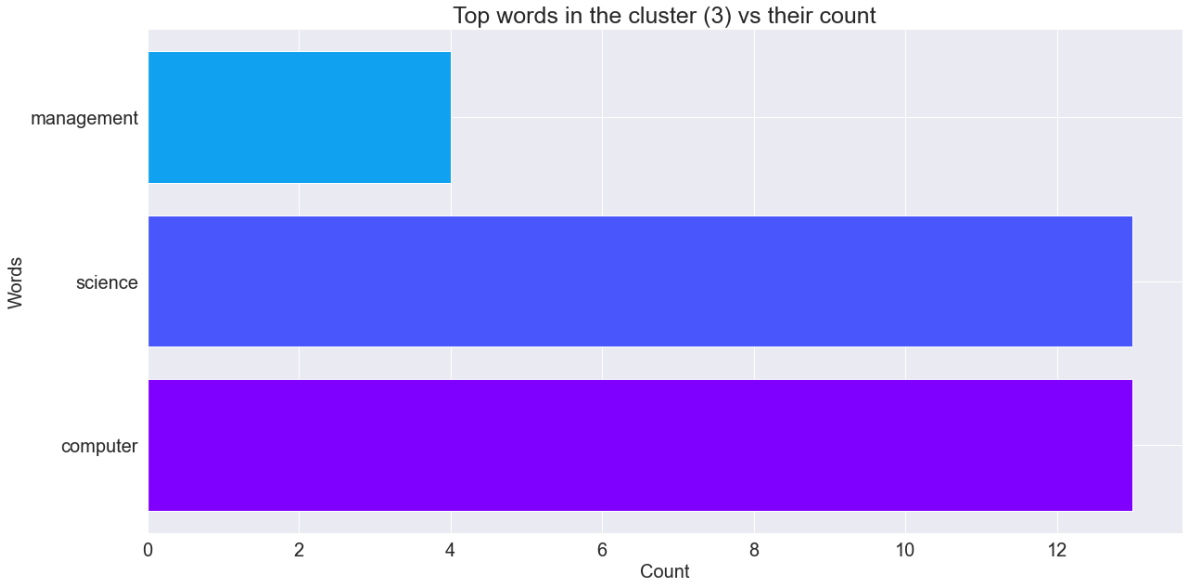
```
1 clus5_df = word_cloud_df[word_cloud_df['label'] == 3]
2 plot_wordCloud(clus5_df)
```



In [46]:

```
1 analyse_word_cloud(clus5_df, 3)
```

```
label
```



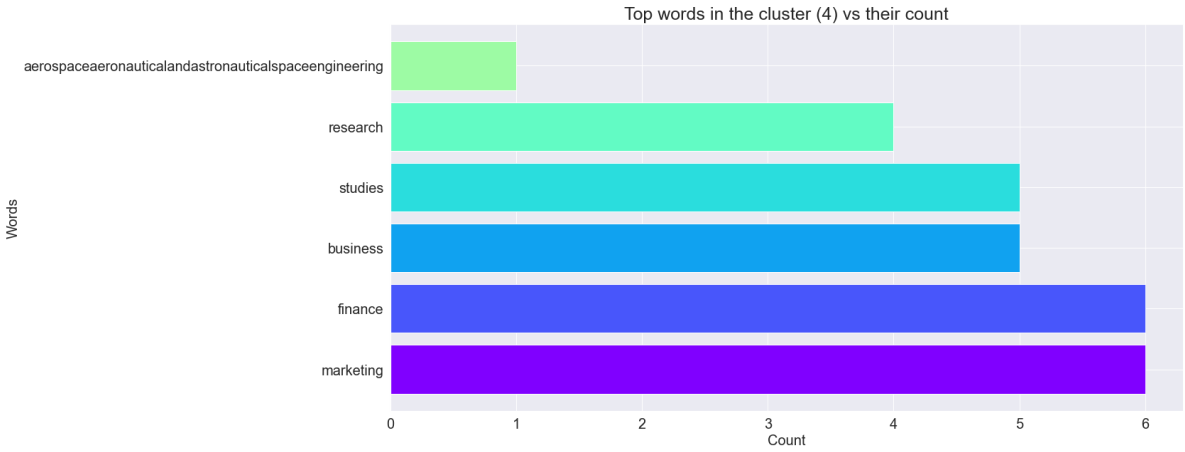
In [47]:

```
1 clus6_df = word_cloud_df[word_cloud_df['label'] == 4]
2 plot_wordCloud(clus6_df)
```

In [48]:

```
1 analyse_word_cloud(clus6_df, 4)
```

```
label
```



In [49]:

```
1 clus7_df = word_cloud_df[word_cloud_df['label'] == 5]
2 plot_wordCloud(clus7_df)
```

In [50]:

```
1 analyse_word_cloud(clus7_df, 5)
```

```
label
```