4412A_P3_TASK2_KMeans

July 30, 2022

0.1 EECS 4412 A Phase 3 Task 2

0.1.1 PART 1: Exploratory Data Analysis

[917]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
from sklearn.cluster import KMeans
from sklearn import preprocessing
from sklearn.decomposition import PCA
from scipy.spatial.distance import cdist

%matplotlib inline

#file MUST be in same folder as this .ipynb file
student_data = pd.read_csv('216771875-216328387-215122856-T2Org.csv')
student_data.head()
```

[917]:

	sex	age	address	traveltime	studytime	failures	romantic	freetime	goout	\
0	F	18	U	2	2	0	no	3	4	
1	F	17	U	1	2	0	no	3	3	
2	F	15	U	1	2	3	no	3	2	
3	F	15	U	1	3	0	yes	2	2	
4	F	16	U	1	2	0	no	3	2	

	Dalc	Walc	absences	G1	G2	G3
0	1	1	6	5	6	6
1	1	1	4	5	5	6
2	2	3	10	7	8	10
3	1	1	2	15	14	15
4	1	2	4	6	10	10

[918]:
```
student_data.describe()
```

[918]:

	age	traveltime	studytime	failures	freetime	goout	\
count	50.000000	50.000000	50.00000	50.000000	50.00000	50.000000	
mean	15.540000	1.260000	1.94000	0.220000	3.28000	2.620000	
std	0.705951	0.527218	0.71171	0.678835	1.03095	1.085902	

```
min    15.000000    1.000000    1.00000   0.000000   1.00000   1.000000
25%    15.000000    1.000000    1.25000   0.000000   3.00000   2.000000
50%    15.000000    1.000000    2.00000   0.000000   3.00000   2.500000
75%    16.000000    1.000000    2.00000   0.000000   4.00000   3.000000
max    18.000000    3.000000    4.00000   3.000000   5.00000   5.000000
```

```
            Dalc       Walc   absences         G1         G2         G3
count  50.000000  50.000000  50.000000  50.000000  50.000000  50.000000
mean    1.260000   1.840000   4.480000  11.360000  11.940000  12.080000
std     0.694292   1.149268   5.357581   3.718459   3.593702   3.713406
min     1.000000   1.000000   0.000000   5.000000   5.000000   5.000000
25%     1.000000   1.000000   0.000000   8.000000  10.000000  10.000000
50%     1.000000   1.000000   2.000000  12.000000  12.000000  12.000000
75%     1.000000   2.000000   6.000000  14.000000  15.000000  15.000000
max     5.000000   5.000000  25.000000  19.000000  19.000000  20.000000
```

[919]:
```
#-------------------------------------------------------------
# Following chunk of code is to convert certain pieces of data
# (such as famsize) to be numeric so it can be used in the
# KMeans algorithm
#-------------------------------------------------------------

#Dropping some unnecessary data
drop = ['sex', 'age', 'address', 'romantic']
student_data.drop(drop, axis=1, inplace=True)


#Changing G3 to be of the following scale
rating = []
for row in student_data['G3']:
    if (0 <= row < 10):  rating.append('0')
    elif (10 <= row < 15):  rating.append('1')
    elif (15 <= row <= 20):  rating.append('2')
student_data['rating_G3'] = rating


#Dropping data which is now adjusted
drop = ['G3']
student_data.drop(drop, axis=1, inplace=True)

student_data.head()
```

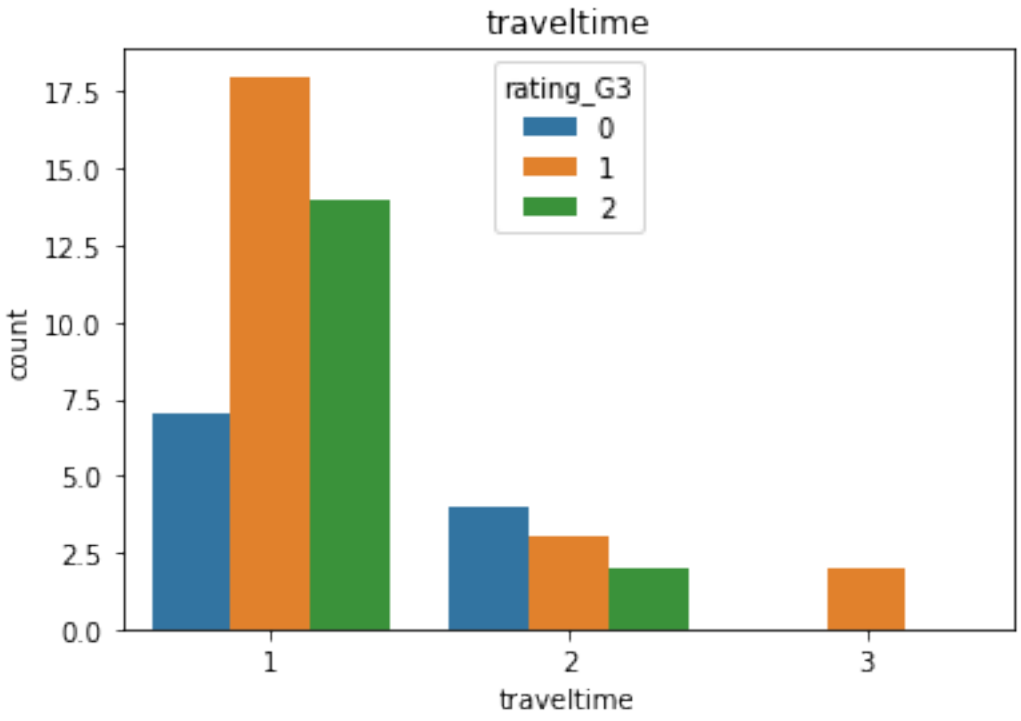
[919]:
```
   traveltime  studytime  failures  freetime  goout  Dalc  Walc  absences  G1  \
0           2          2         0         3      4     1     1         6   5
1           1          2         0         3      3     1     1         4   5
2           1          2         3         3      2     2     3        10   7
3           1          3         0         2      2     1     1         2  15
```

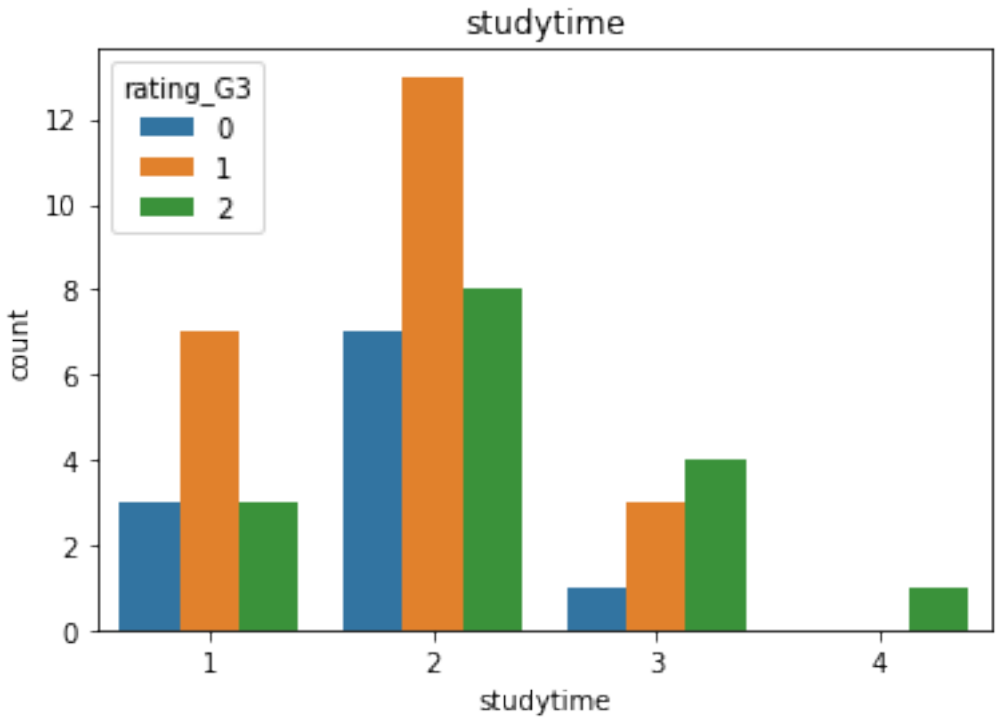
```
4           1           2          0          3       2      1      2          4    6

   G2 rating_G3
0   6          0
1   5          0
2   8          1
3  14          2
4  10          1
```

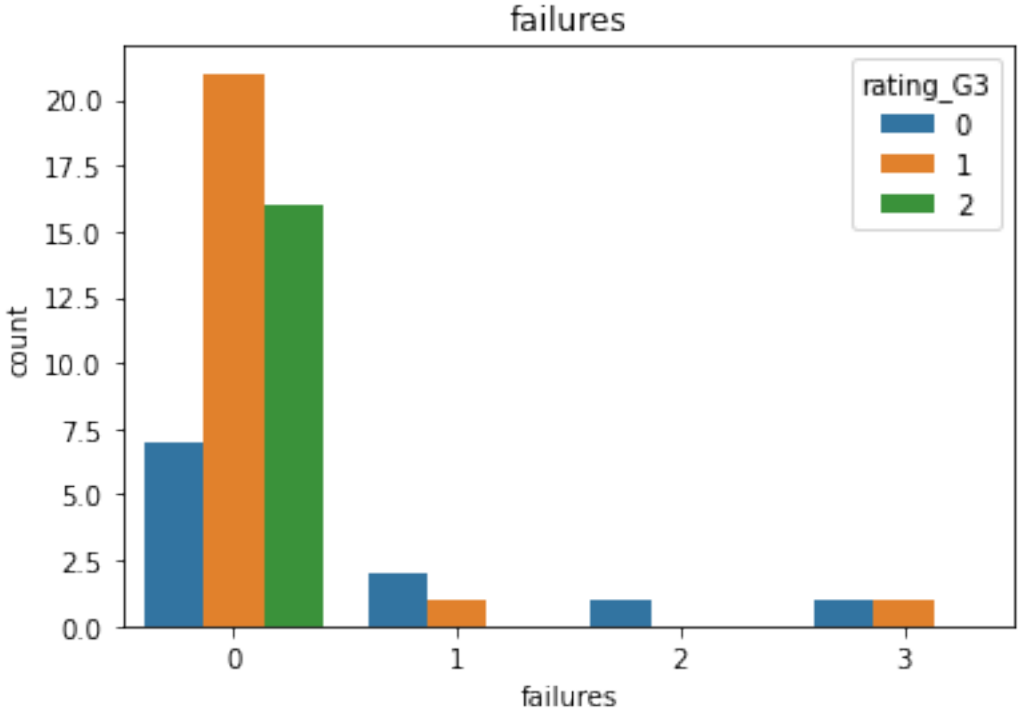
0.1.2 Notes:

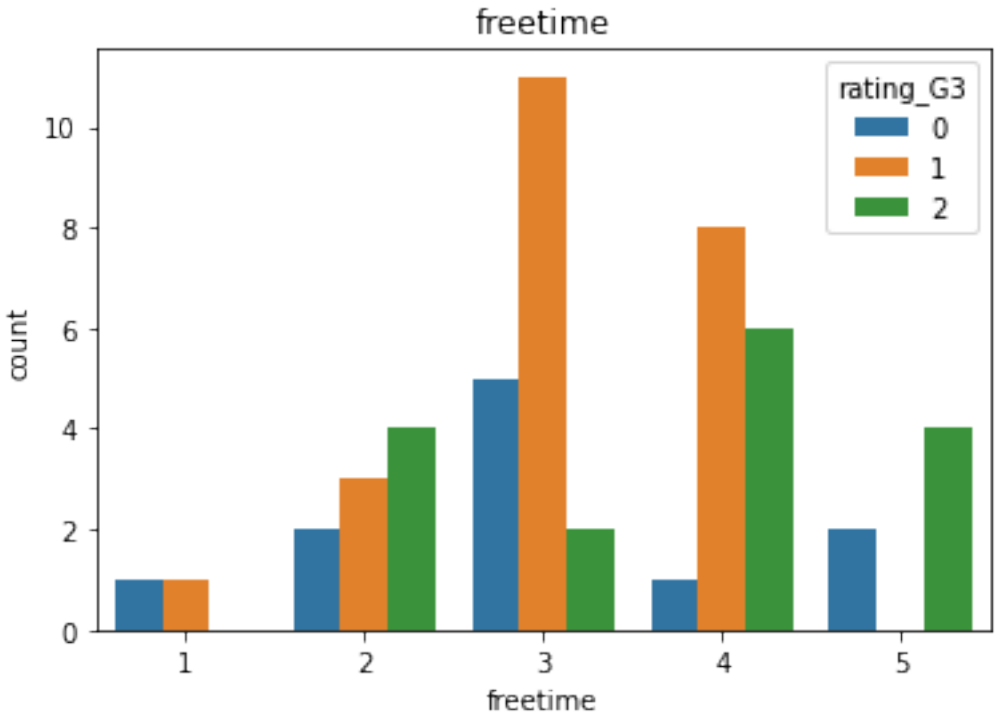
Will now check for an attribute's relation to rating_G3, if there is no meaningful data that can be related to G3 or the attribute is not one from our intial questions it may be dropped.

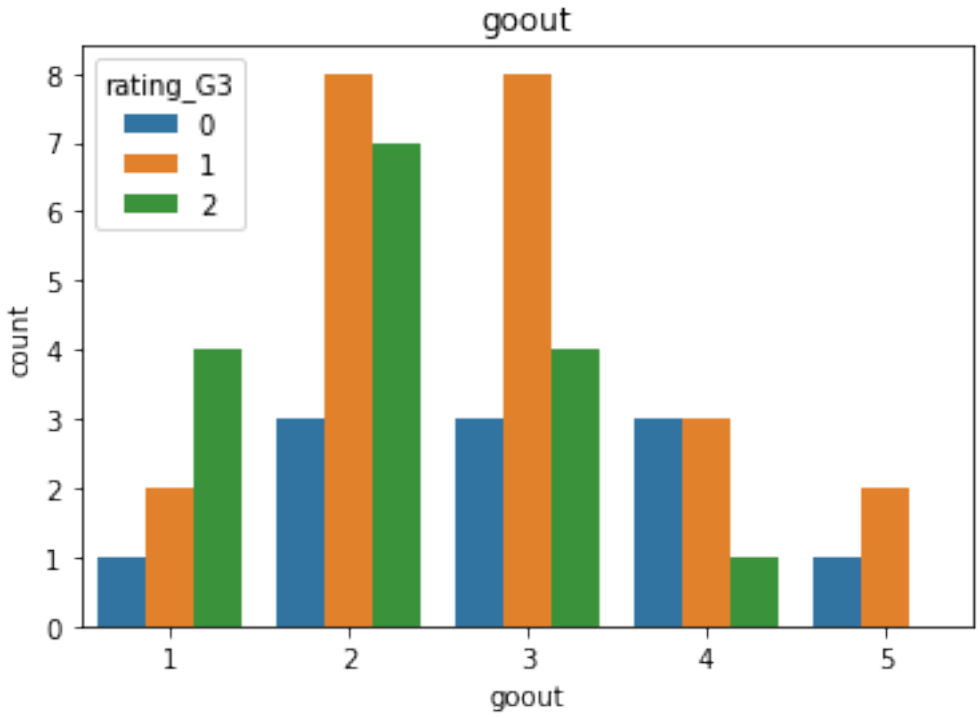
[920]:
```
attri_names = student_data.columns

#Printing tables for each of the attributes, counting the number of different␣
 ↪rating_G3 values that exist for a specfic
#value of said attribute
for i in attri_names:
    sns.countplot(x = i, hue = "rating_G3", data = student_data).
 ↪set(title=str(i))
    plt.show()
```

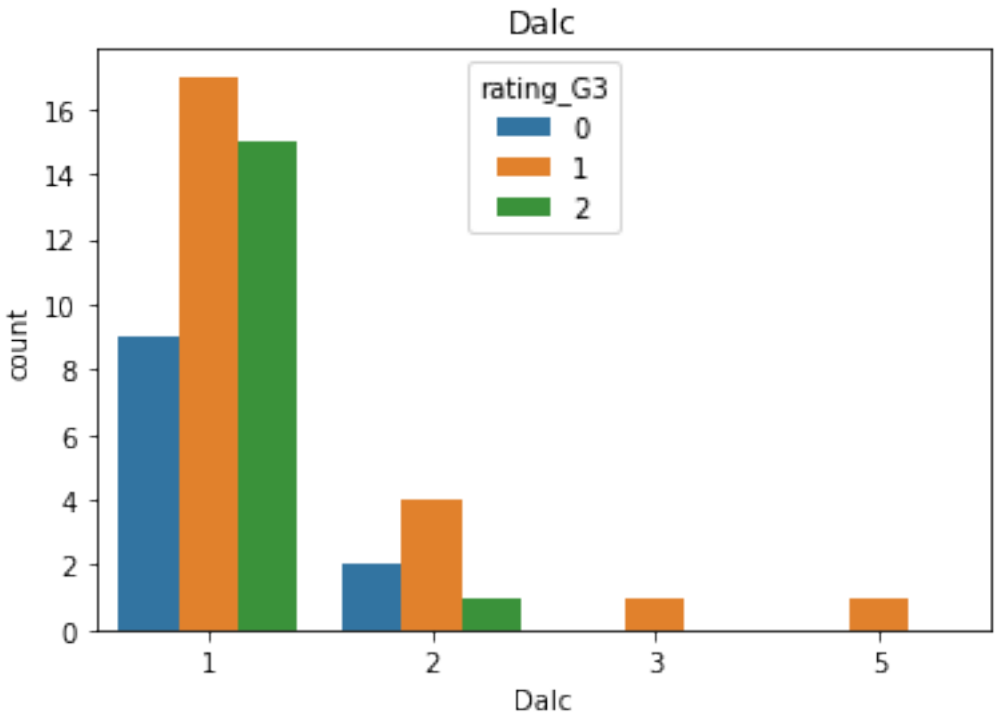


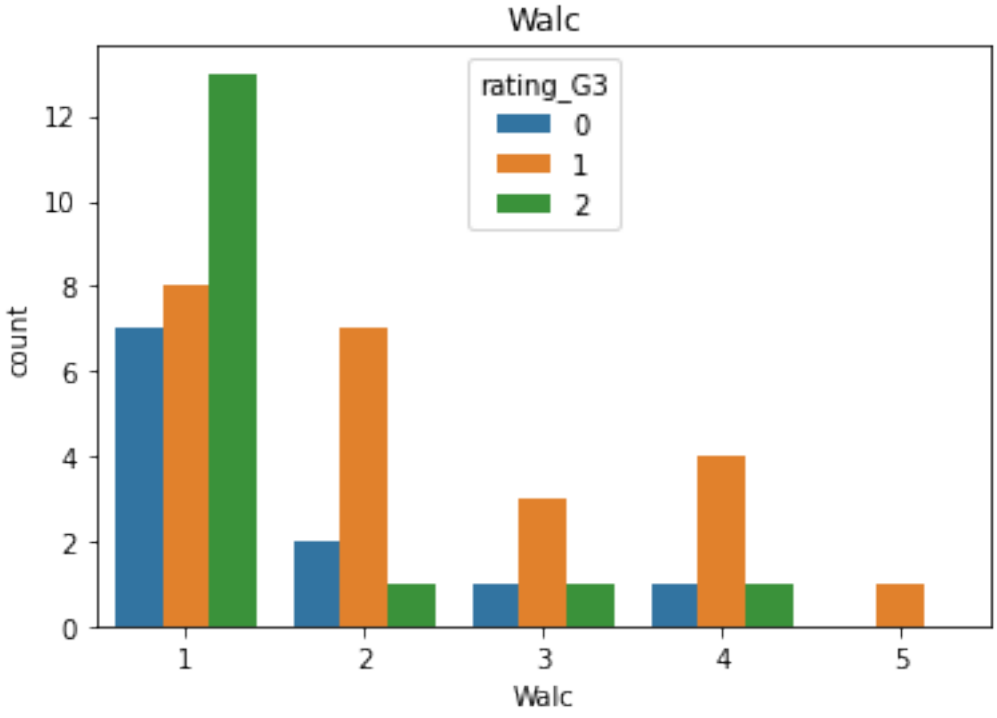

studytime
rating_G3
0
1
2
count
0
2
4
6
8
10
12
1
2
3
4
studytime

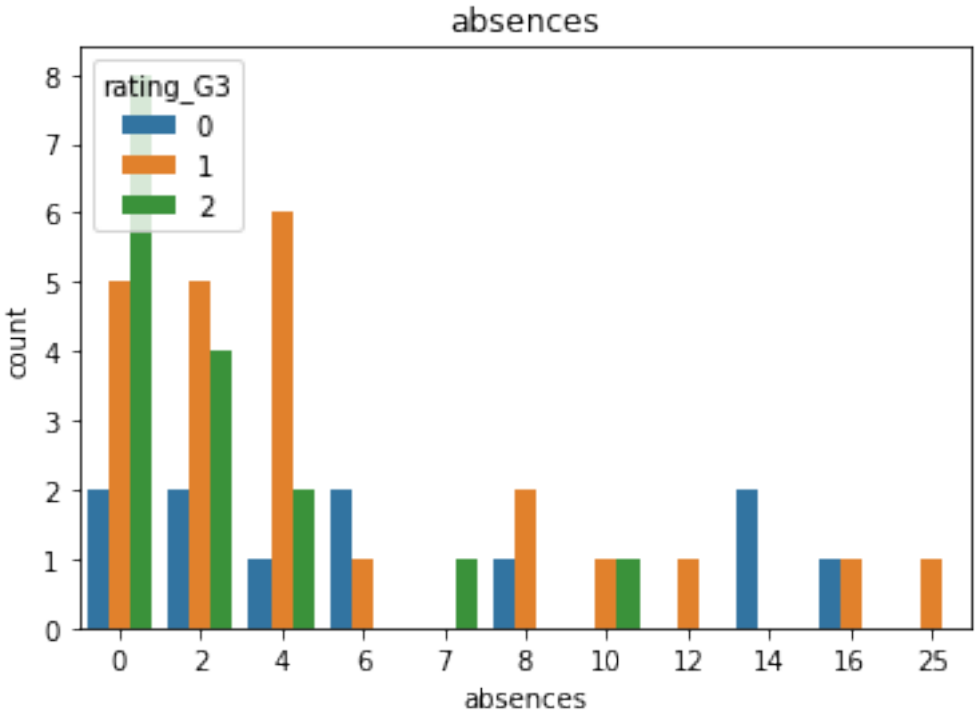

failures
rating_G3
0
1
2
count
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
1
2
3
failures

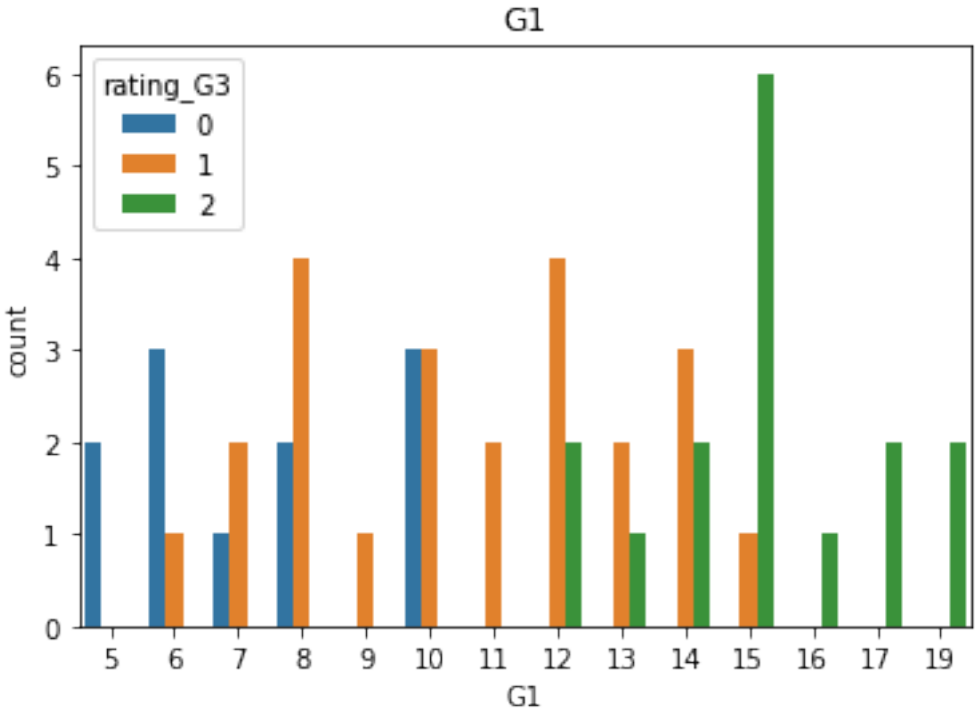

freetime
rating_G3
0
1
2
count
freetime
0
2
4
6
8
10
1
2
3
4
5

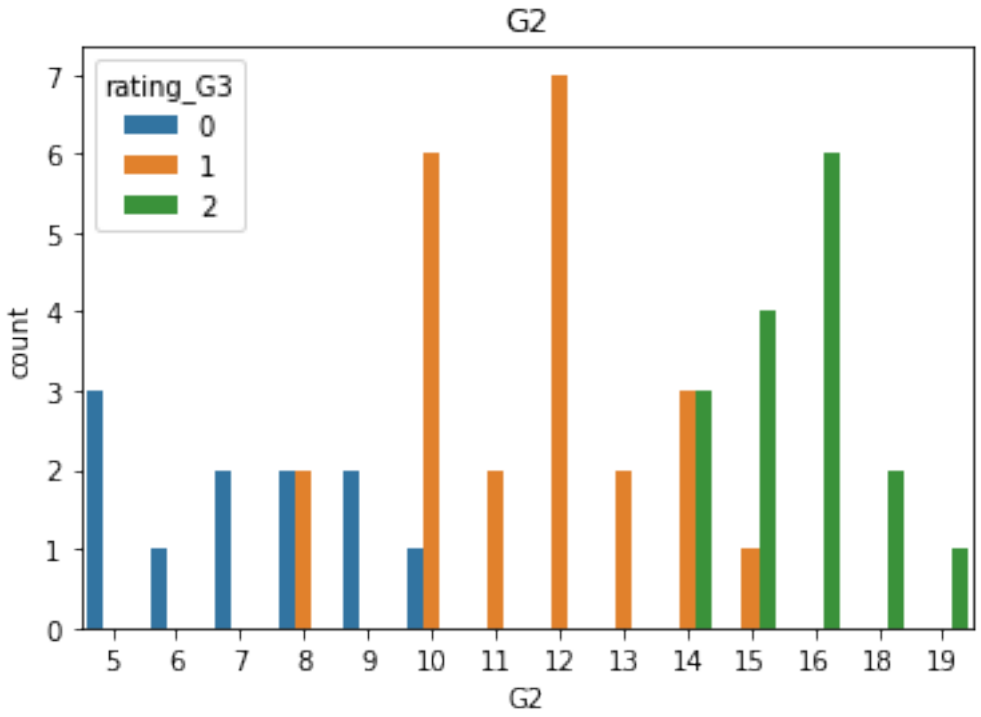

goout
rating_G3
0
1
2
count
goout
0
1
2
3
4
5
6
7
8
1
2
3
4
5

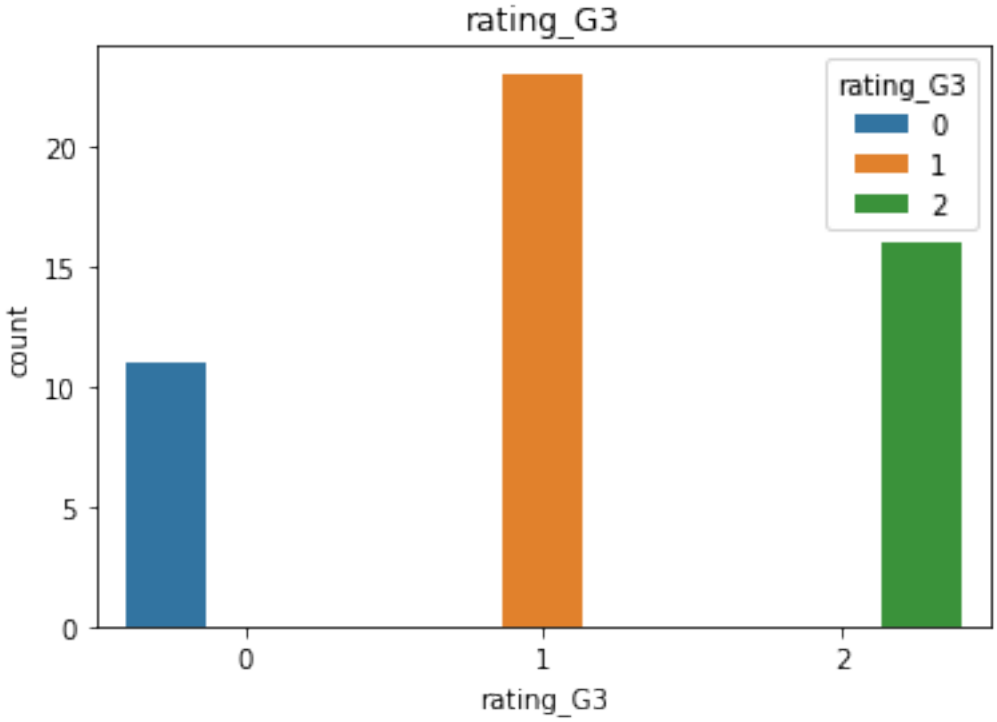

Dalc
rating_G3
0
1
2
count
16
14
12
10
8
6
4
2
0
1
2
3
5
Dalc


Walc
rating_G3
0
1
2
count
12
10
8
6
4
2
0
1
2
3
4
5
Walc


absences
rating_G3
0
1
2
count
absences
0
2
4
6
7
8
10
12
14
16
25


G1
rating_G3
0
1
2
count
G1
5
6
7
8
9
10
11
12
13
14
15
16
17
19


G2
rating_G3
0
1
2
count
0
1
2
3
4
5
6
7
5
6
7
8
9
10
11
12
13
14
15
16
18
19
G2

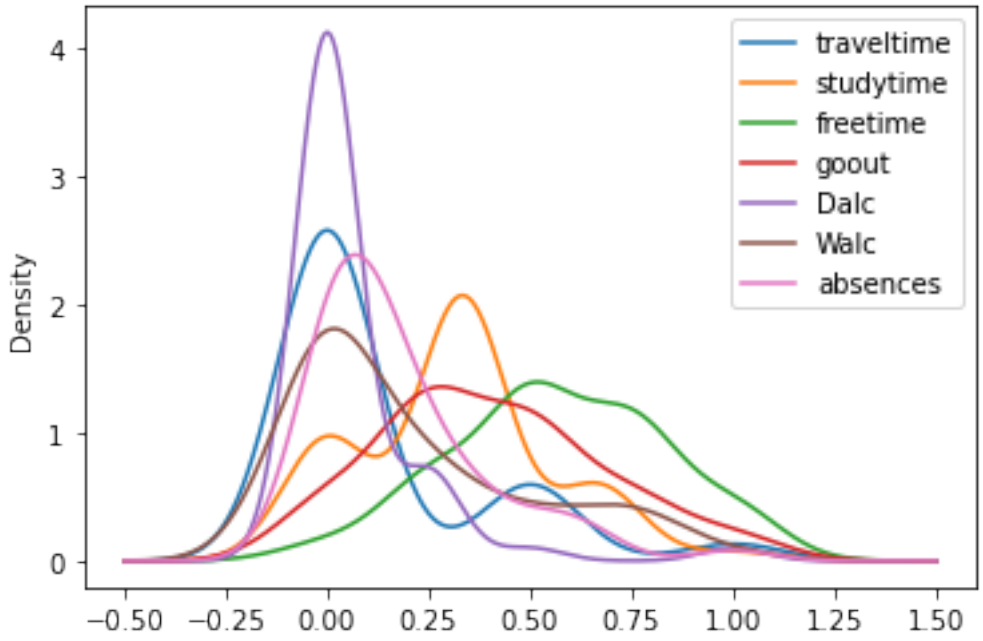

rating_G3
rating_G3
0
1
2
count
0
5
10
15
20
0
1
2
rating_G3

[921]:
```
#Storing rating_G3 data to be used for analysis later
student_target = student_data['rating_G3'].to_numpy()

#Dropping data deemed unncessary after EDA
drop = ['failures', 'G1', 'G2']
student_data.drop(drop, axis=1, inplace=True)

#============================================================================================
#============================================================================================
# Uncomment the following line for data table with 'rating_G3' still as an␣
 ↪attribute
# and no normalization
#
# student_data.to_csv('216771875-216328387-215122856-T2Mod_WITH-G3.csv')
#============================================================================================
#============================================================================================

drop = ['rating_G3']
student_data.drop(drop, axis=1, inplace=True)

#Using MinMaxScalar to perform normalization, where data is adjusted to be of␣
 ↪range [0,1]
scale = preprocessing.MinMaxScaler()

tableTrnsfrm = scale.fit_transform(student_data)
student_data_norm = pd.DataFrame(tableTrnsfrm, columns=(student_data.columns))

student_data_norm.to_csv('216771875-216328387-215122856-T2Mod.csv')
student_data_norm.head()
```

[921]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences
0	0.5	0.333333	0.50	0.75	0.00	0.00	0.24
1	0.0	0.333333	0.50	0.50	0.00	0.00	0.16
2	0.0	0.333333	0.50	0.25	0.25	0.50	0.40
3	0.0	0.666667	0.25	0.25	0.00	0.00	0.08
4	0.0	0.333333	0.50	0.25	0.00	0.25	0.16

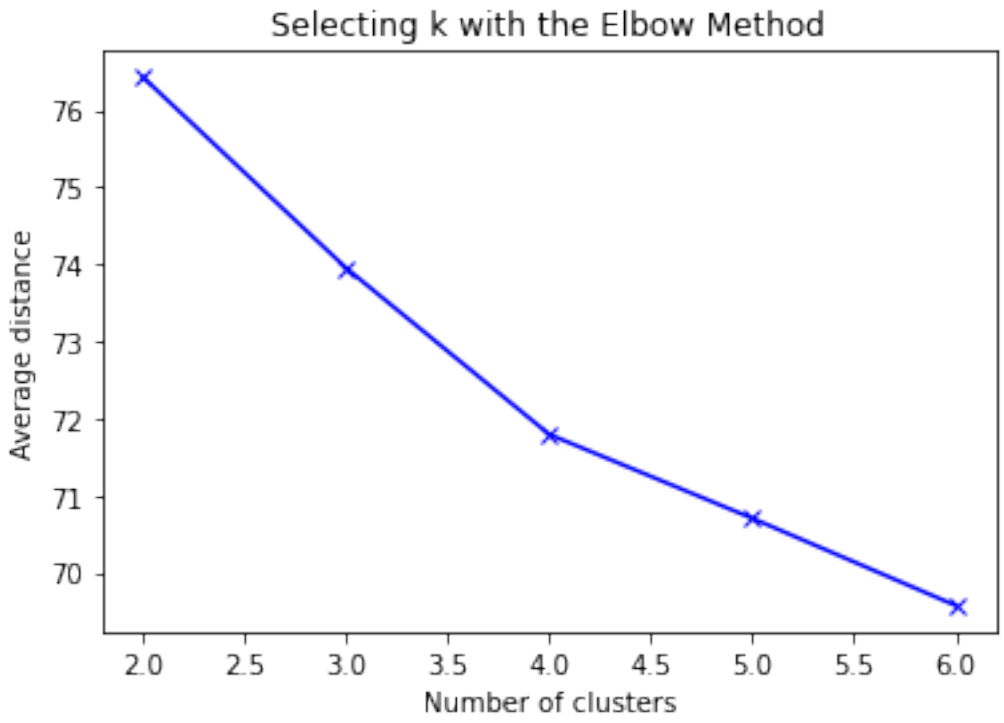
[922]:
```
pd.DataFrame(student_data_norm).plot(kind='kde');
```



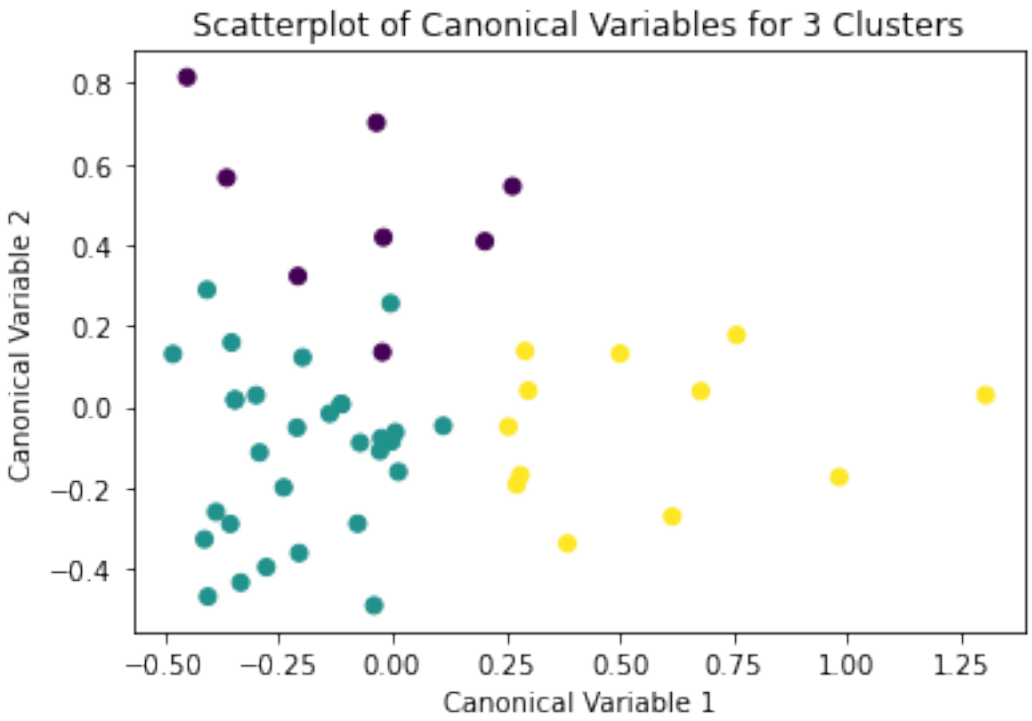
0.1.3 PART 2: Performing KMeans Clustering

[923]:
```
#Finding sum of squared error for each k from 2 to 6
clusters=range(2,7)
meandist=[]

for k in clusters:
    model=KMeans(n_clusters=k)
    model.fit(student_data_norm)
    clusassign=model.predict(student_data_norm)
    meandist.append(sum(np.min(cdist(student_data_norm, model.cluster_centers_,␣
 ↪'euclidean'), axis=1),student_data_norm.shape[0]))

#Display the data
plt.plot(clusters, meandist, 'bx-')
plt.xlabel('Number of clusters')
plt.ylabel('Average distance')
plt.title('Selecting k with the Elbow Method')
```

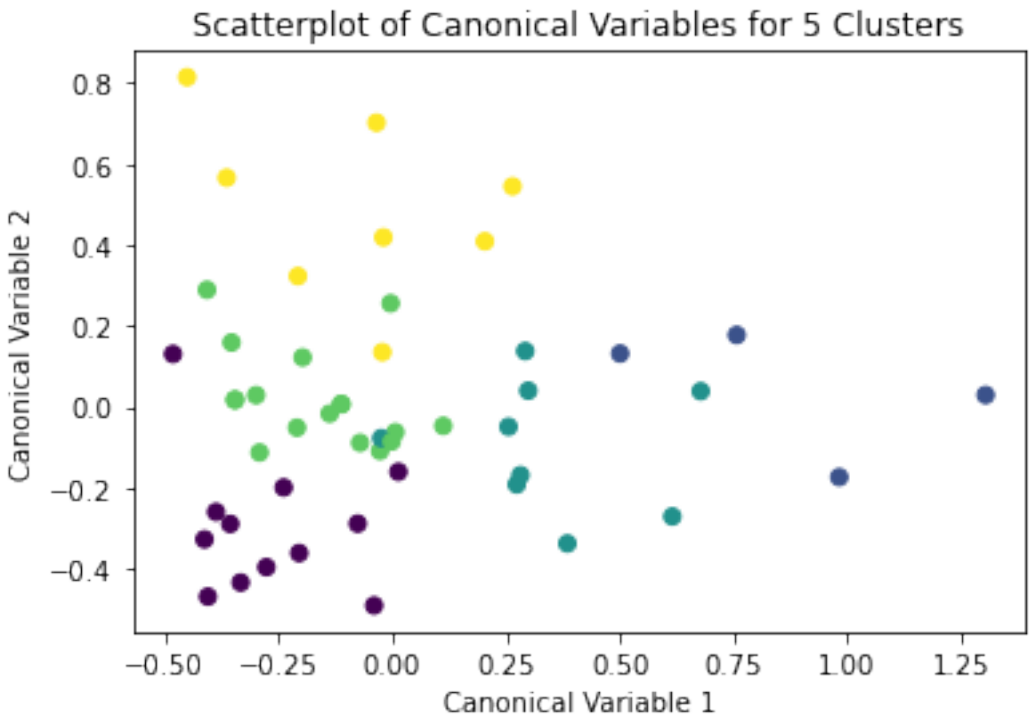
[923]:
```
Text(0.5, 1.0, 'Selecting k with the Elbow Method')
```



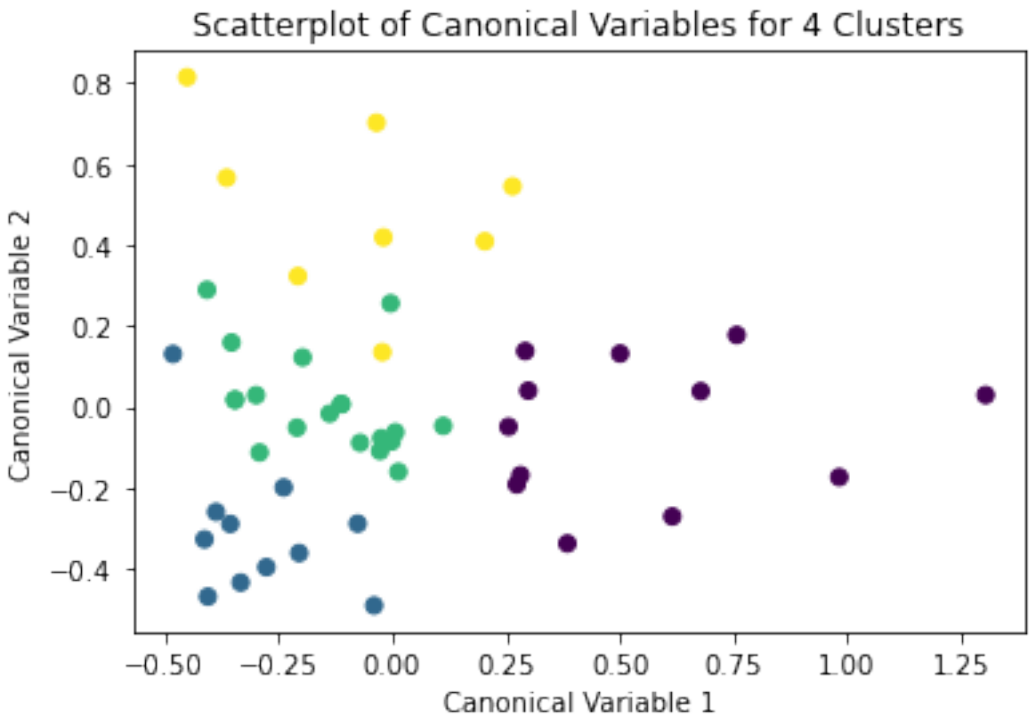
[924]:
```
#Plotting the clusters for KMeans (3)

clusterNum = KMeans(n_clusters = 3)
clusterNum.fit(student_data_norm)
pred = clusterNum.predict(student_data_norm)

pca_2 = PCA(2)
plot_columns = pca_2.fit_transform(student_data_norm)
plt.scatter(x=plot_columns[:,0], y=plot_columns[:,1], c=clusterNum.labels_,)
plt.xlabel('Canonical Variable 1')
plt.ylabel('Canonical Variable 2')
plt.title('Scatterplot of Canonical Variables for 3 Clusters')
plt.show()
```



[925]:
```
#Plotting the clusters for KMeans (5)

clusterNum = KMeans(n_clusters = 5)
clusterNum.fit(student_data_norm)
pred = clusterNum.predict(student_data_norm)

pca_2 = PCA(2)
plot_columns = pca_2.fit_transform(student_data_norm)
plt.scatter(x=plot_columns[:,0], y=plot_columns[:,1], c=clusterNum.labels_,)
plt.xlabel('Canonical Variable 1')
plt.ylabel('Canonical Variable 2')
plt.title('Scatterplot of Canonical Variables for 5 Clusters')
plt.show()
```



[926]:
```
#Plotting the clusters for KMeans (4, most optimal for current dataset)

clusterNum = KMeans(n_clusters = 4)
clusterNum.fit(student_data_norm)
pred = clusterNum.predict(student_data_norm)

pca_2 = PCA(2)
plot_columns = pca_2.fit_transform(student_data_norm)
plt.scatter(x=plot_columns[:,0], y=plot_columns[:,1], c=clusterNum.labels_,)
plt.xlabel('Canonical Variable 1')
plt.ylabel('Canonical Variable 2')
plt.title('Scatterplot of Canonical Variables for 4 Clusters')
plt.show()
```



0.1.4 PART 3: Analysis of the Clusters

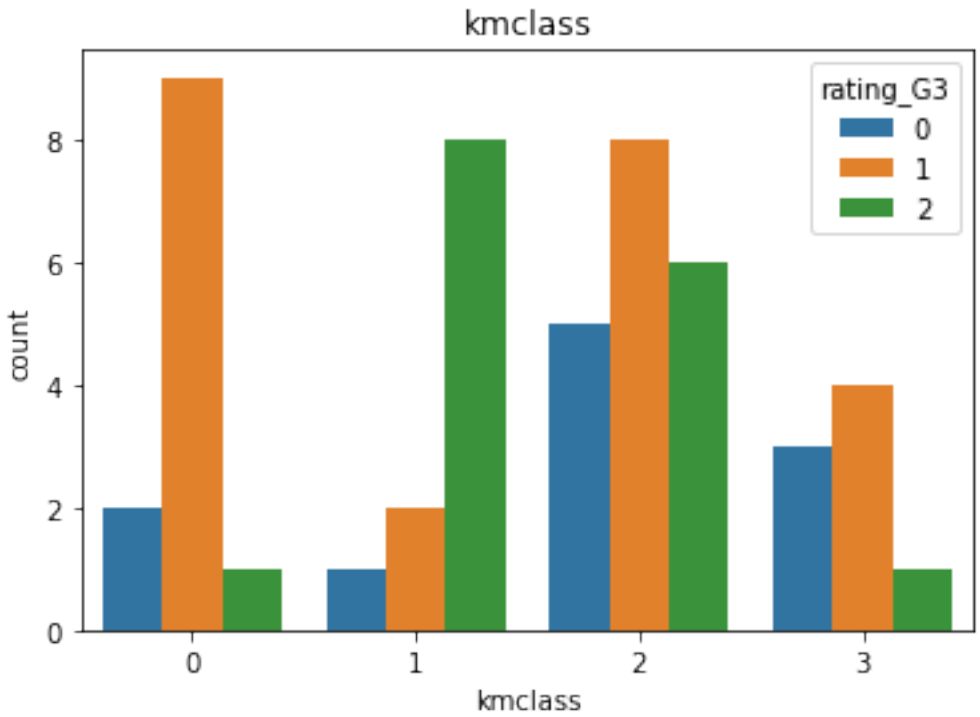
[927]:
```
# Take the classifications made using KMeans and assign them to the correlated␣
 ↪student and add back rating_G3
# to the inital table

int_student = pd.read_csv('216771875-216328387-215122856-T2Org.csv')
int_student.drop('G3', axis=1, inplace=True)
int_student['rating_G3'] = student_target
int_student['kmclass'] = clusterNum.labels_

int_student.to_csv('216771875-216328387-215122856-T2Class.csv')

#=============================================================================================
#=============================================================================================
# Below we are taking our modifed table and adding back rating_G3 and kmclass
# If you wish to view the whole table uncomment the line below
#=============================================================================================
#=============================================================================================
student_data_norm['rating_G3'] = student_target
student_data_norm['kmclass'] = clusterNum.labels_

#student_data_norm.to_csv('216771875-216328387-215122856-T2Class_MODIFIED.csv')
```

```
student_data_norm.head()
```

[927]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences	rating_G3	kmclass
0	0.5	0.333333	0.50	0.75	0.00	0.00	0.24	0	3
1	0.0	0.333333	0.50	0.50	0.00	0.00	0.16	0	2
2	0.0	0.333333	0.50	0.25	0.25	0.50	0.40	1	0
3	0.0	0.666667	0.25	0.25	0.00	0.00	0.08	2	2
4	0.0	0.333333	0.50	0.25	0.00	0.25	0.16	1	2

[928]:
```
#Counting all instances of 0, 1 and 2 from rating_G3 in each of the (4) clusters identified (kmclass)
sns.countplot(x = 'kmclass', hue = 'rating_G3', data = student_data_norm).set(title=str('kmclass'))
plt.show()
```



[929]:
```
#Making a new table with data classifed as 0, and describing it
student_data_A = student_data_norm[student_data_norm.kmclass==0]
student_data_A.describe()
```

[929]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences	kmclass
count	12.000000	12.000000	12.000000	12.000000	12.000000	12.000000	12.000000	12.0
mean	0.041667	0.138889	0.562500	0.625000	0.229167	0.645833	0.300000	0.0
std	0.144338	0.171643	0.284545	0.291937	0.291125	0.198240	0.239089	0.0
min	0.000000	0.000000	0.000000	0.250000	0.000000	0.250000	0.000000	0.0
25%	0.000000	0.000000	0.437500	0.437500	0.000000	0.500000	0.140000	0.0
50%	0.000000	0.000000	0.625000	0.625000	0.250000	0.750000	0.240000	0.0
75%	0.000000	0.333333	0.750000	0.812500	0.250000	0.750000	0.500000	0.0
max	0.500000	0.333333	1.000000	1.000000	1.000000	1.000000	0.640000	0.0

[930]:
```
#Making a new table with data classifed as 1, and describing it
student_data_B = student_data_norm[student_data_norm.kmclass==1]
student_data_B.describe()
```

[930]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences	kmclass
count	11.000000	11.000000	11.000000	11.000000	11.0	11.000000	11.000000	11.0
mean	0.090909	0.212121	0.818182	0.113636	0.0	0.045455	0.036364	1.0
std	0.202260	0.224733	0.196561	0.171888	0.0	0.150756	0.097085	0.0
min	0.000000	0.000000	0.500000	0.000000	0.0	0.000000	0.000000	1.0
25%	0.000000	0.000000	0.750000	0.000000	0.0	0.000000	0.000000	1.0
50%	0.000000	0.333333	0.750000	0.000000	0.0	0.000000	0.000000	1.0
75%	0.000000	0.333333	1.000000	0.250000	0.0	0.000000	0.000000	1.0
max	0.500000	0.666667	1.000000	0.500000	0.0	0.500000	0.320000	1.0

[931]:
```
#Making a new table with data classifed as 2, and describing it
student_data_C = student_data_norm[student_data_norm.kmclass==2]
student_data_C.describe()
```

[931]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences	kmclass
count	19.0	19.000000	19.000000	19.000000	19.000000	19.000000	19.000000	19.0
mean	0.0	0.438596	0.473684	0.394737	0.013158	0.078947	0.117895	2.0
std	0.0	0.223679	0.184367	0.173121	0.057354	0.119392	0.107888	0.0
min	0.0	0.000000	0.250000	0.250000	0.000000	0.000000	0.000000	2.0
25%	0.0	0.333333	0.250000	0.250000	0.000000	0.000000	0.080000	2.0
50%	0.0	0.333333	0.500000	0.250000	0.000000	0.000000	0.080000	2.0
75%	0.0	0.666667	0.500000	0.500000	0.000000	0.250000	0.160000	2.0
max	0.0	1.000000	0.750000	0.750000	0.250000	0.250000	0.400000	2.0

[932]:
```
#Making a new table with data classifed as 3, and describing it
student_data_D = student_data_norm[student_data_norm.kmclass==3]
student_data_D.describe()
```

[932]:

	traveltime	studytime	freetime	goout	Dalc	Walc	absences	kmclass
count	8.000000	8.000000	8.000000	8.000000	8.000000	8.000000	8.000000	8.0
mean	0.625000	0.416667	0.468750	0.500000	0.031250	0.093750	0.340000	3.0
std	0.231455	0.154303	0.247758	0.188982	0.088388	0.129387	0.302372	0.0
min	0.500000	0.333333	0.000000	0.250000	0.000000	0.000000	0.080000	3.0
25%	0.500000	0.333333	0.437500	0.437500	0.000000	0.000000	0.160000	3.0
50%	0.500000	0.333333	0.500000	0.500000	0.000000	0.000000	0.240000	3.0
75%	0.625000	0.416667	0.562500	0.562500	0.000000	0.250000	0.350000	3.0
max	1.000000	0.666667	0.750000	0.750000	0.250000	0.250000	1.000000	3.0