k-means-and-k-medoids-5

September 29, 2023

1 K-means and K-medoids

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2 introdução

Aplicaremos os método de K-means e K-medoids para classificar universidades como públicas ou privadas.

3 Bibliotecas e Dataframe

primeiramente importamos as bibliotecas usadas

[498]:
```
!pip install scikit-learn-extra

import pandas as pd
import seaborn as sns
import numpy as np
from scipy import stats
import matplotlib.pyplot as plt

from sklearn.metrics import pairwise_distances
from sklearn.metrics import classification_report
from sklearn.cluster import KMeans
from sklearn_extra.cluster import KMedoids
from sklearn import preprocessing
import sklearn.cluster as cluster
import sklearn.metrics as metrics
from sklearn.preprocessing import MinMaxScaler
from matplotlib import pyplot as plt
%matplotlib inline
```

```
Requirement already satisfied: scikit-learn-extra in
/usr/local/lib/python3.10/dist-packages (0.3.0)
Requirement already satisfied: numpy>=1.13.3 in /usr/local/lib/python3.10/dist-
packages (from scikit-learn-extra) (1.23.5)
Requirement already satisfied: scipy>=0.19.1 in /usr/local/lib/python3.10/dist-
packages (from scikit-learn-extra) (1.11.2)
```

```
Requirement already satisfied: scikit-learn>=0.23.0 in
/usr/local/lib/python3.10/dist-packages (from scikit-learn-extra) (1.2.2)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-
packages (from scikit-learn>=0.23.0->scikit-learn-extra) (1.3.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from scikit-learn>=0.23.0->scikit-
learn-extra) (3.2.0)
```

E carregamos nossa base de dados

[499]:
```
df = pd.read_csv('https://raw.githubusercontent.com/gabriel-ferreira-da-silva/
  ↪K-mean/main/dados/College.csv')
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 777 entries, 0 to 776
Data columns (total 19 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   Unnamed: 0   777 non-null    object
 1   Private      777 non-null    object
 2   Apps         777 non-null    int64
 3   Accept       777 non-null    int64
 4   Enroll       777 non-null    int64
 5   Top10perc    777 non-null    int64
 6   Top25perc    777 non-null    int64
 7   F.Undergrad  777 non-null    int64
 8   P.Undergrad  777 non-null    int64
 9   Outstate     777 non-null    int64
 10  Room.Board   777 non-null    int64
 11  Books        777 non-null    int64
 12  Personal     777 non-null    int64
 13  PhD          777 non-null    int64
 14  Terminal     777 non-null    int64
 15  S.F.Ratio    777 non-null    float64
 16  perc.alumni  777 non-null    int64
 17  Expend       777 non-null    int64
 18  Grad.Rate    777 non-null    int64
dtypes: float64(1), int64(16), object(2)
memory usage: 115.5+ KB
```

[500]:
```
df.describe()
```

[500]:

	Apps	Accept	Enroll	Top10perc	Top25perc	\
count	777.000000	777.000000	777.000000	777.000000	777.000000	
mean	3001.638353	2018.804376	779.972973	27.558559	55.796654	
std	3870.201484	2451.113971	929.176190	17.640364	19.804778	
min	81.000000	72.000000	35.000000	1.000000	9.000000	

```
25%      776.000000    604.000000   242.000000   15.000000   41.000000
50%     1558.000000   1110.000000   434.000000   23.000000   54.000000
75%     3624.000000   2424.000000   902.000000   35.000000   69.000000
max    48094.000000  26330.000000  6392.000000   96.000000  100.000000

        F.Undergrad   P.Undergrad      Outstate   Room.Board        Books  \
count    777.000000    777.000000    777.000000   777.000000   777.000000
mean    3699.907336    855.298584  10440.669241  4357.526384   549.380952
std     4850.420531   1522.431887   4023.016484  1096.696416   165.105360
min      139.000000      1.000000   2340.000000  1780.000000    96.000000
25%      992.000000     95.000000   7320.000000  3597.000000   470.000000
50%     1707.000000    353.000000   9990.000000  4200.000000   500.000000
75%     4005.000000    967.000000  12925.000000  5050.000000   600.000000
max    31643.000000  21836.000000  21700.000000  8124.000000  2340.000000

          Personal         PhD    Terminal   S.F.Ratio  perc.alumni  \
count   777.000000  777.000000  777.000000  777.000000   777.000000
mean   1340.642214   72.660232   79.702703   14.089704    22.743887
std     677.071454   16.328155   14.722359    3.958349    12.391801
min     250.000000    8.000000   24.000000    2.500000     0.000000
25%     850.000000   62.000000   71.000000   11.500000    13.000000
50%    1200.000000   75.000000   82.000000   13.600000    21.000000
75%    1700.000000   85.000000   92.000000   16.500000    31.000000
max    6800.000000  103.000000  100.000000   39.800000    64.000000

              Expend  Grad.Rate
count    777.000000  777.00000
mean    9660.171171   65.46332
std     5221.768440   17.17771
min     3186.000000   10.00000
25%     6751.000000   53.00000
50%     8377.000000   65.00000
75%    10830.000000   78.00000
max    56233.000000  118.00000
```

precimos converter o paramêtro Private de object para inteiro.

[501]:
```
Private = []
for p in df['Private']:
  if p == 'Yes':
    Private.append(1)
  else:
    Private.append(0)
```

[502]:
```
p = pd.DataFrame(Private, columns=['Private'])
df = df.drop('Private', axis = 1)
df = df.drop('Unnamed: 0', axis = 1)
```

```
df['Private'] = Private
df.describe()
```

[502]:

	Apps	Accept	Enroll	Top10perc	Top25perc
count	777.000000	777.000000	777.000000	777.000000	777.000000
mean	3001.638353	2018.804376	779.972973	27.558559	55.796654
std	3870.201484	2451.113971	929.176190	17.640364	19.804778
min	81.000000	72.000000	35.000000	1.000000	9.000000
25%	776.000000	604.000000	242.000000	15.000000	41.000000
50%	1558.000000	1110.000000	434.000000	23.000000	54.000000
75%	3624.000000	2424.000000	902.000000	35.000000	69.000000
max	48094.000000	26330.000000	6392.000000	96.000000	100.000000

	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books
count	777.000000	777.000000	777.000000	777.000000	777.000000
mean	3699.907336	855.298584	10440.669241	4357.526384	549.380952
std	4850.420531	1522.431887	4023.016484	1096.696416	165.105360
min	139.000000	1.000000	2340.000000	1780.000000	96.000000
25%	992.000000	95.000000	7320.000000	3597.000000	470.000000
50%	1707.000000	353.000000	9990.000000	4200.000000	500.000000
75%	4005.000000	967.000000	12925.000000	5050.000000	600.000000
max	31643.000000	21836.000000	21700.000000	8124.000000	2340.000000

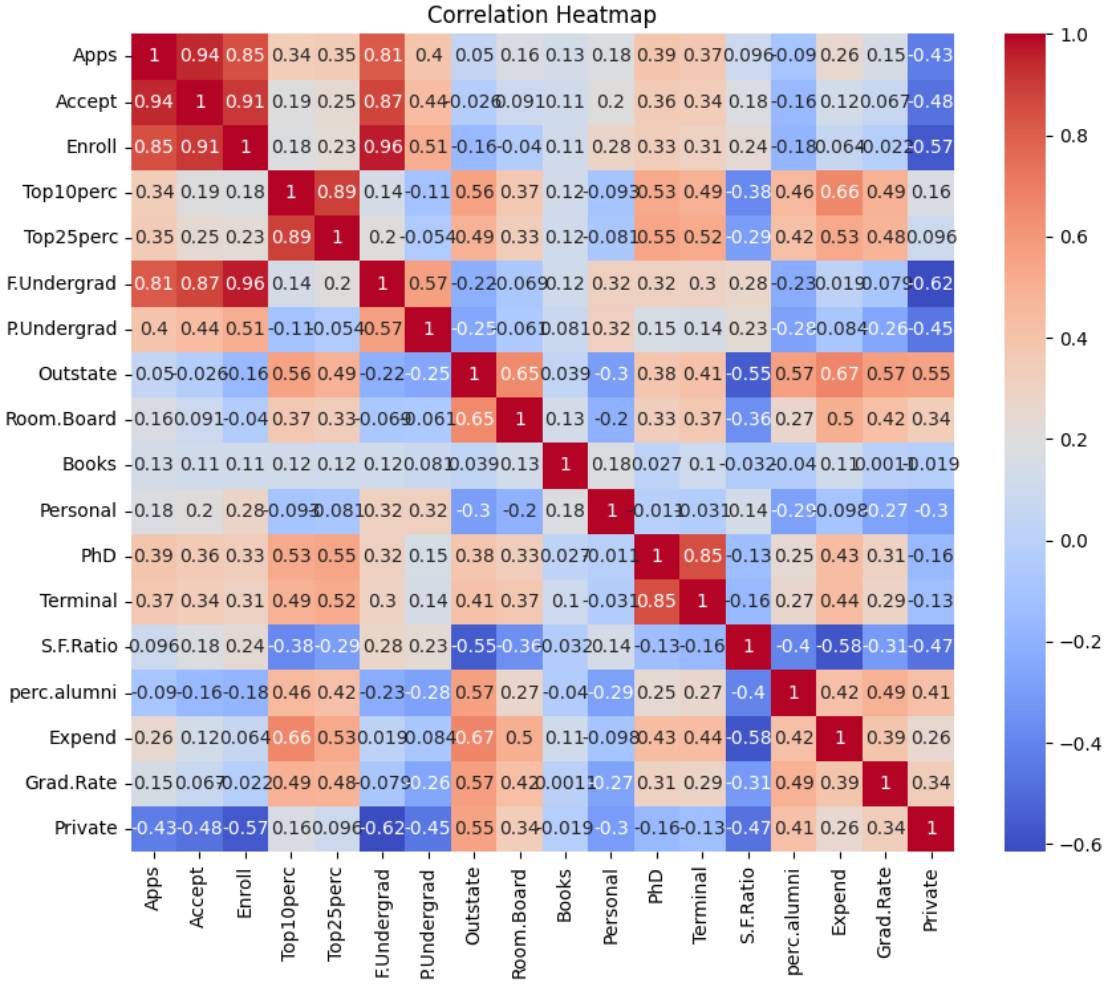
	Personal	PhD	Terminal	S.F.Ratio	perc.alumni
count	777.000000	777.000000	777.000000	777.000000	777.000000
mean	1340.642214	72.660232	79.702703	14.089704	22.743887
std	677.071454	16.328155	14.722359	3.958349	12.391801
min	250.000000	8.000000	24.000000	2.500000	0.000000
25%	850.000000	62.000000	71.000000	11.500000	13.000000
50%	1200.000000	75.000000	82.000000	13.600000	21.000000
75%	1700.000000	85.000000	92.000000	16.500000	31.000000
max	6800.000000	103.000000	100.000000	39.800000	64.000000

	Expend	Grad.Rate	Private
count	777.000000	777.00000	777.000000
mean	9660.171171	65.46332	0.727156
std	5221.768440	17.17771	0.445708
min	3186.000000	10.00000	0.000000
25%	6751.000000	53.00000	0.000000
50%	8377.000000	65.00000	1.000000
75%	10830.000000	78.00000	1.000000
max	56233.000000	118.00000	1.000000

4 Análise dos Dados

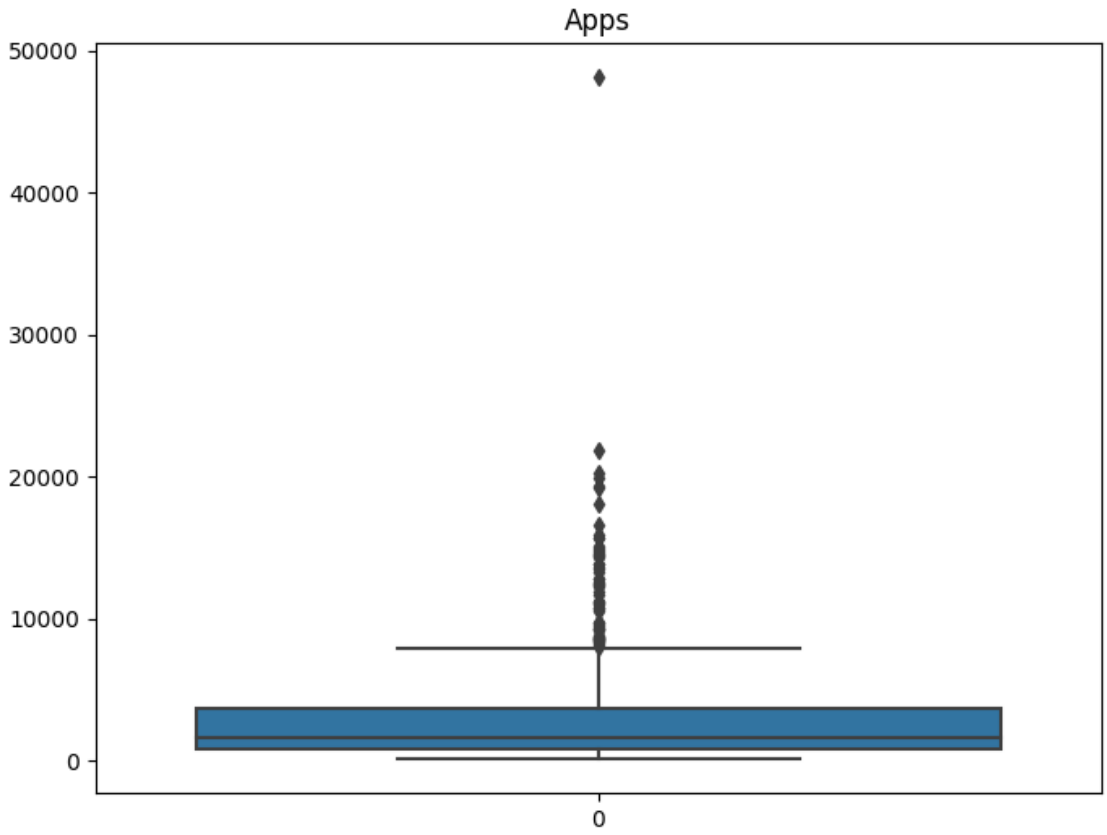
abaixo está o mapa de correlação dos dados

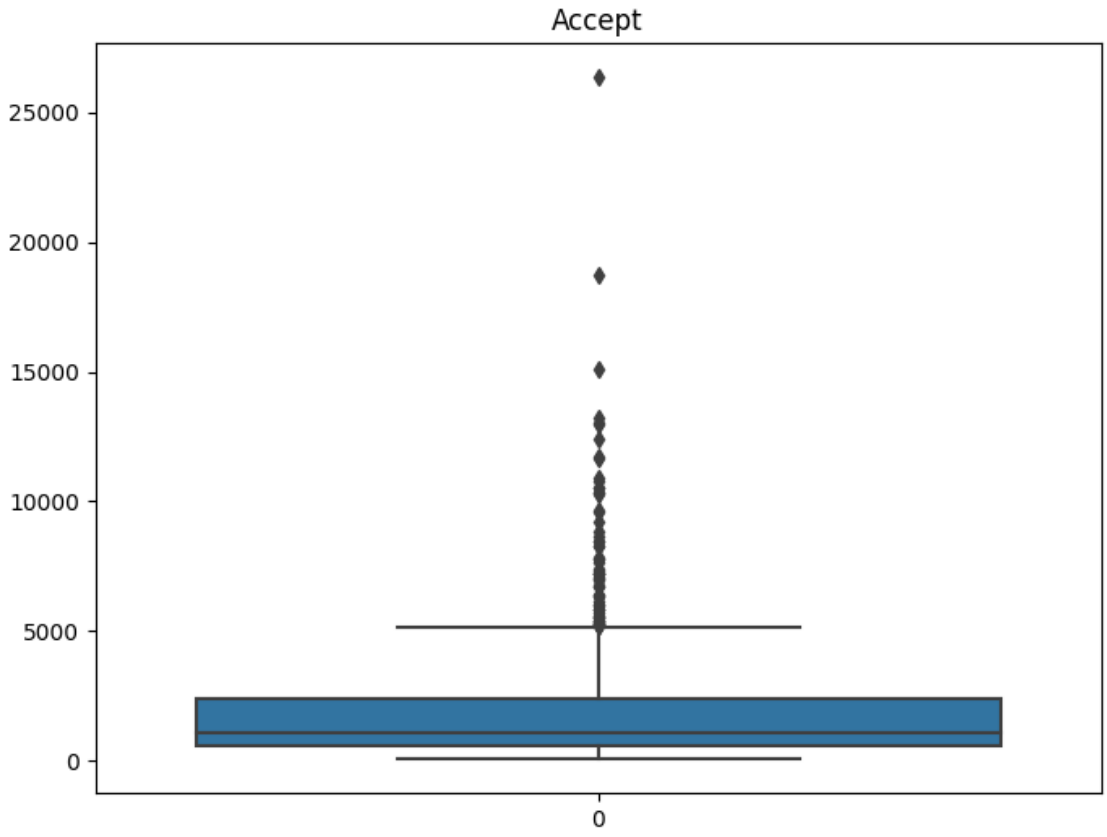
[503]:
```
correlation_matrix = df.corr()
plt.figure(figsize=(10, 8))  # Set the figure size (optional)
sns.heatmap(correlation_matrix, annot=True, cmap="coolwarm")
plt.title("Correlation Heatmap")
plt.show()
```

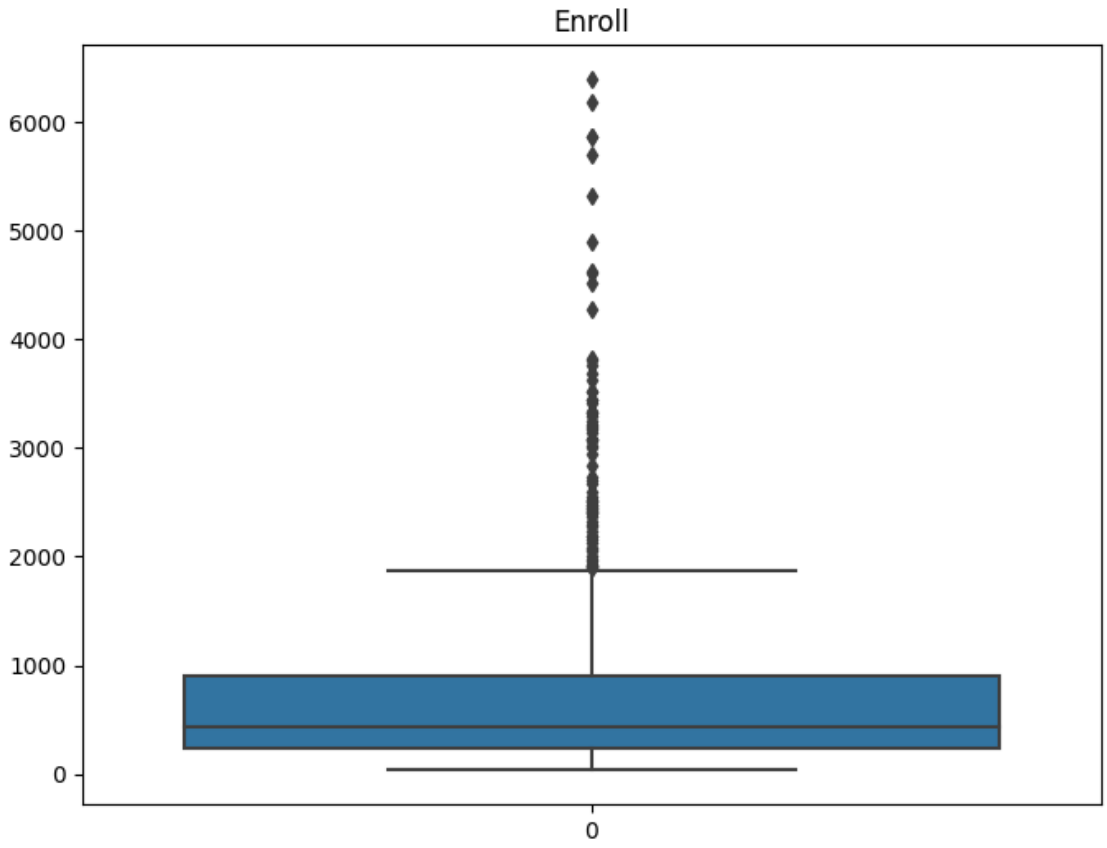


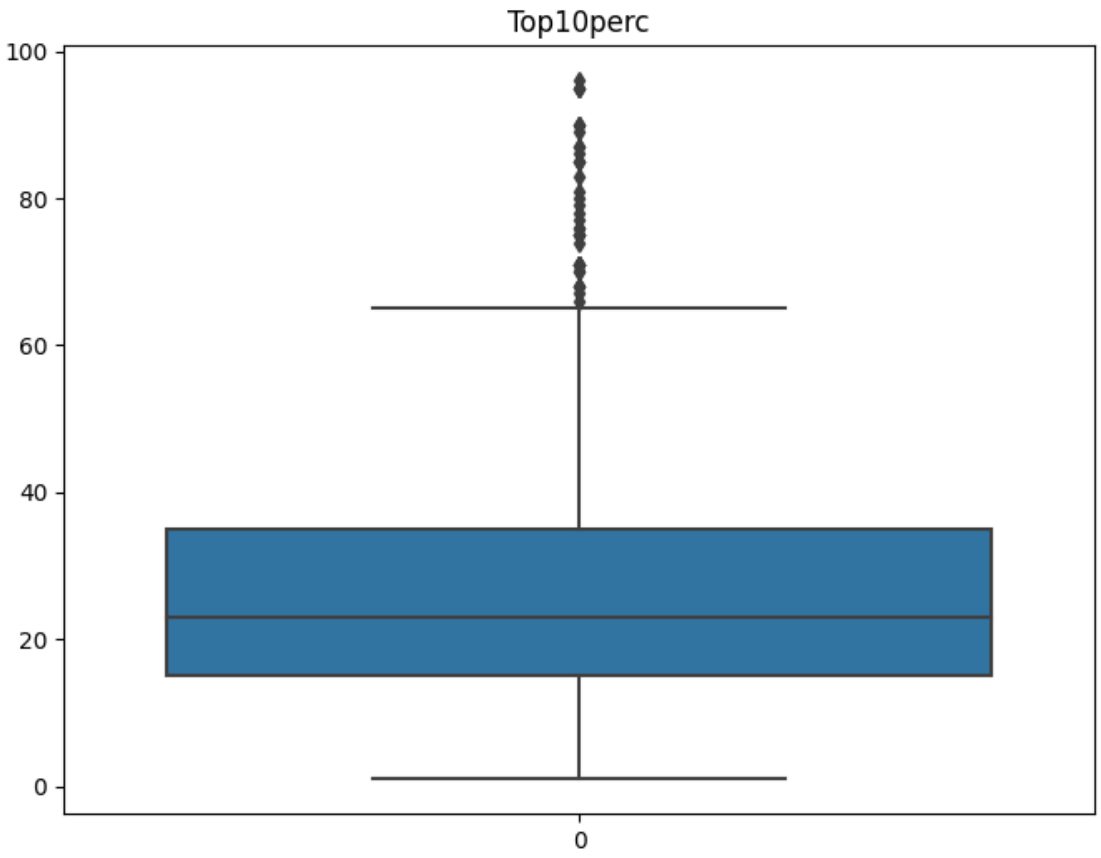
tambem analisaremos box-plots

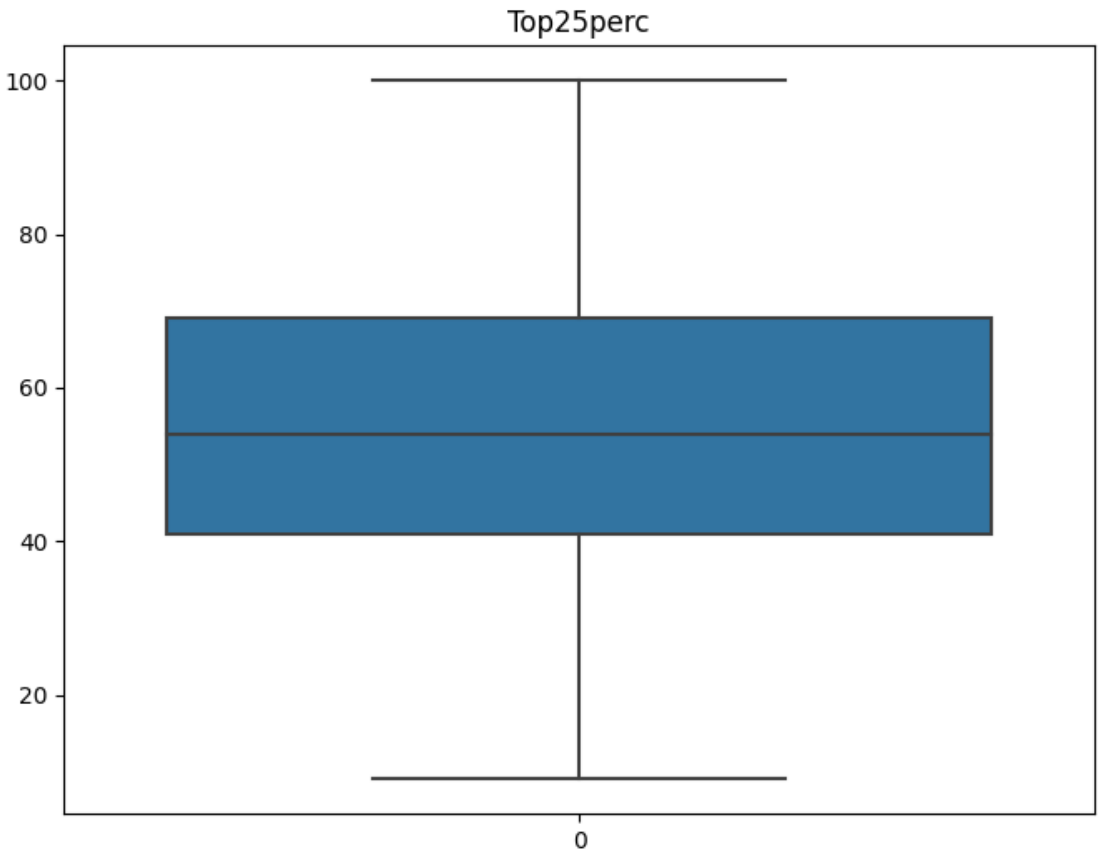
[504]:
```
for i in range(0, 18 ):
  plt.figure(figsize=(8, 6))  # Set the figure size (optional)
  sns.boxplot( data=df[df.columns[i]])
  plt.title(df.columns[i])
  plt.show()
```

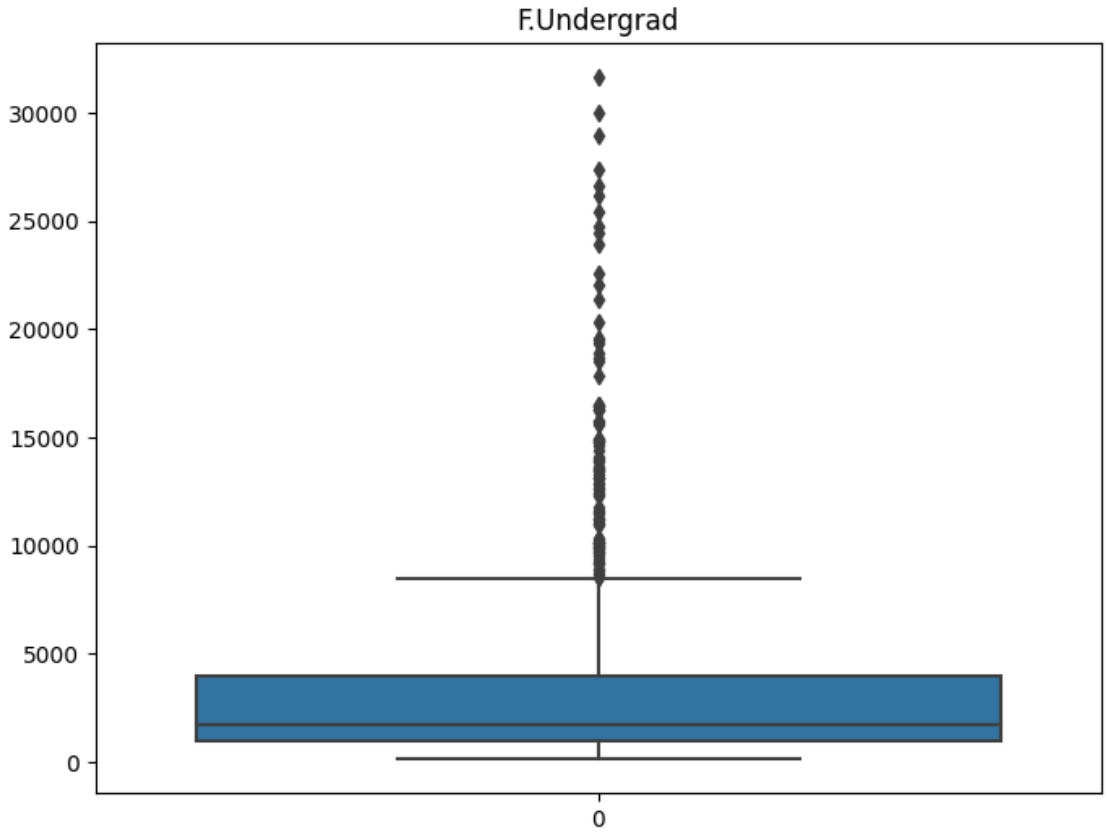

Apps
50000
40000
30000
20000
10000
0
0

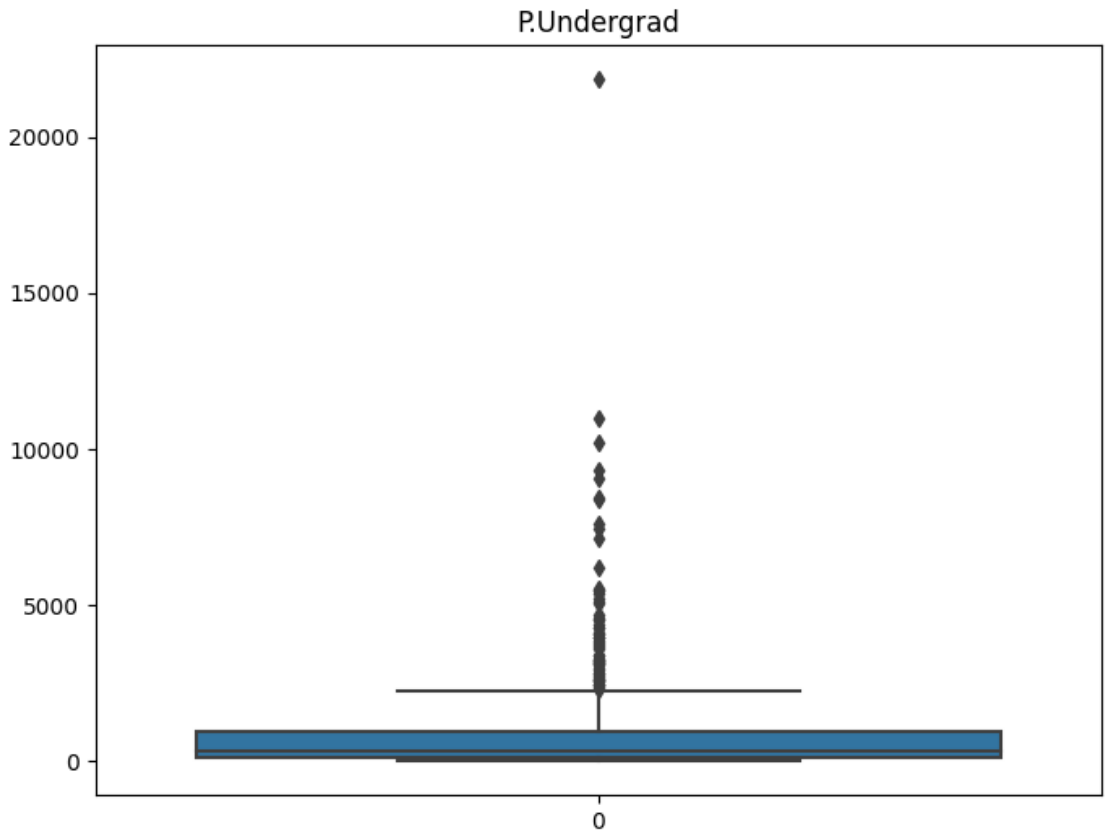

Accept
25000
20000
15000
10000
5000
0
0

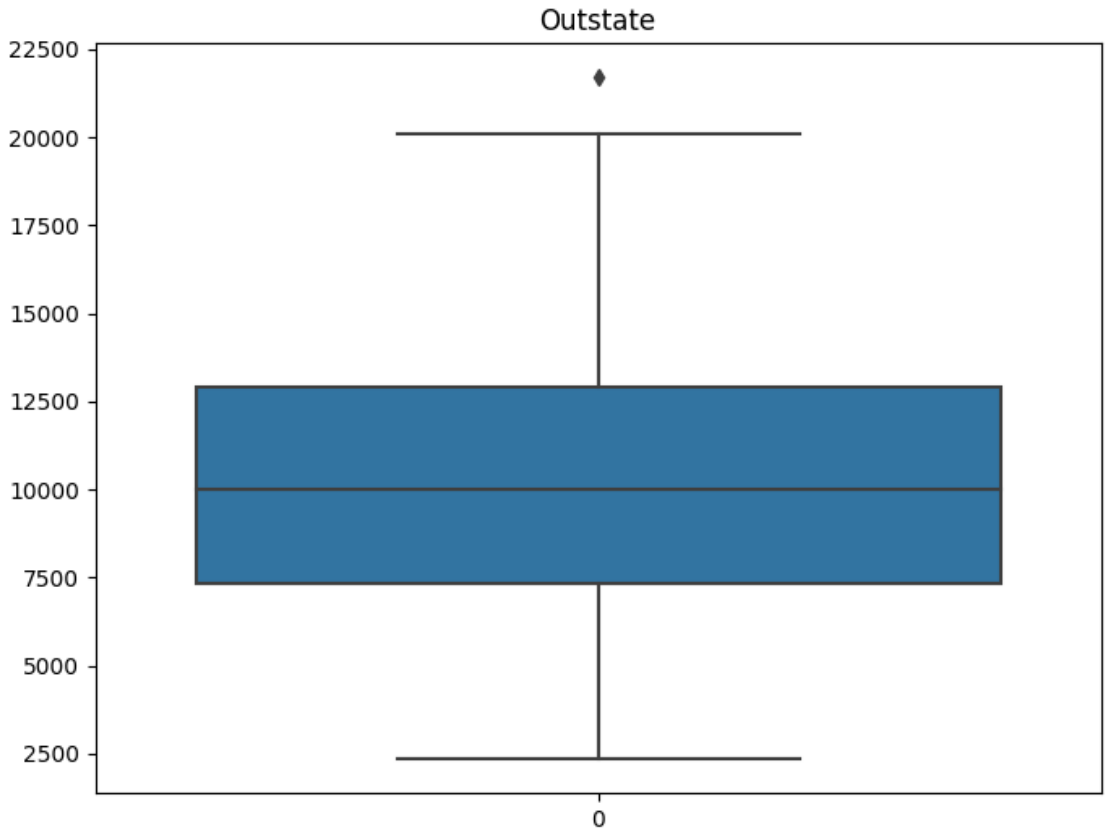

Enroll
6000
5000
4000
3000
2000
1000
0
0

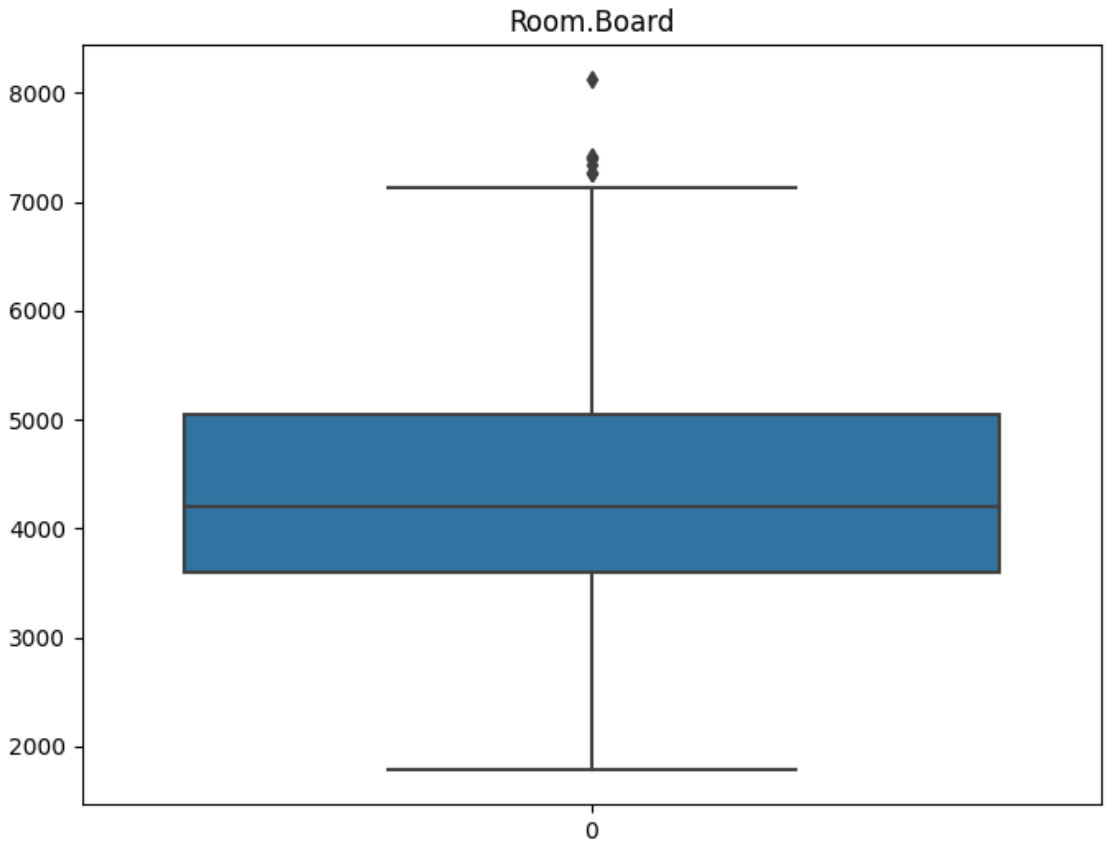

Top10perc
100
80
60
40
20
0
0

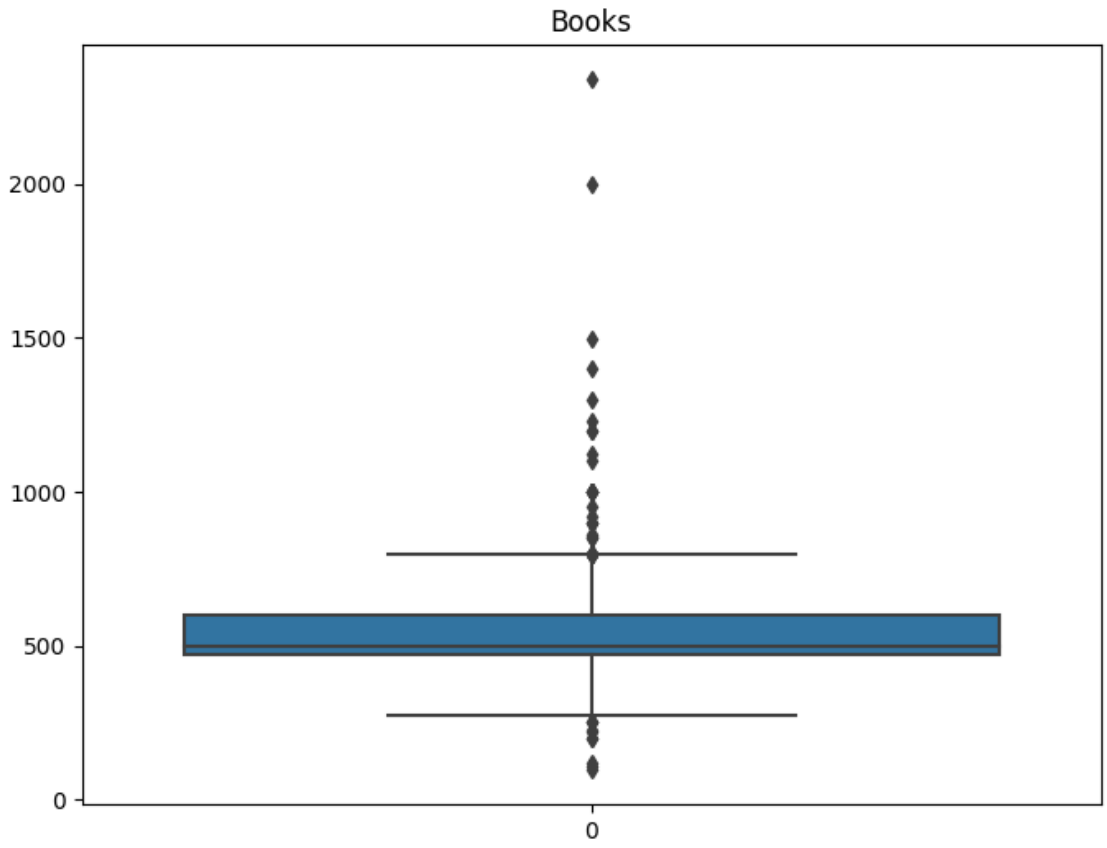

Top25perc
100
80
60
40
20
0

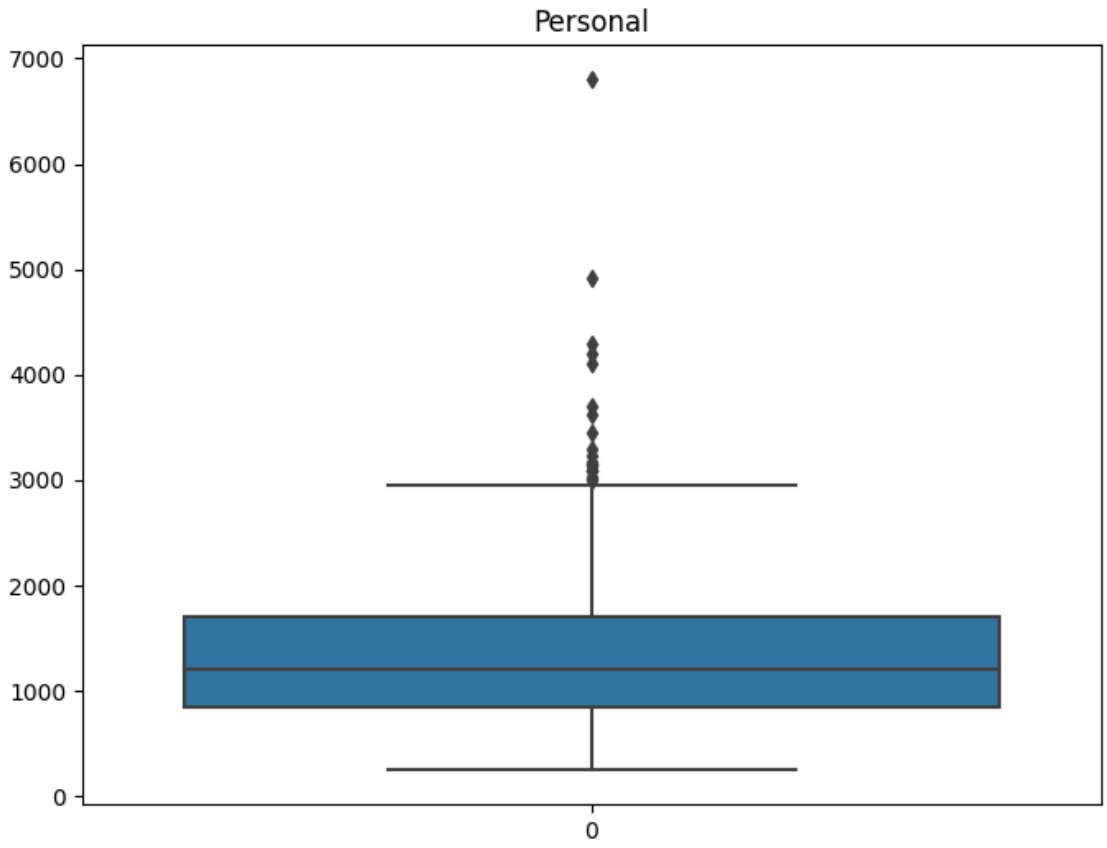

F.Undergrad
30000
25000
20000
15000
10000
5000
0
0


P.Undergrad
20000
15000
10000
5000
0
0


Outstate
22500
20000
17500
15000
12500
10000
7500
5000
2500
0


Room.Board
8000
7000
6000
5000
4000
3000
2000
0


Books
2000
1500
1000
500
0
0


Personal
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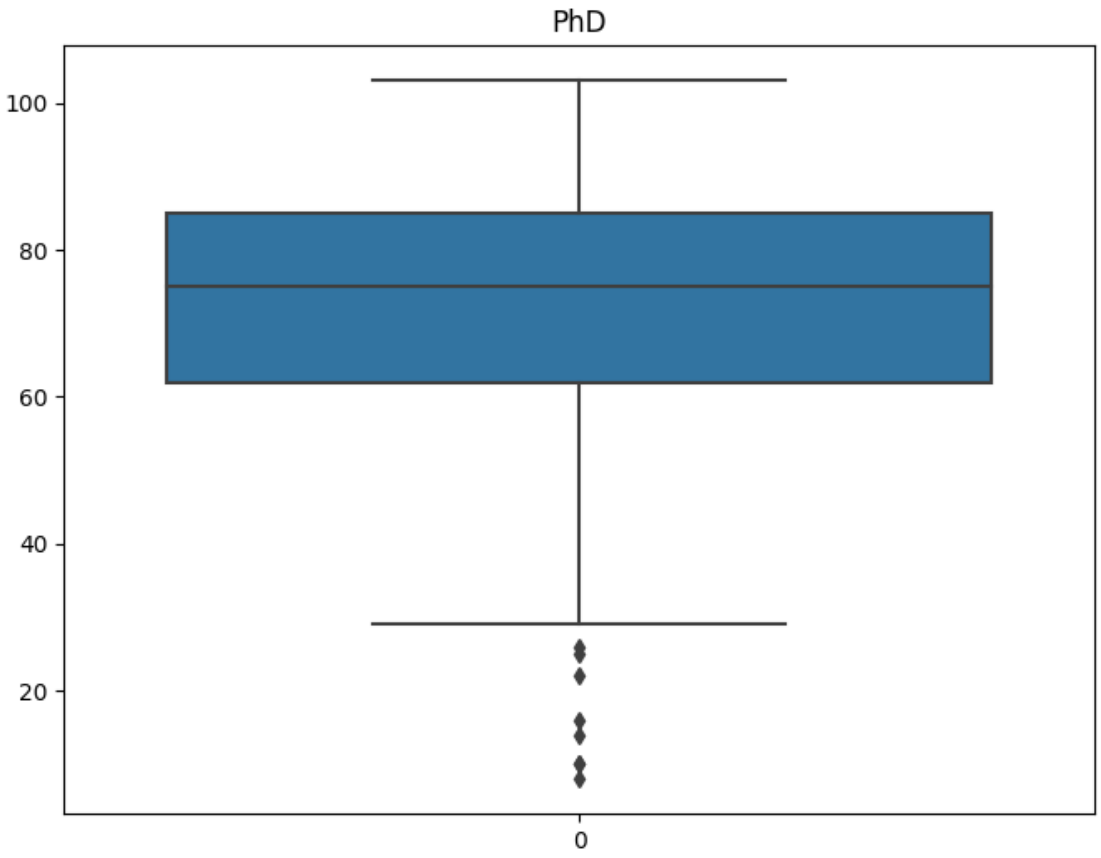
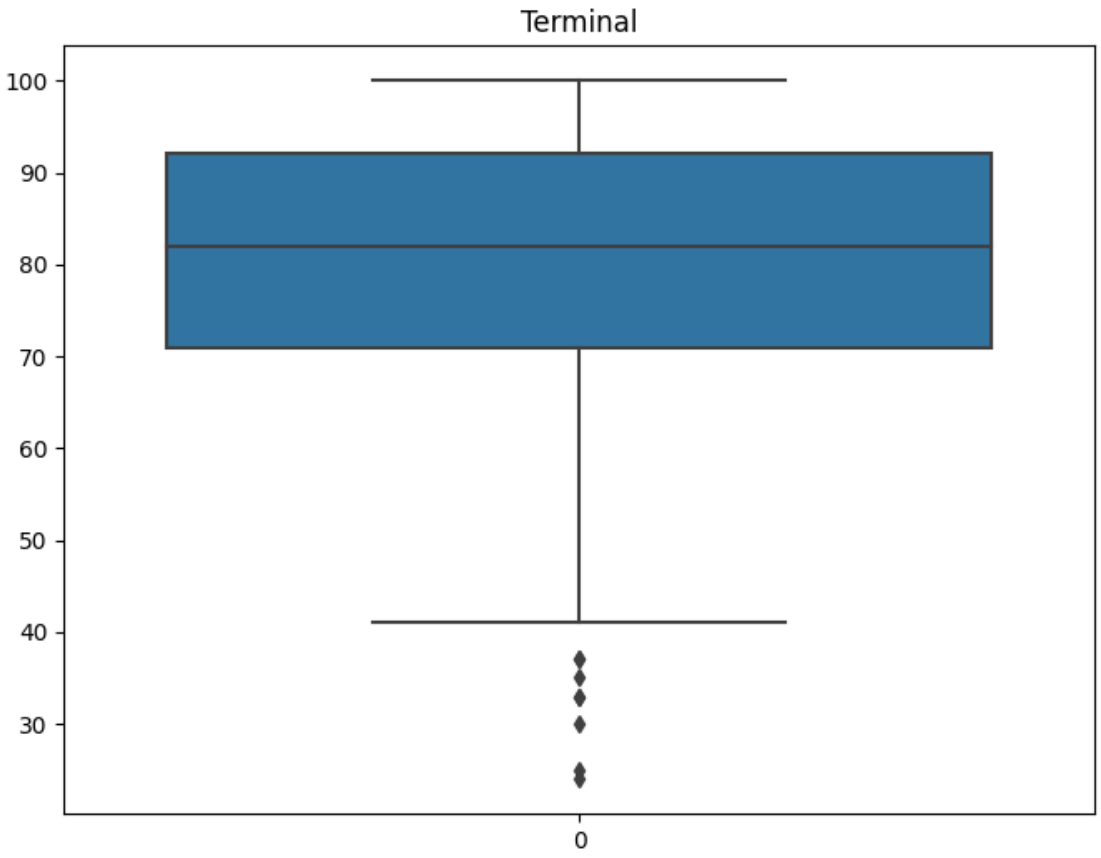
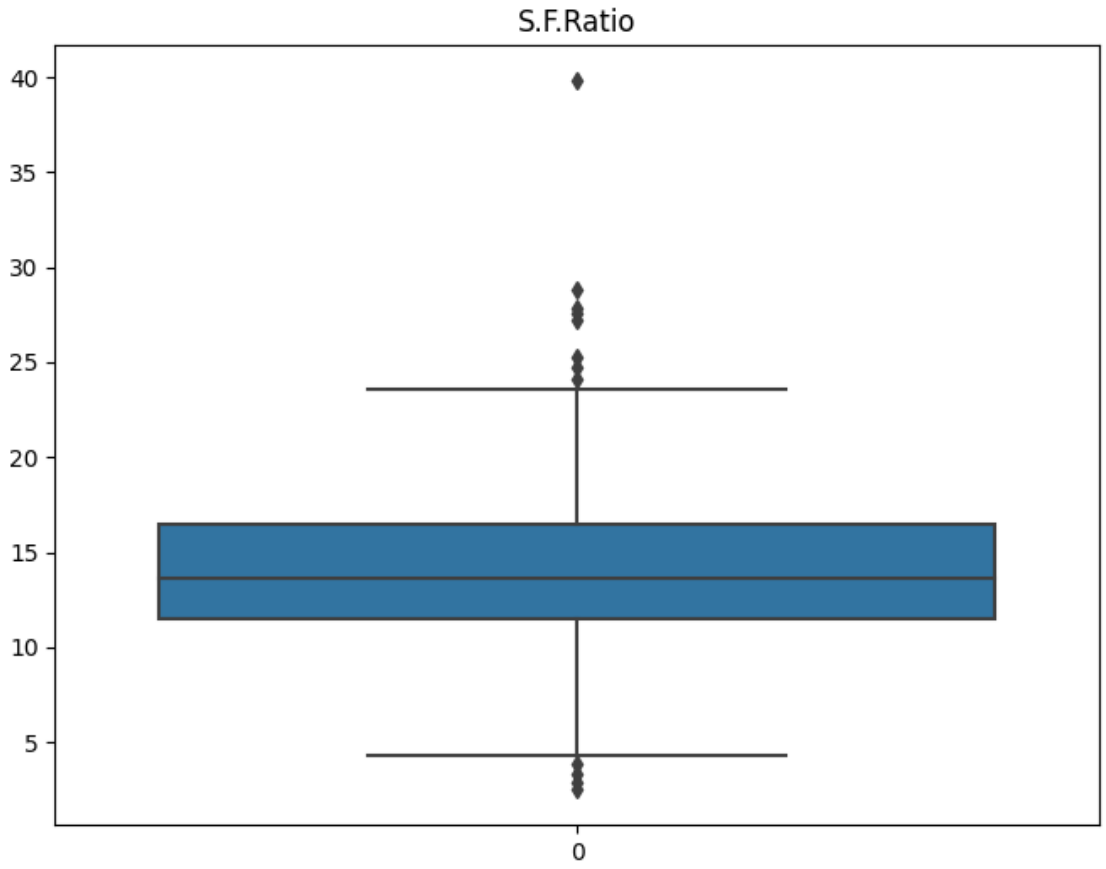
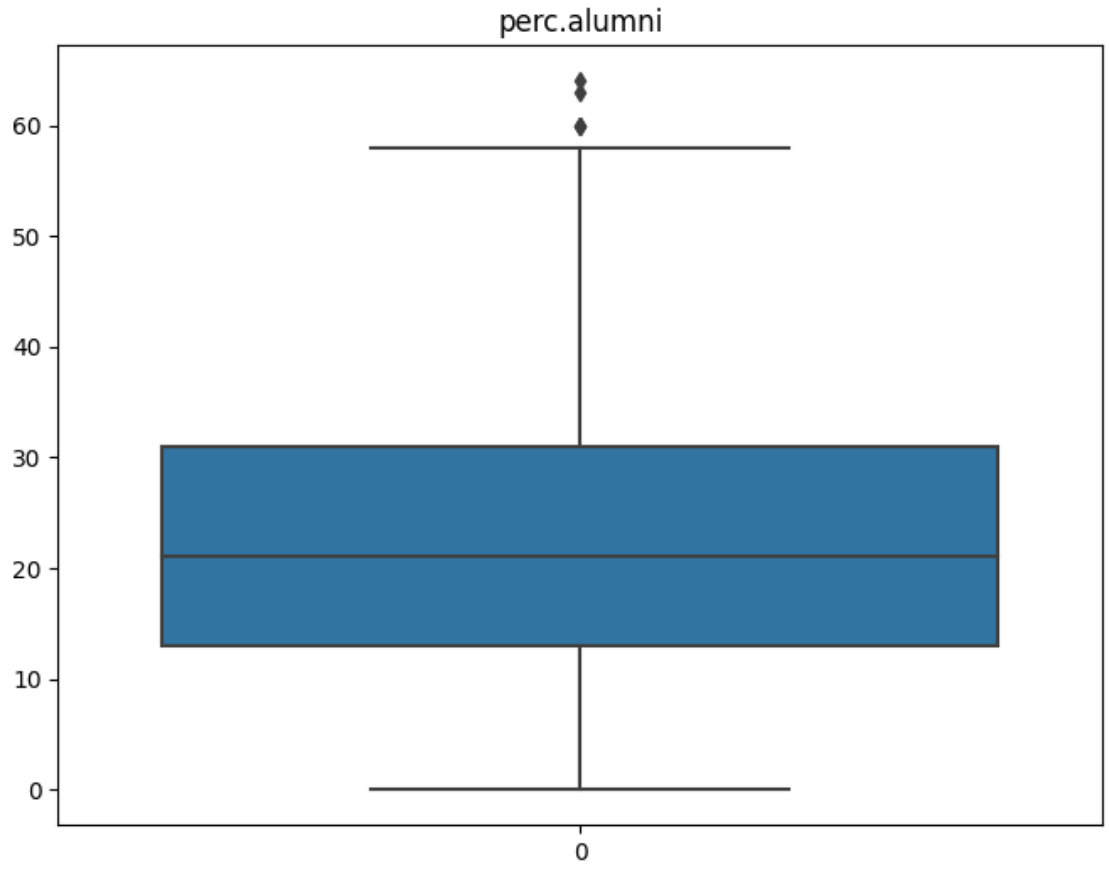
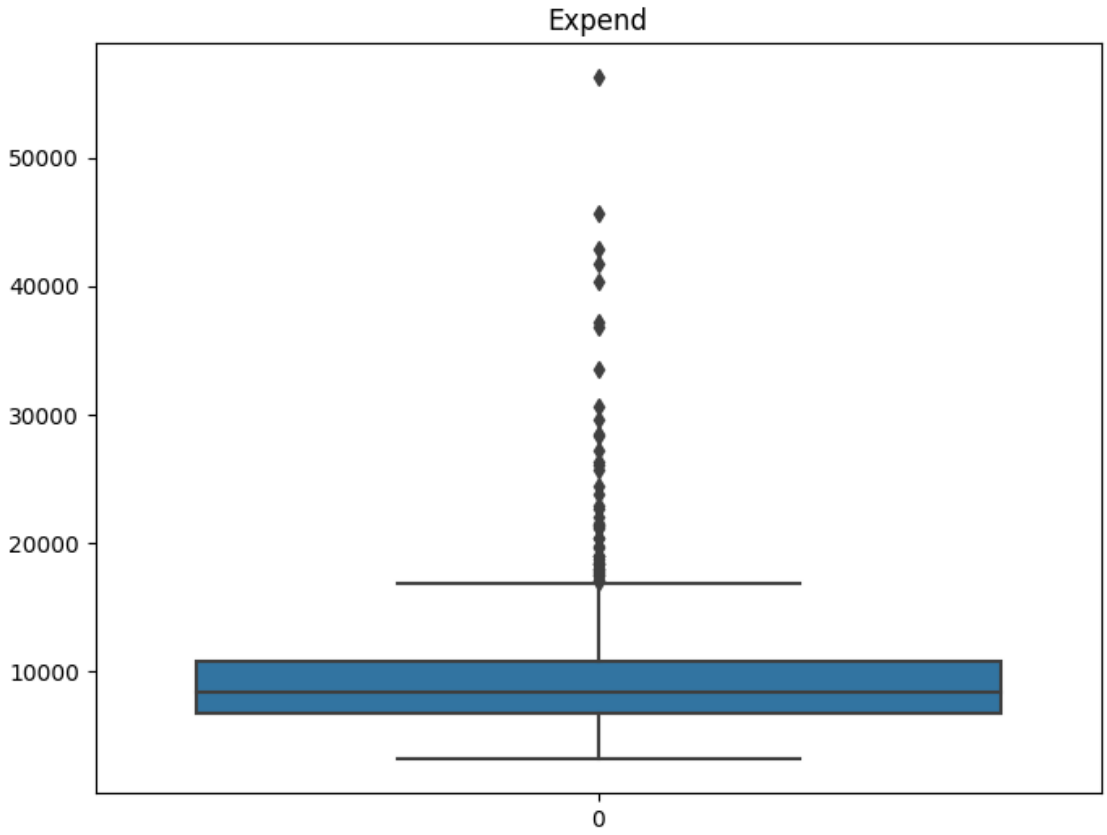
6000
5000
4000
3000
2000
1000
0
0

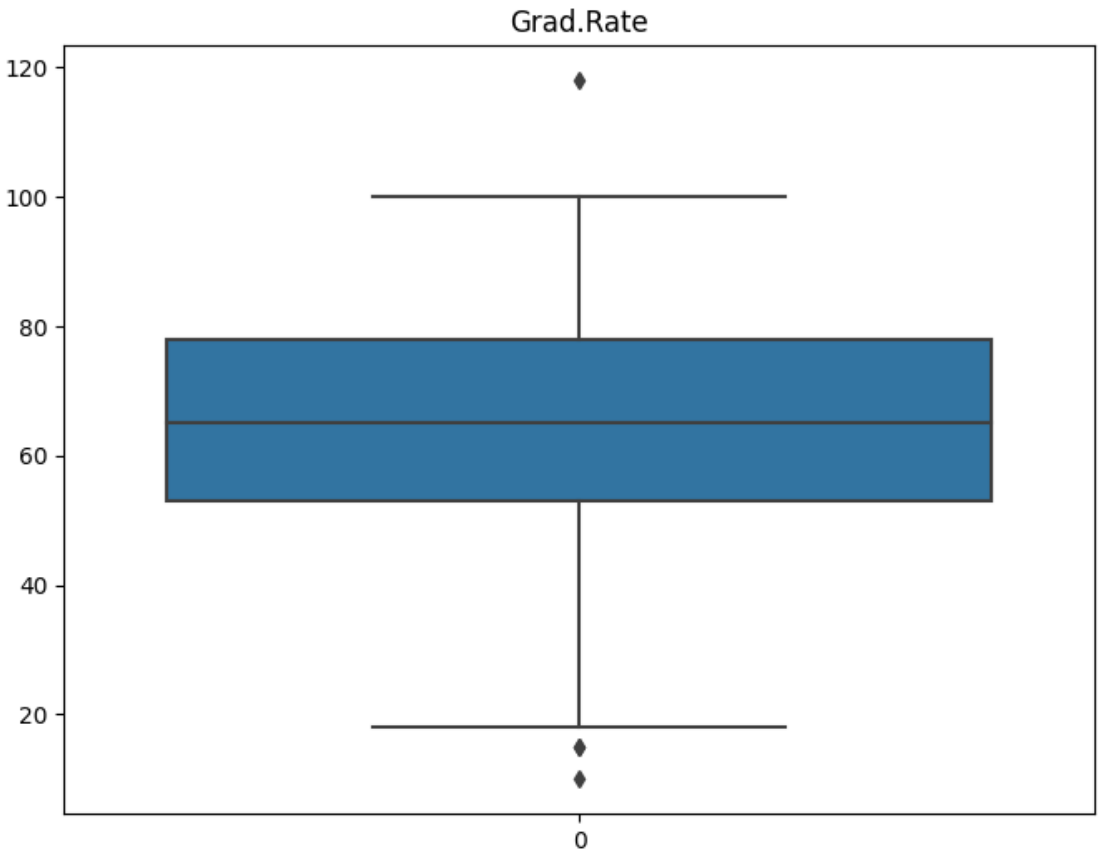

PhD
100
80
60
40
20
0

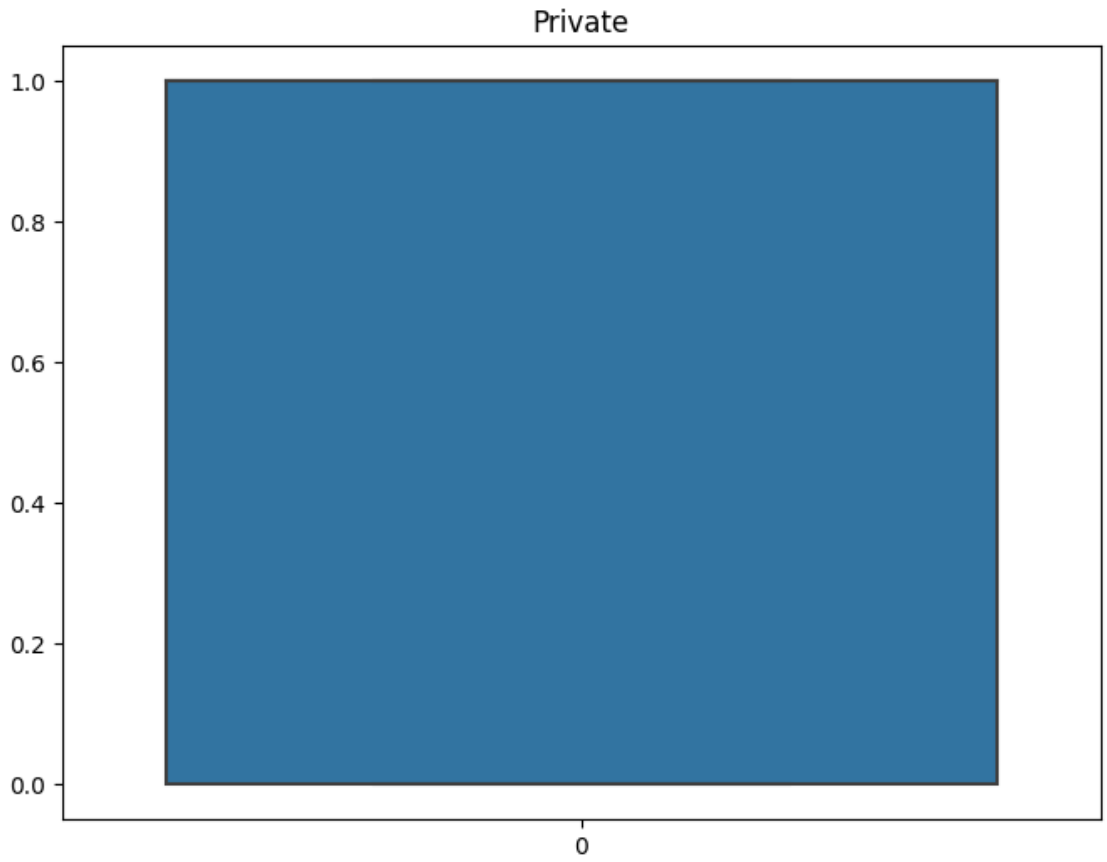

Terminal
100
90
80
70
60
50
40
30
0


S.F.Ratio
40
35
30
25
20
15
10
5
0


perc.alumni
60
50
40
30
20
10
0
0


Expend
50000
40000
30000
20000
10000
0


Grad.Rate
120
100
80
60
40
20
0

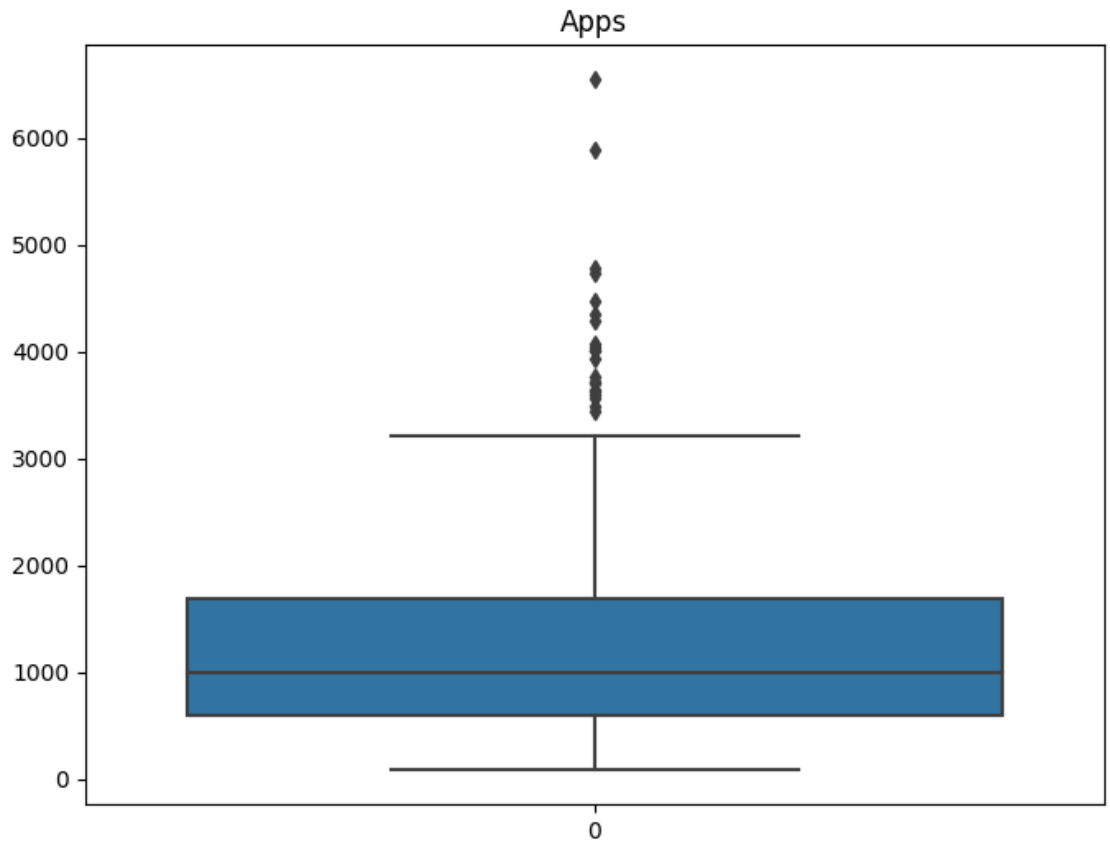


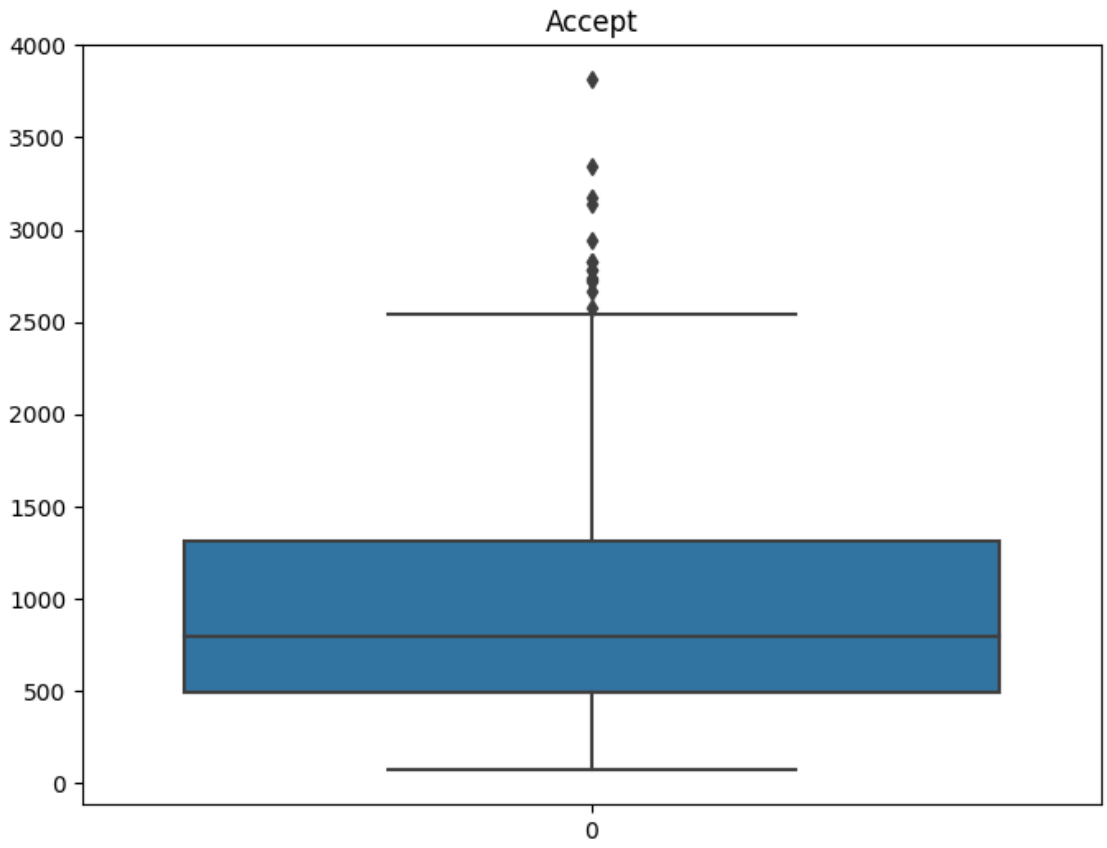
vamos remover os outliers e checar os outliers e correlação com o dataframe limpo.

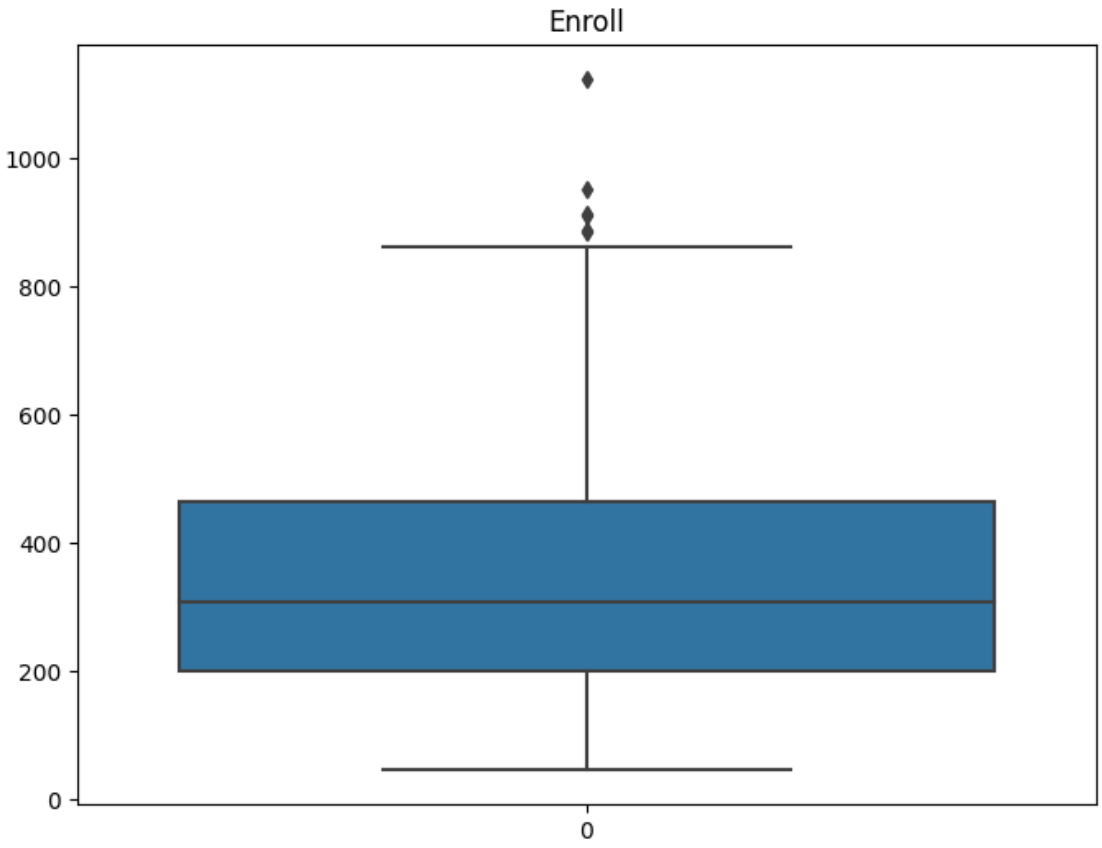
[505]:
```
def remove_outliers_iqr(df, column_name):
    Q1 = df[column_name].quantile(0.25)
    Q3 = df[column_name].quantile(0.75)
    IQR = Q3 - Q1

    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR

    df_cleaned = df[(df[column_name] >= lower_bound) & (df[column_name] <=␣
 ↪upper_bound)]
    return df_cleaned

cdf = df
for column in cdf:
  if column !="Private":
    print(column)
    cdf = remove_outliers_iqr(cdf,column)
```

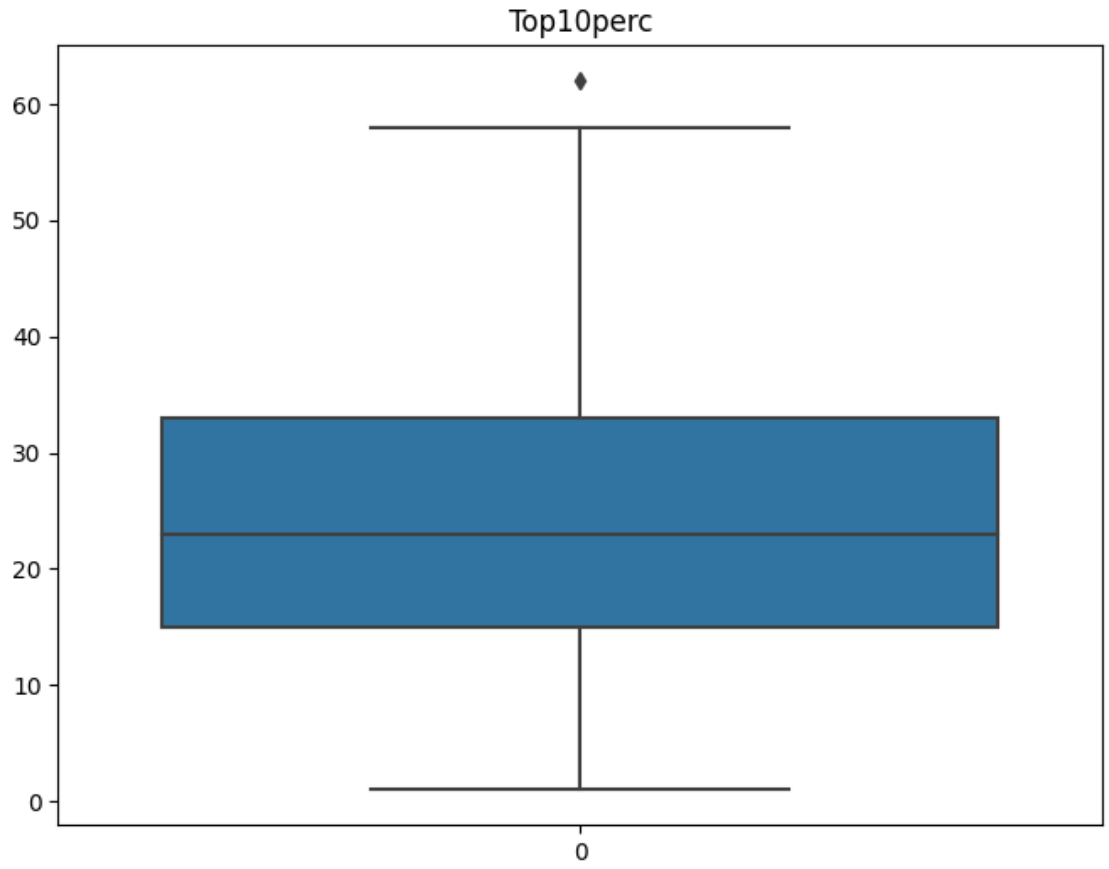
```
for i in range(0, 18 ):
  plt.figure(figsize=(8, 6))  # Set the figure size (optional)
  sns.boxplot( data=cdf[cdf.columns[i]])
  plt.title(cdf.columns[i])
  plt.show()
```

```
Apps
Accept
Enroll
Top10perc
Top25perc
F.Undergrad
P.Undergrad
Outstate
Room.Board
Books
Personal
PhD
Terminal
S.F.Ratio
perc.alumni
Expend
Grad.Rate
```


Apps
6000
5000
4000
3000
2000
1000
0
0


Accept
4000
3500
3000
2500
2000
1500
1000
500
0
0


Enroll
1000
800
600
400
200
0
0


Top10perc
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50
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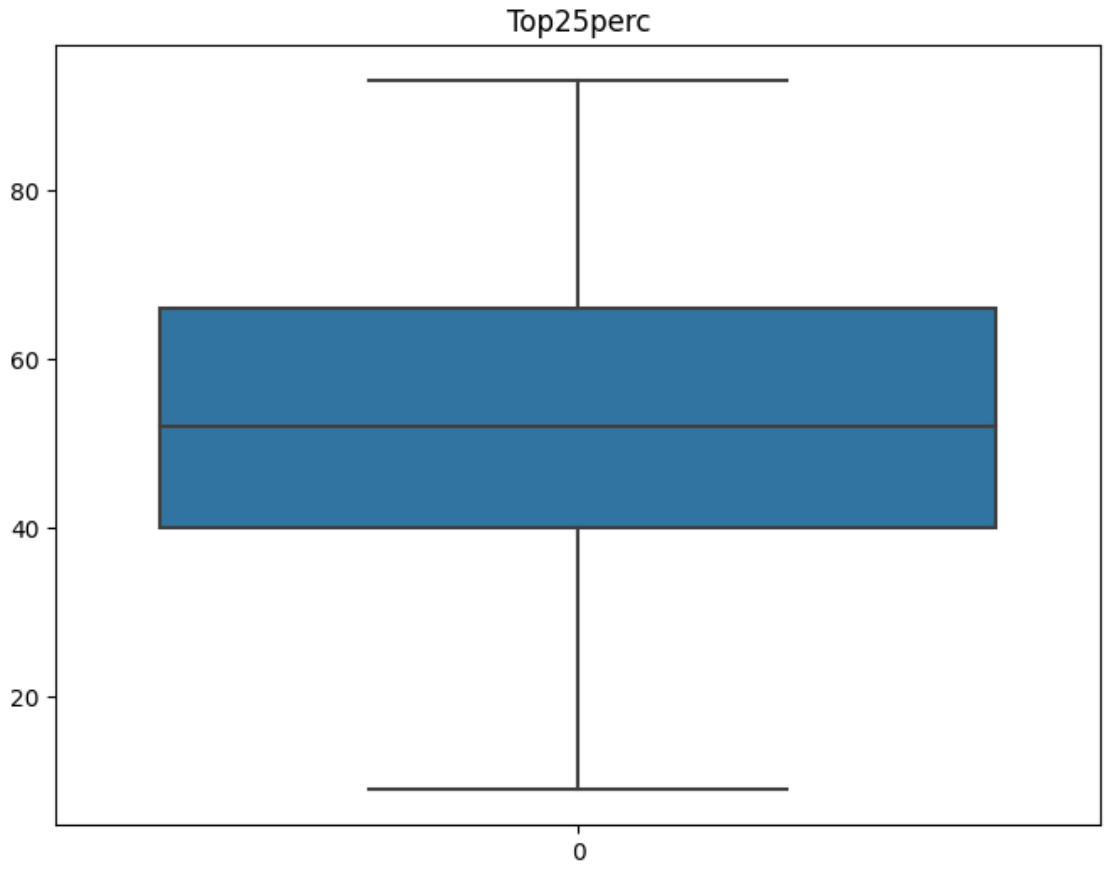
30
20
10
0
0


Top25perc
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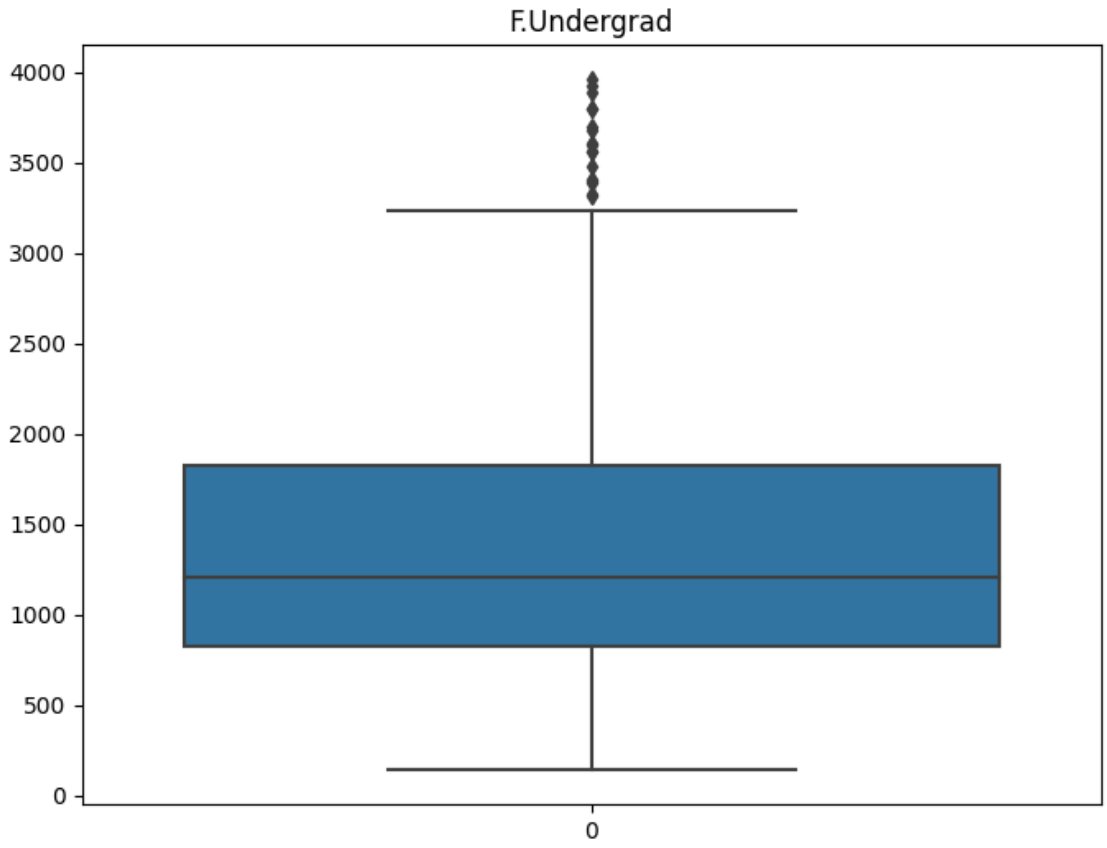
F.Undergrad
4000
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3000
2500
2000
1500
1000
500
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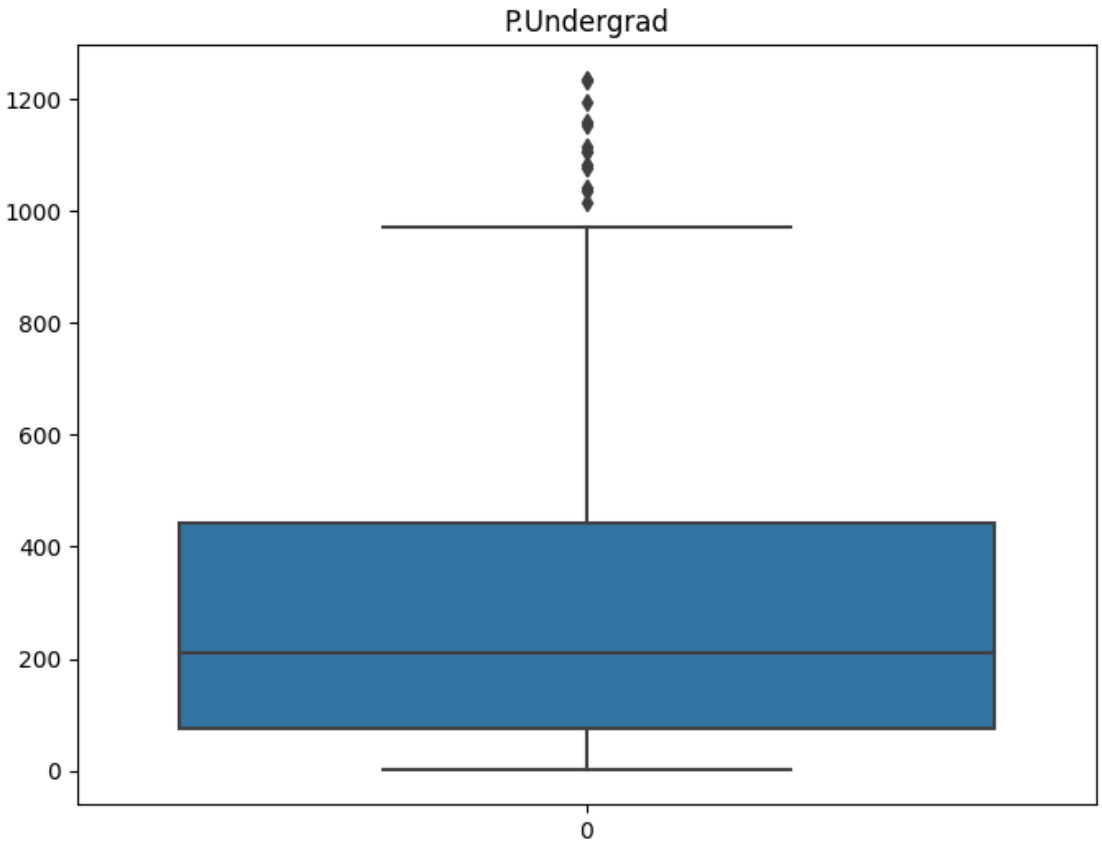
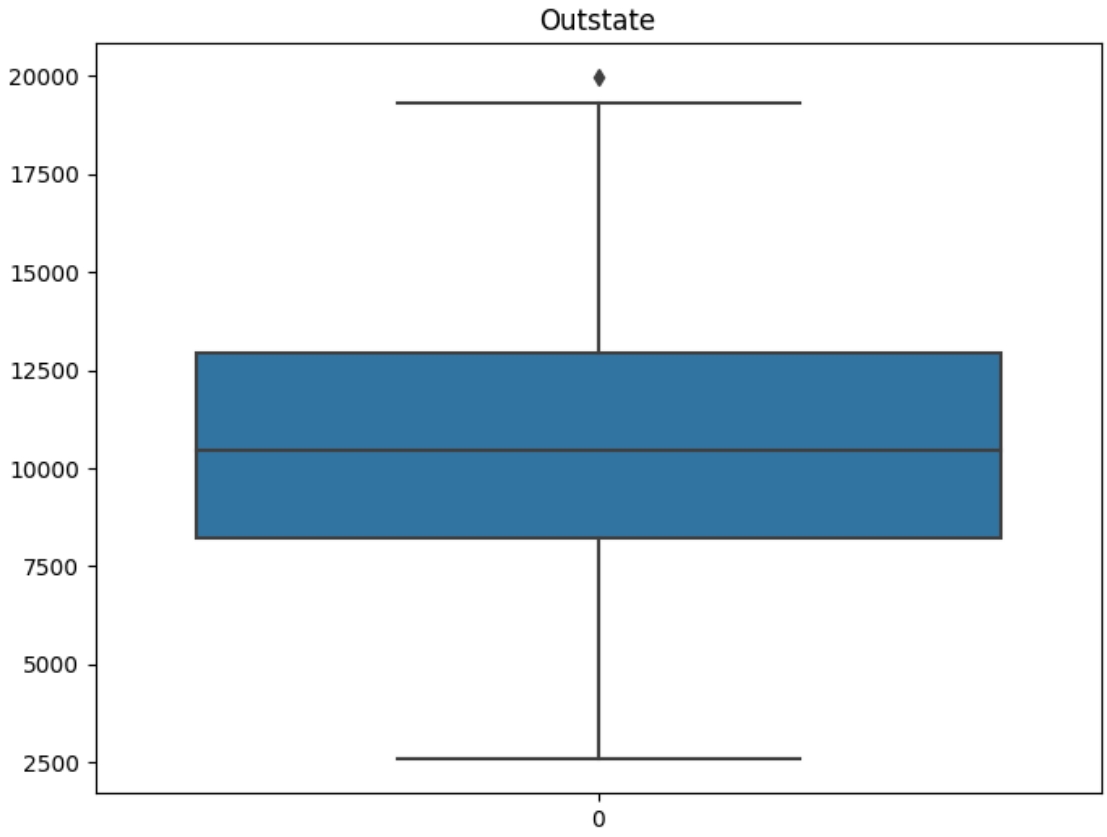
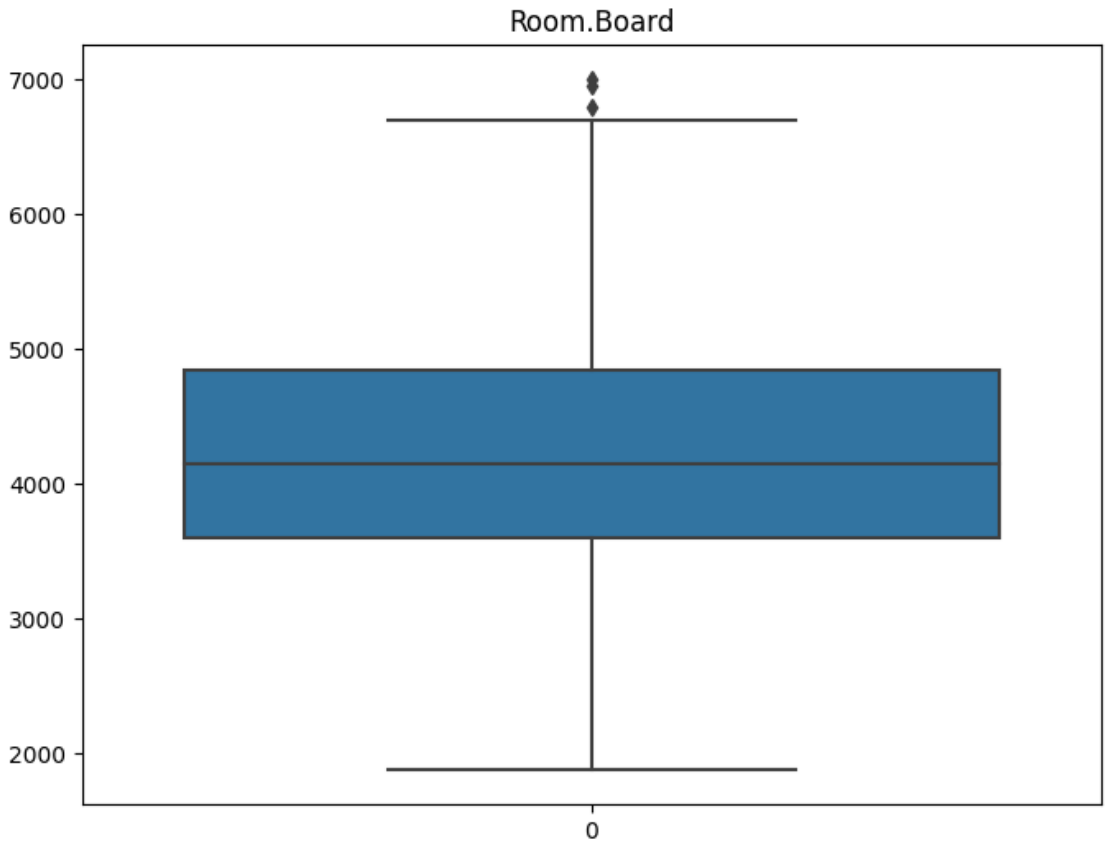
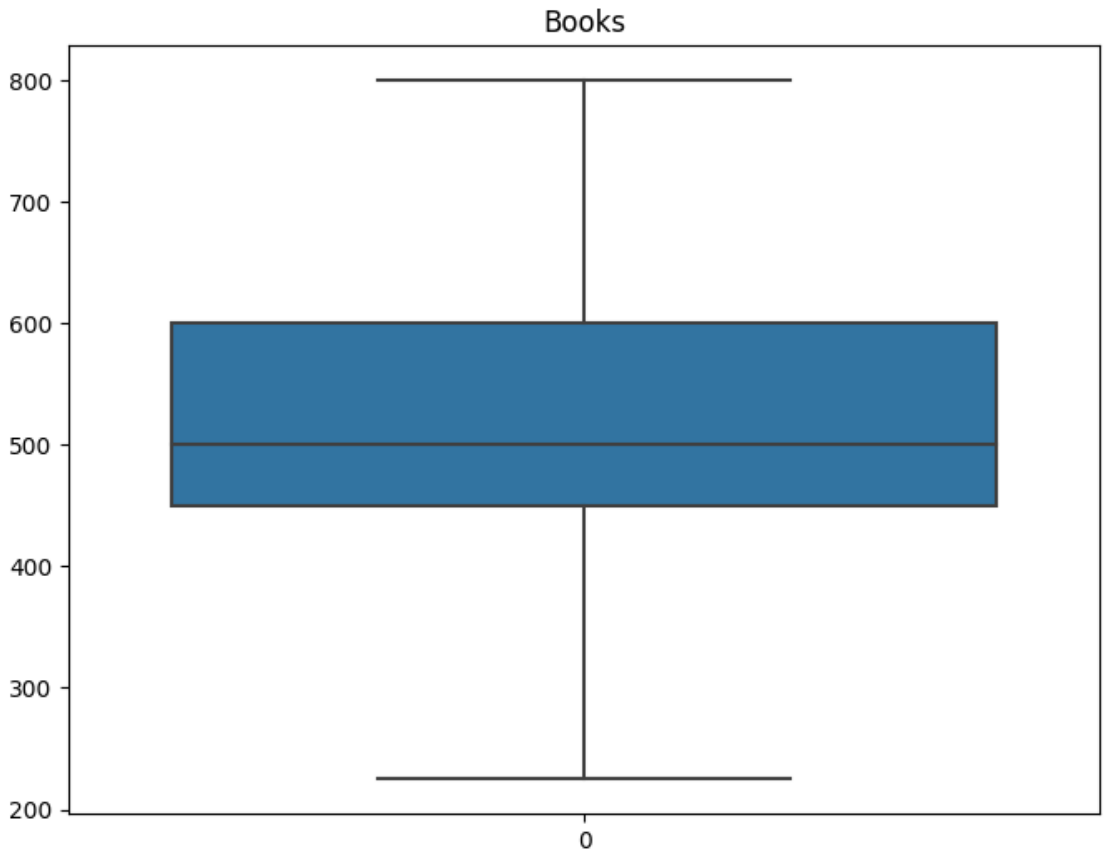
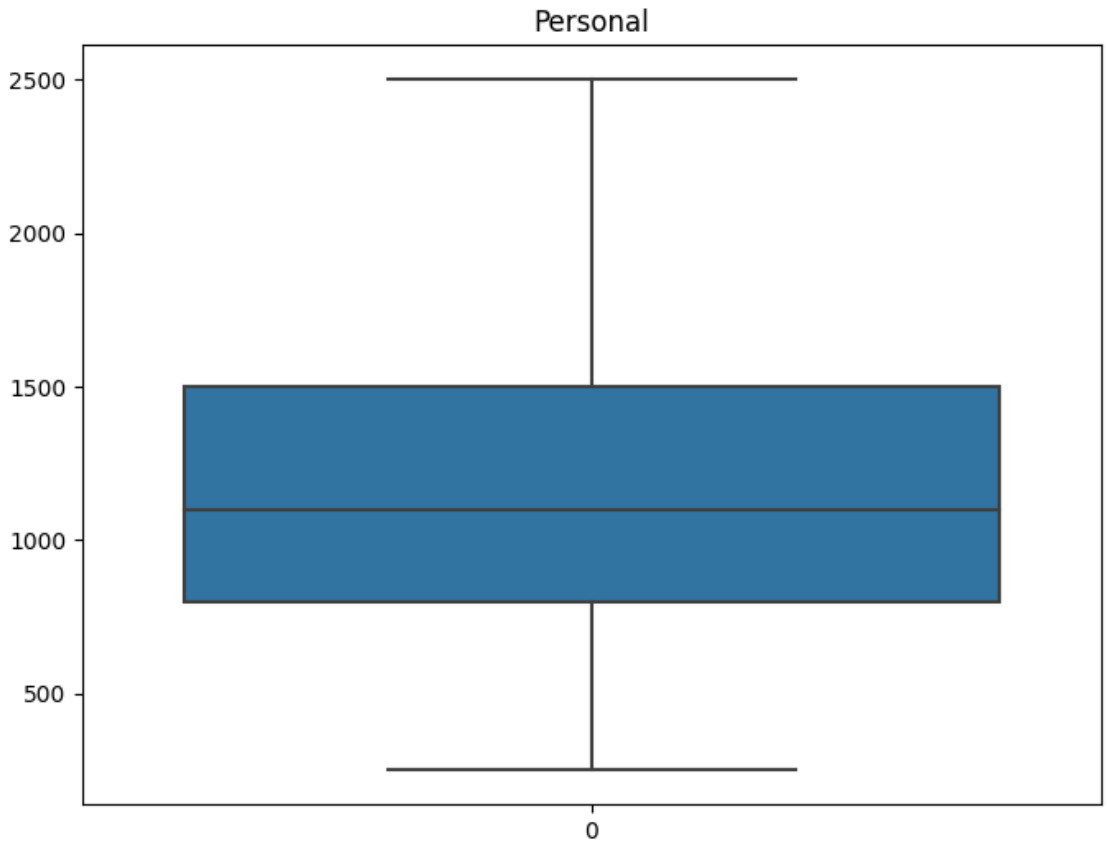
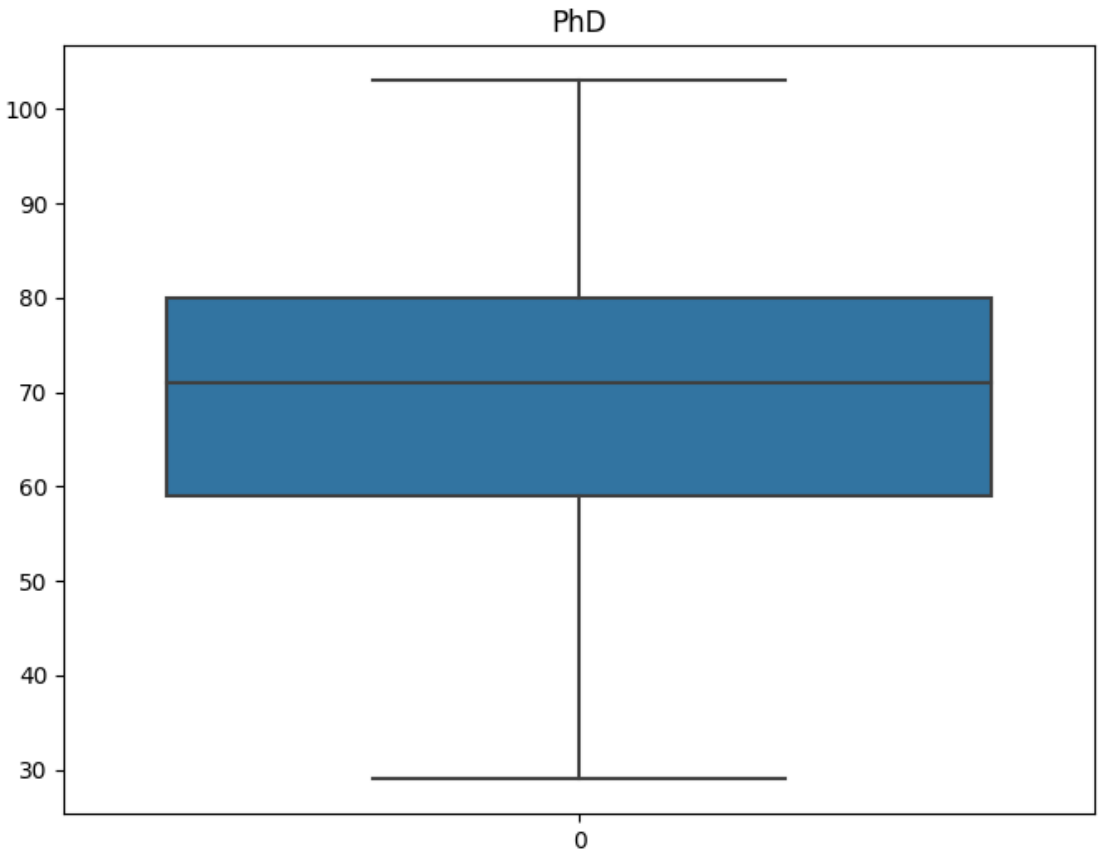

P.Undergrad
1200
1000
800
600
400
200
0
0

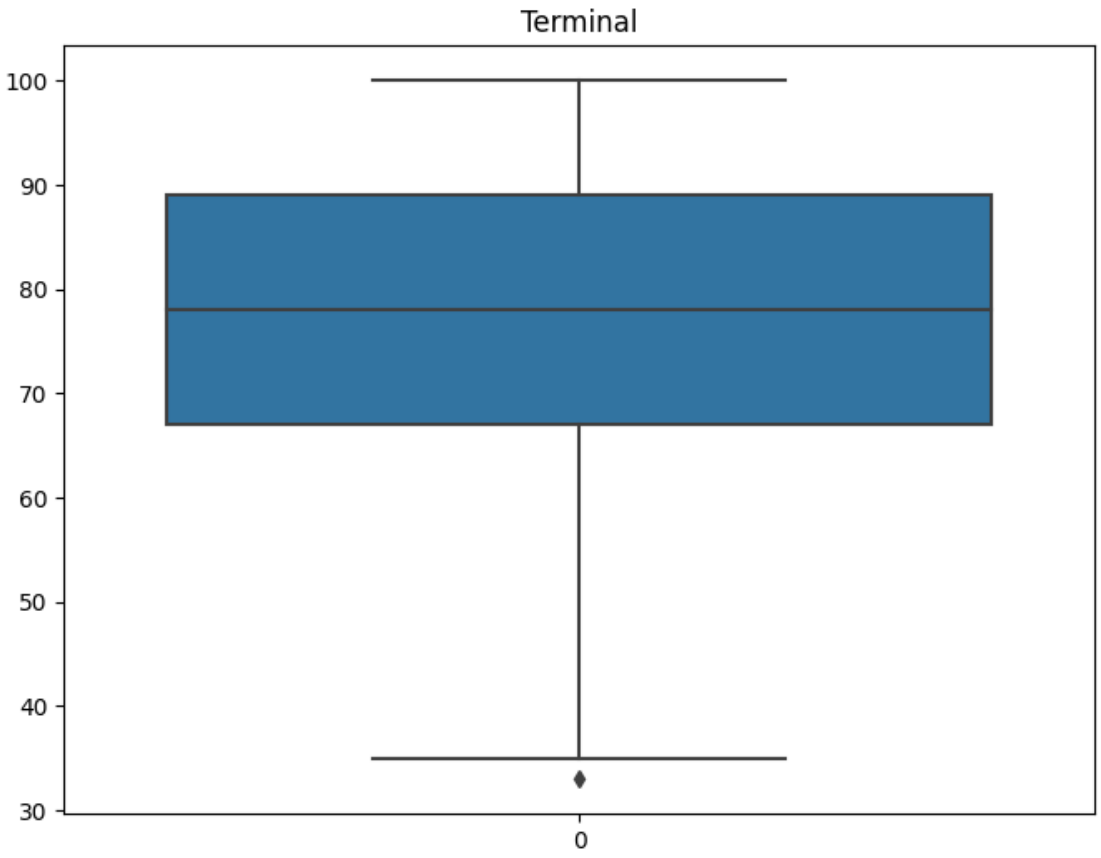

Outstate
20000
17500
15000
12500
10000
7500
5000
2500
0

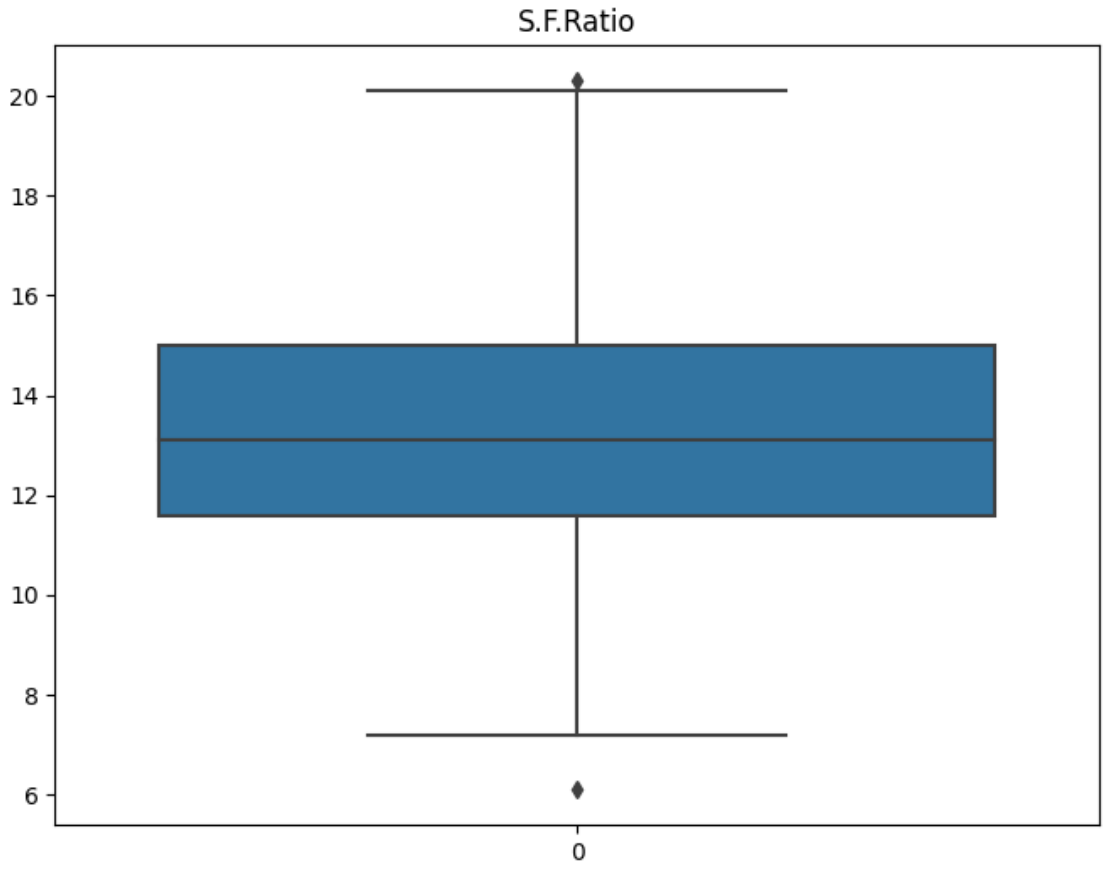

Room.Board
7000
6000
5000
4000
3000
2000
0

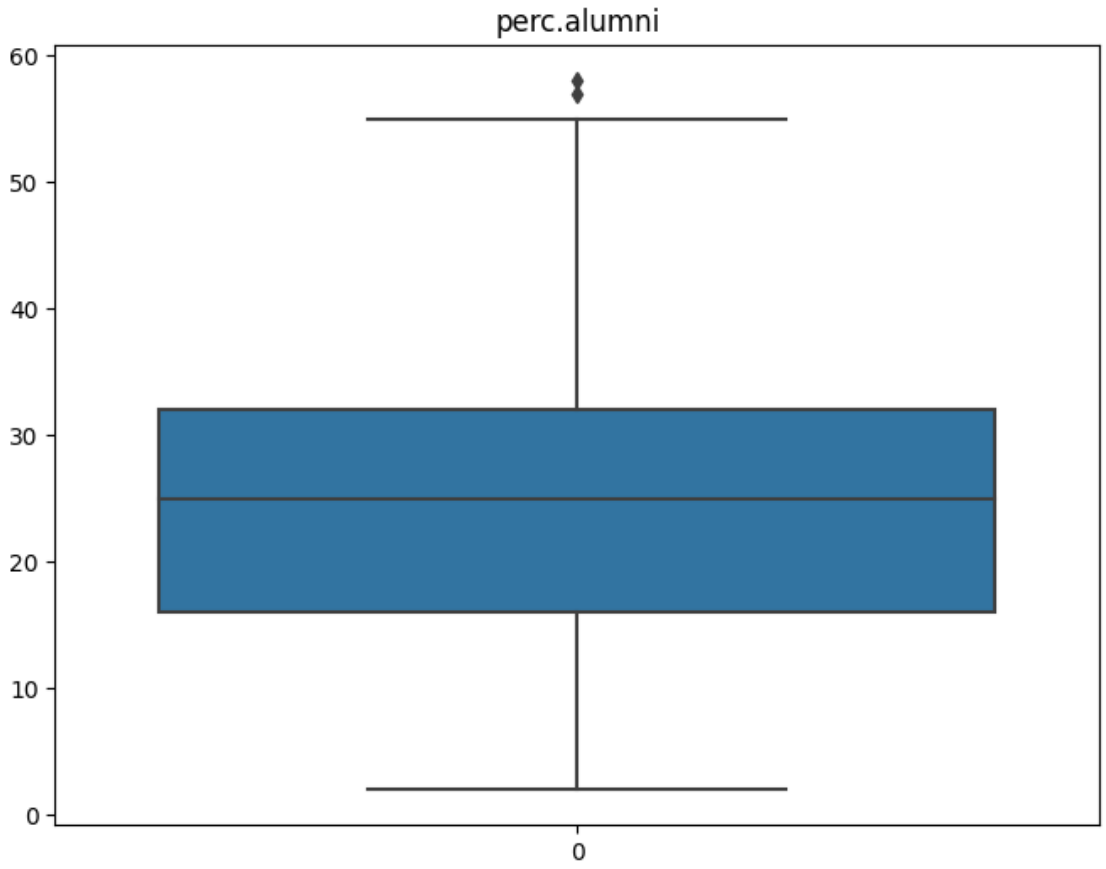

Books
800
700
600
500
400
300
200
0

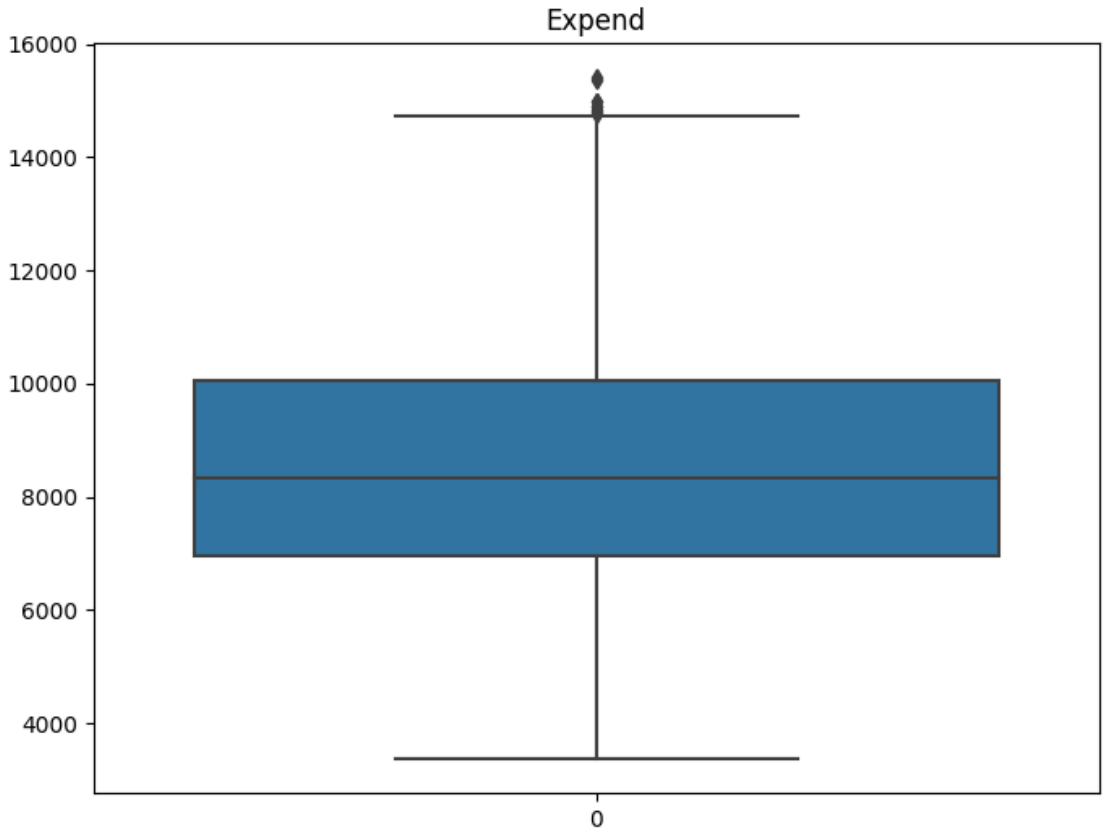

Personal
2500
2000
1500
1000
500
0

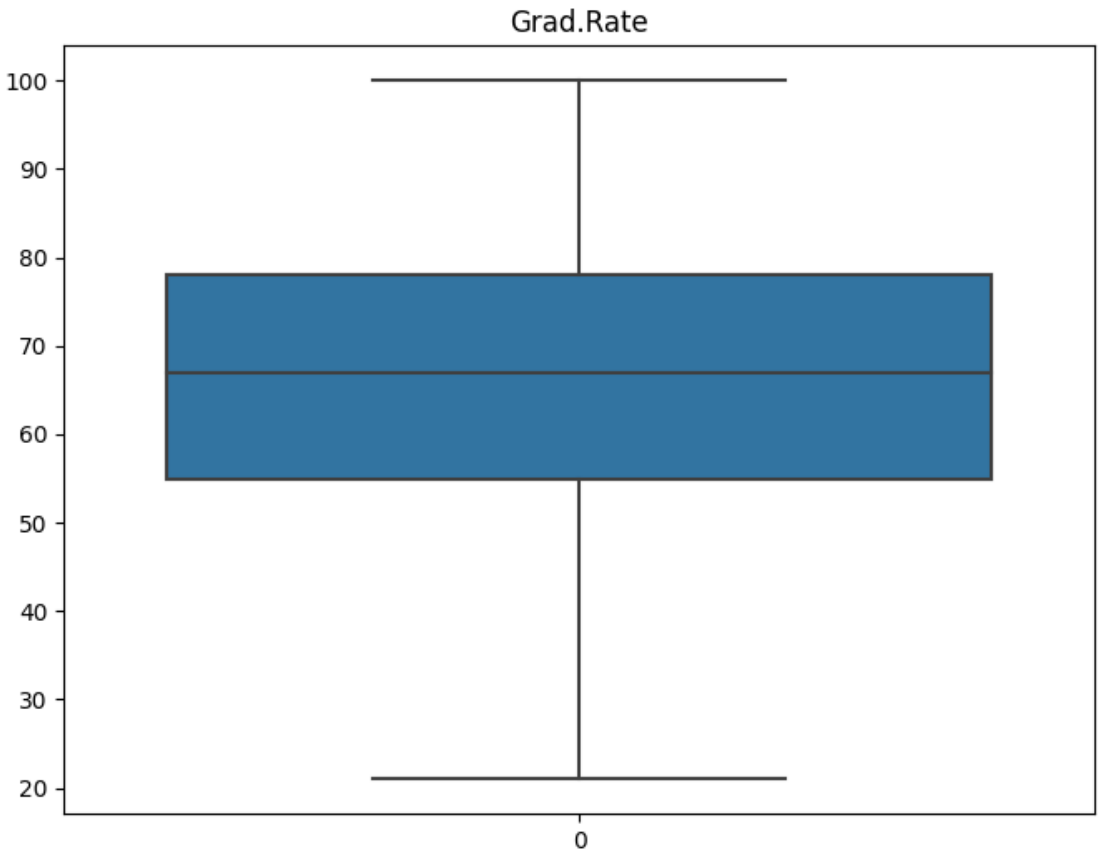

PhD
100
90
80
70
60
50
40
30
0

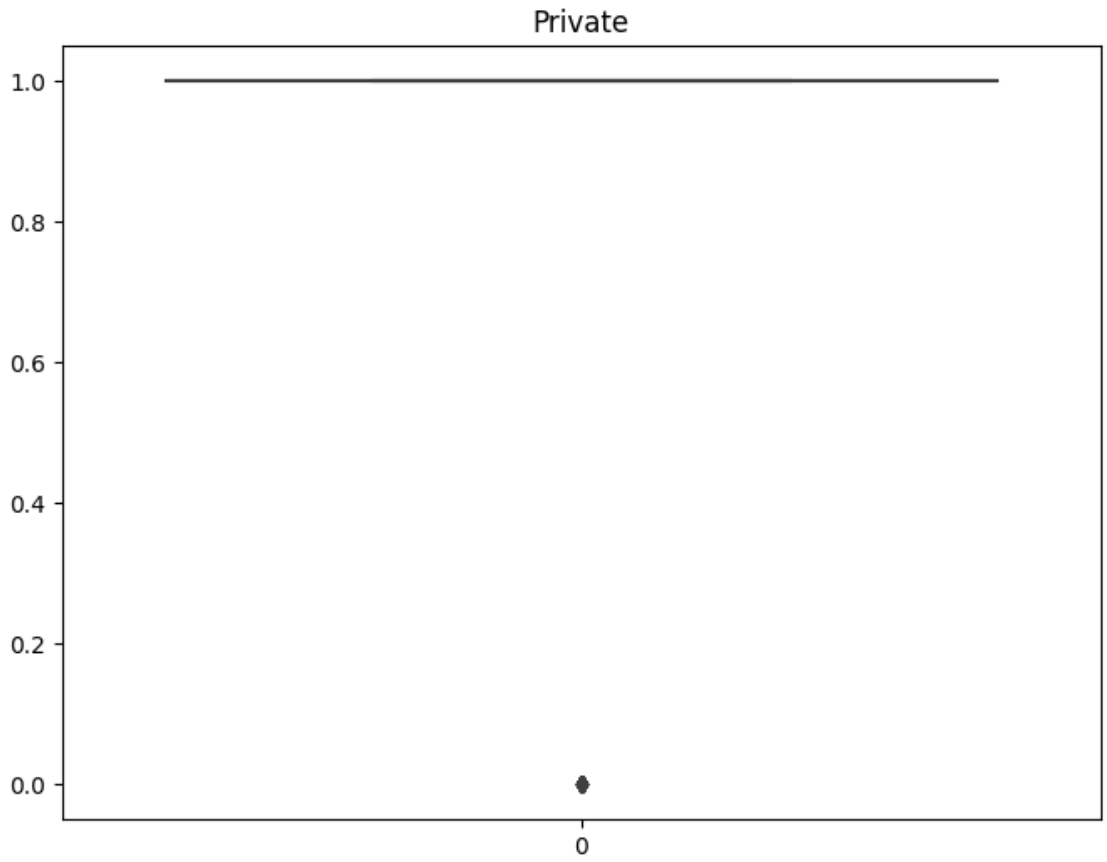

Terminal
100
90
80
70
60
50
40
30
0


S.F.Ratio
20
18
16
14
12
10
8
6
0


perc.alumni
60
50
40
30
20
10
0
0


Expend
16000
14000
12000
10000
8000
6000
4000
0


Grad.Rate
100
90
80
70
60
50
40
30
20
0



[506]:
```
cdf.describe()
```

[506]:

	Apps	Accept	Enroll	Top10perc	Top25perc
count	445.000000	445.000000	445.000000	445.000000	445.000000
mean	1287.422472	967.157303	353.343820	24.874157	53.078652
std	961.633921	645.092296	196.882484	12.607462	17.482053
min	81.000000	72.000000	46.000000	1.000000	9.000000
25%	600.000000	494.000000	200.000000	15.000000	40.000000
50%	996.000000	798.000000	307.000000	23.000000	52.000000
75%	1681.000000	1313.000000	465.000000	33.000000	66.000000
max	6548.000000	3813.000000	1123.000000	62.000000	93.000000

	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books
count	445.000000	445.000000	445.000000	445.000000	445.000000
mean	1417.552809	297.912360	10613.332584	4266.921348	515.422472
std	804.525782	281.004952	3463.667351	964.470076	97.902330
min	139.000000	1.000000	2580.000000	1880.000000	225.000000
25%	822.000000	74.000000	8236.000000	3600.000000	450.000000
50%	1202.000000	209.000000	10475.000000	4150.000000	500.000000

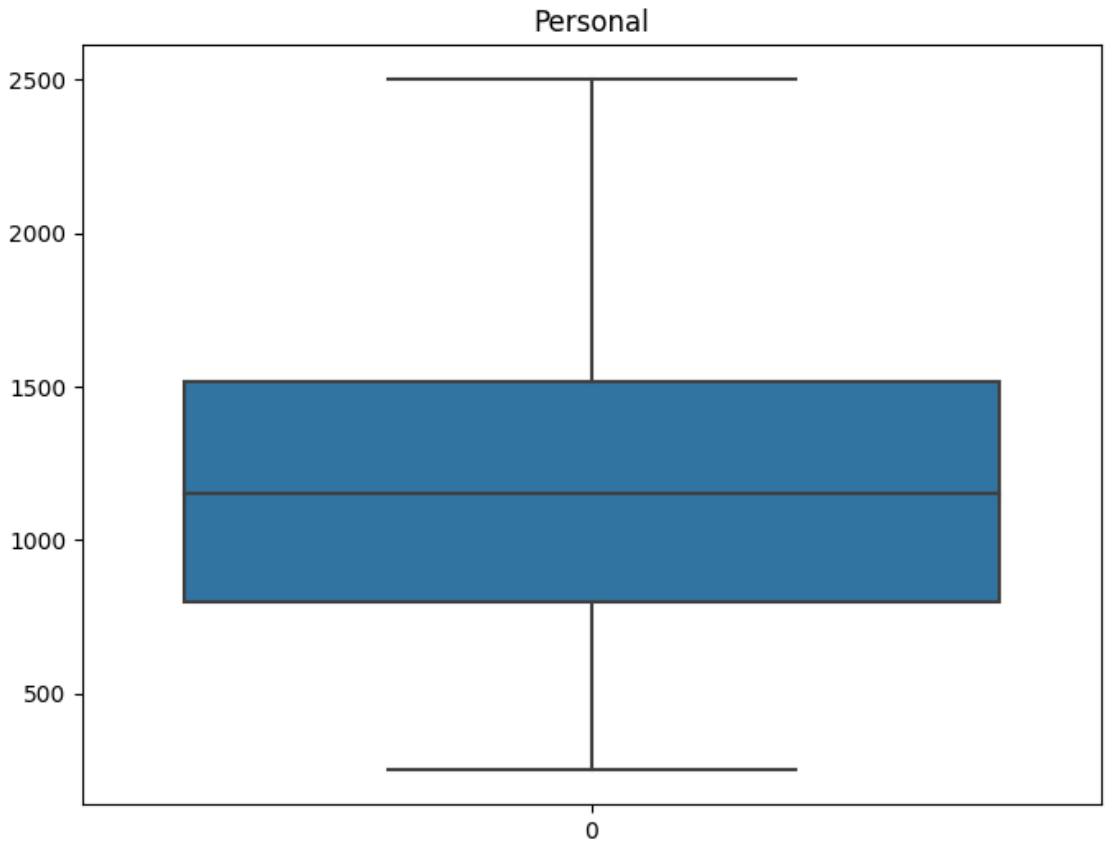
```
75%    1819.000000   442.000000  12925.000000  4840.000000  600.000000
max    3957.000000  1235.000000  19964.000000  7000.000000  800.000000

          Personal         PhD    Terminal   S.F.Ratio  perc.alumni  \
count   445.000000  445.000000  445.000000  445.000000   445.000000
mean   1163.930337   69.784270   76.874157   13.432809    24.624719
std     486.511573   14.973196   14.107930    2.516048    11.296807
min     250.000000   29.000000   33.000000    6.100000     2.000000
25%     800.000000   59.000000   67.000000   11.600000    16.000000
50%    1100.000000   71.000000   78.000000   13.100000    25.000000
75%    1500.000000   80.000000   89.000000   15.000000    32.000000
max    2500.000000  103.000000  100.000000   20.300000    58.000000

             Expend   Grad.Rate     Private
count    445.000000  445.000000  445.000000
mean    8711.303371   66.065169    0.892135
std     2501.412008   15.856416    0.310559
min     3365.000000   21.000000    0.000000
25%     6955.000000   55.000000    1.000000
50%     8324.000000   67.000000    1.000000
75%    10062.000000   78.000000    1.000000
max    15411.000000  100.000000    1.000000
```

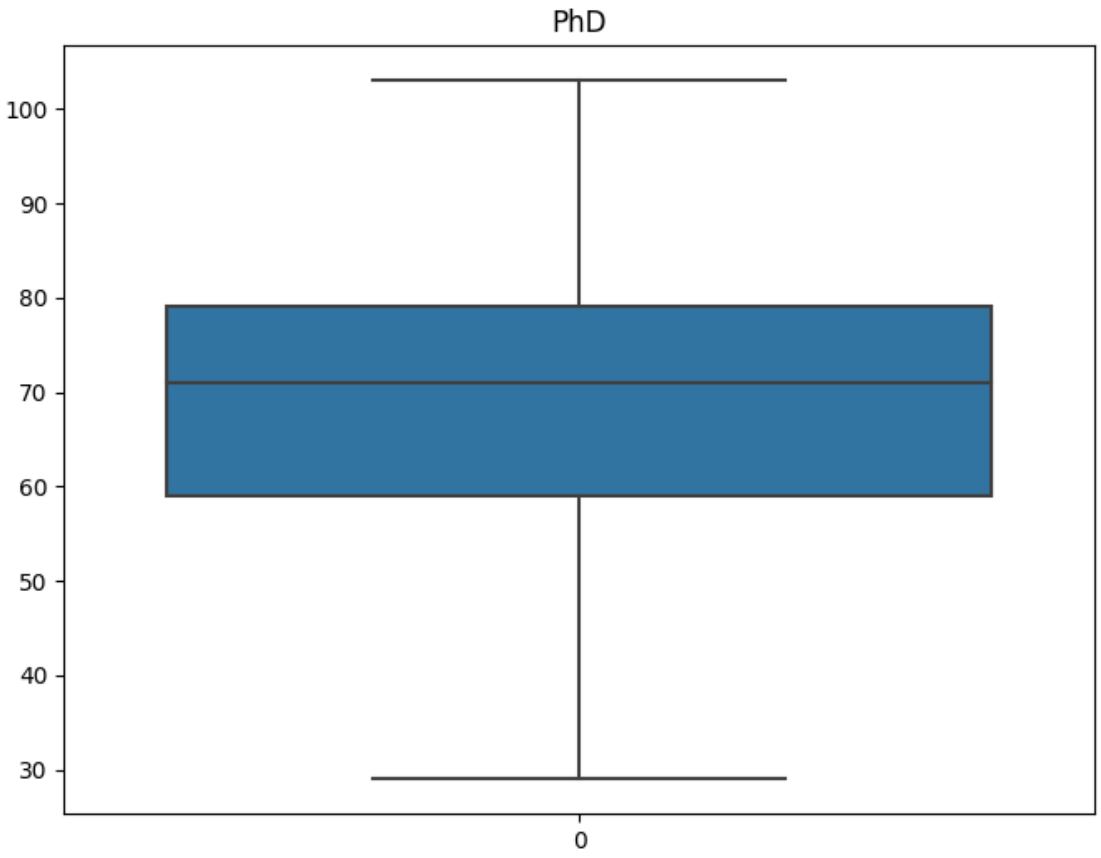
[507]:
```
zeroes = cdf[cdf["Private"] == 0]
zeroes.describe()

res=[]
res.append(cdf)
for i in range(3):
  res.append(zeroes)

cdf = pd.concat(res)
cdf.describe()
```

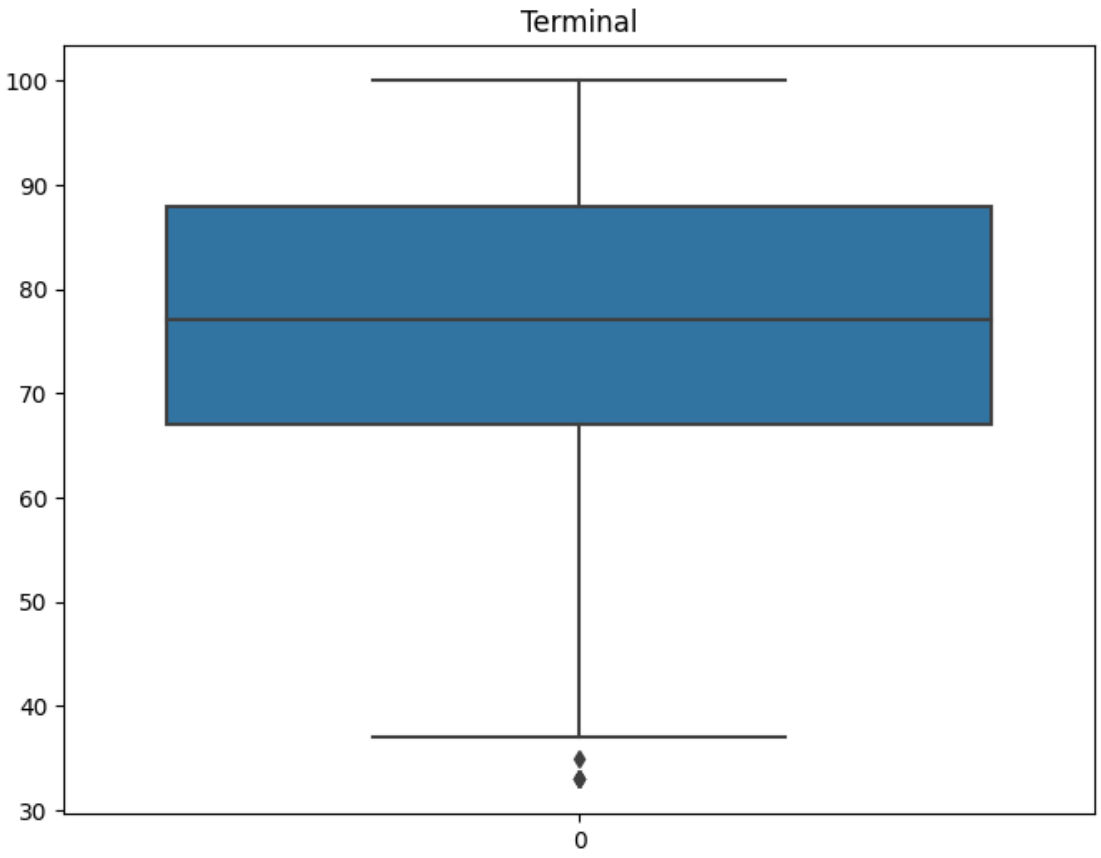
[507]:
```
              Apps       Accept       Enroll   Top10perc   Top25perc  \
count   589.000000   589.000000   589.000000  589.000000  589.000000
mean   1340.025467  1007.249576   389.524618   23.081494   50.772496
std     968.244889   651.343938   214.922660   13.253038   18.634760
min      81.000000    72.000000    46.000000    1.000000    9.000000
25%     610.000000   503.000000   223.000000   13.000000   36.000000
50%    1082.000000   850.000000   342.000000   20.000000   50.000000
75%    1742.000000  1360.000000   510.000000   32.000000   65.000000
max    6548.000000  3813.000000  1123.000000   62.000000   93.000000

       F.Undergrad  P.Undergrad      Outstate   Room.Board       Books  \
count   589.000000   589.000000    589.000000   589.000000  589.000000
mean   1609.672326   328.748727   9498.707980  4063.022071  516.480475
```

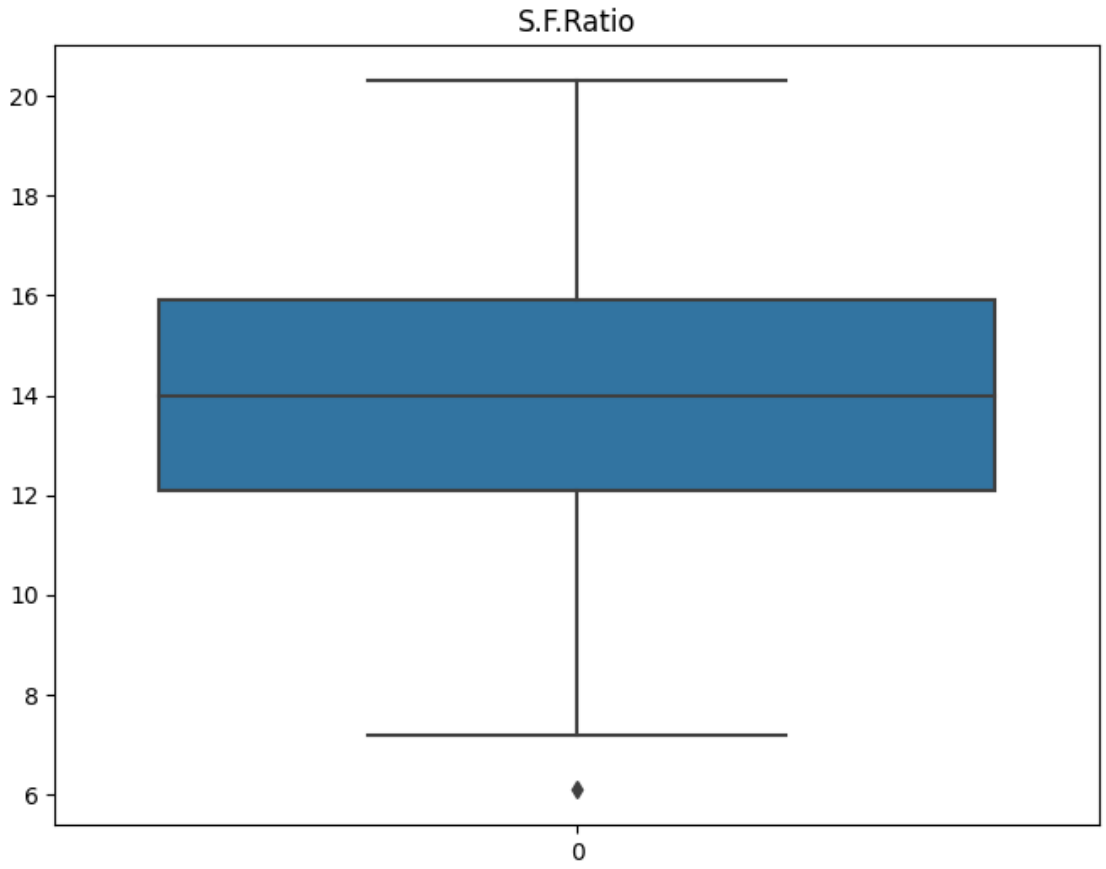
```
std     919.346139   280.781607   3717.185953  1001.403828   97.905367
min     139.000000     1.000000   2580.000000  1880.000000  225.000000
25%     950.000000    95.000000   6600.000000  3392.000000  450.000000
50%    1337.000000   258.000000   9100.000000  3970.000000  500.000000
75%    2091.000000   486.000000  12040.000000  4690.000000  600.000000
max    3957.000000  1235.000000  19964.000000  7000.000000  800.000000

          Personal         PhD    Terminal   S.F.Ratio  perc.alumni  \
count   589.000000  589.000000  589.000000  589.000000   589.000000
mean   1215.181664   69.490662   76.069610   14.131239    22.317487
std     510.763104   14.994738   14.137333    2.731881    11.291713
min     250.000000   29.000000   33.000000    6.100000     2.000000
25%     800.000000   59.000000   67.000000   12.100000    13.000000
50%    1150.000000   71.000000   77.000000   14.000000    22.000000
75%    1516.000000   79.000000   88.000000   15.900000    31.000000
max    2500.000000  103.000000  100.000000   20.300000    58.000000

             Expend   Grad.Rate     Private
count    589.000000  589.000000  589.000000
mean    8104.103565   62.947368    0.674024
std     2546.029602   16.301860    0.469137
min     3365.000000   21.000000    0.000000
25%     6374.000000   51.000000    0.000000
50%     7735.000000   63.000000    1.000000
75%     9511.000000   75.000000    1.000000
max    15411.000000  100.000000    1.000000
```

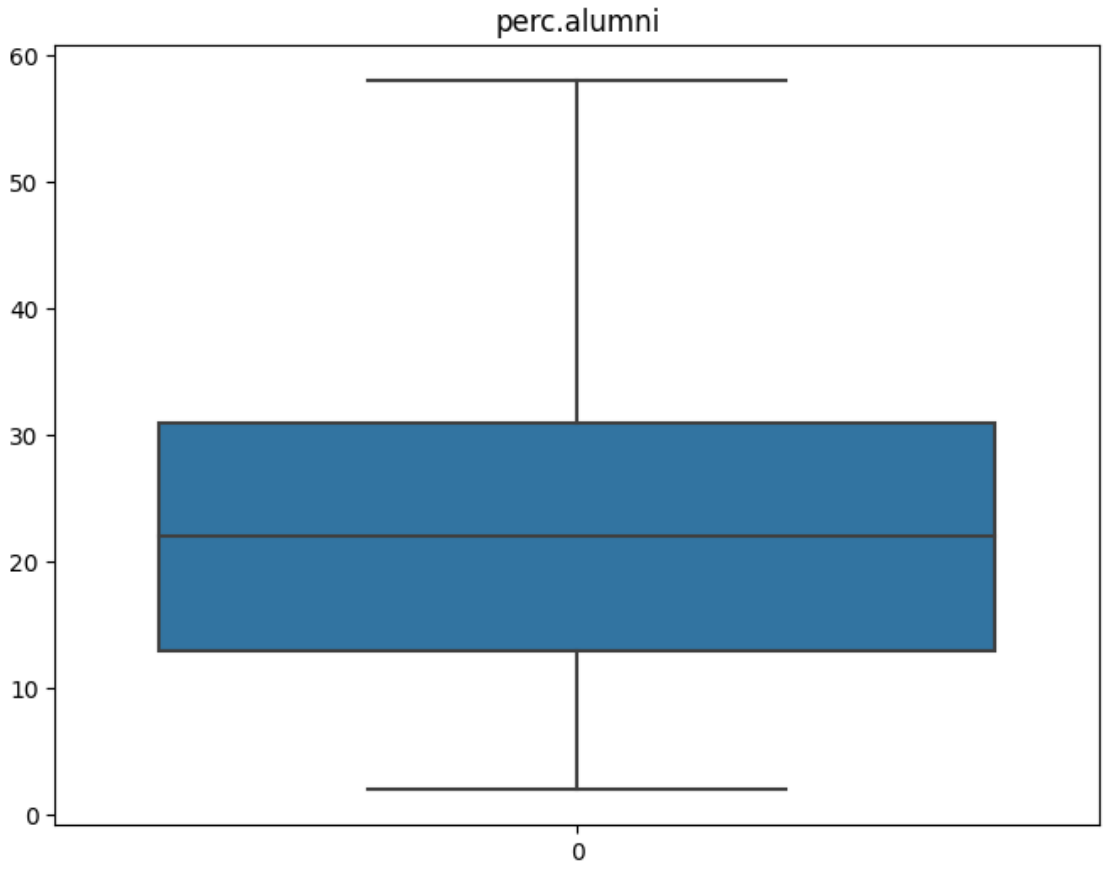
[508]:
```
for i in range(10, 18 ):
  plt.figure(figsize=(8, 6))  # Set the figure size (optional)
  sns.boxplot( data=cdf[cdf.columns[i]])
  plt.title(cdf.columns[i])
  plt.show()
```

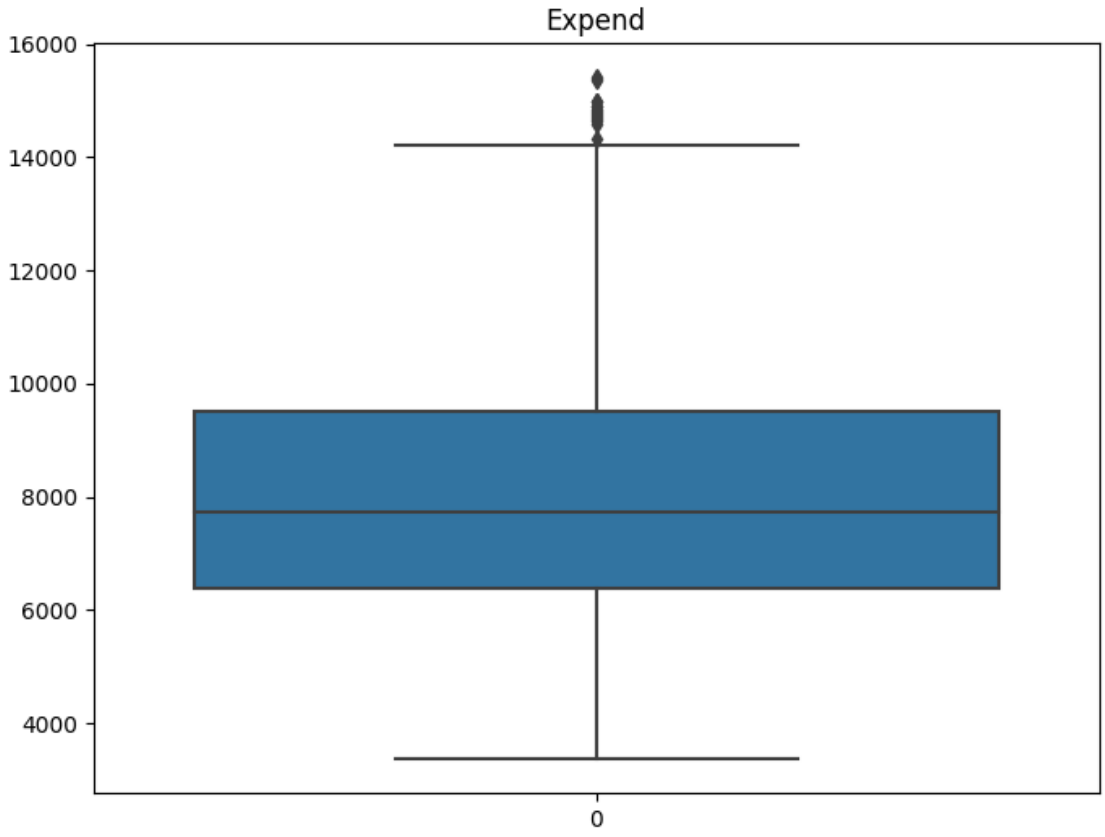

Personal
2500
2000
1500
1000
500
0

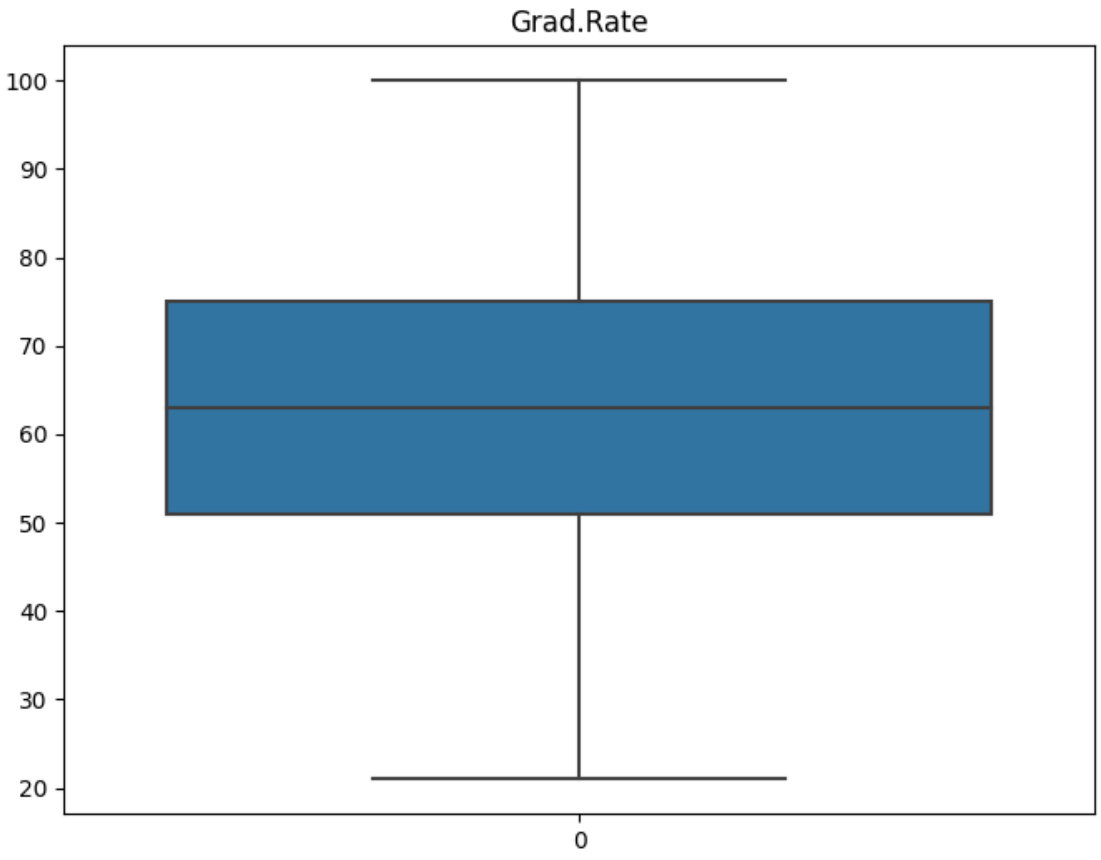

PhD
100
90
80
70
60
50
40
30
0

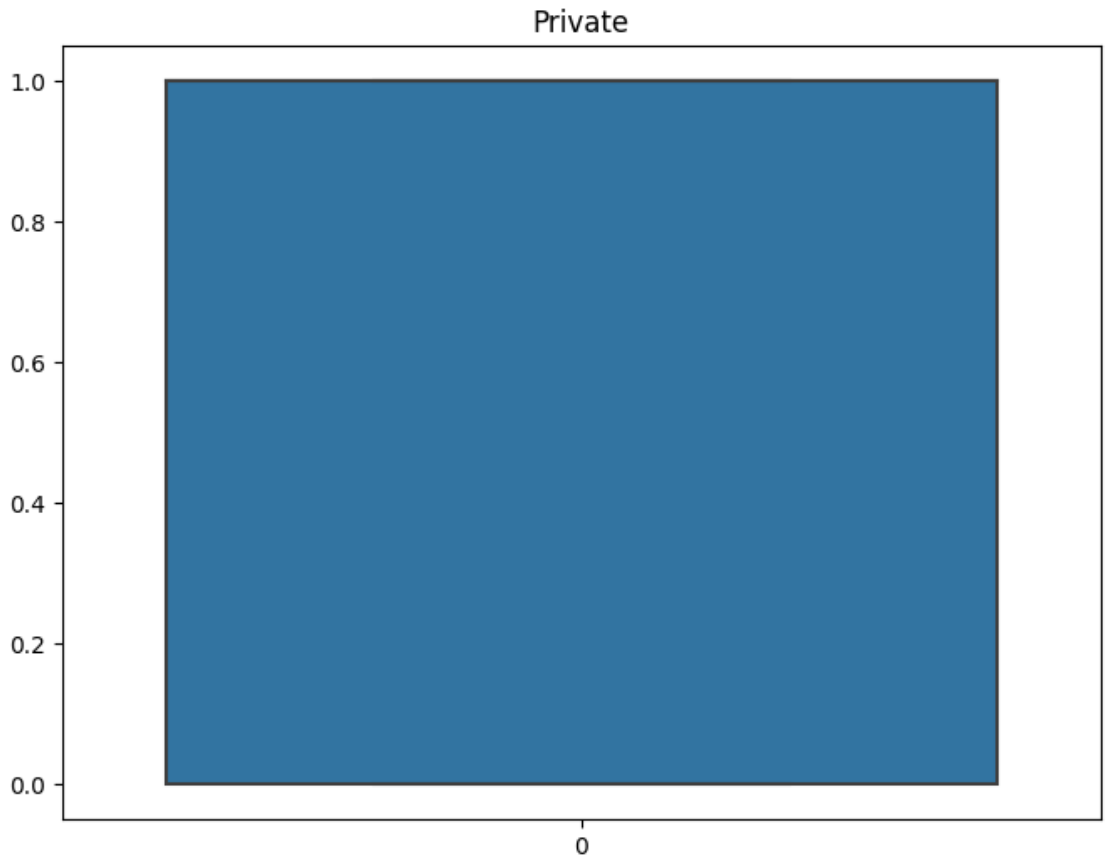

Terminal
100
90
80
70
60
50
40
30
0


S.F.Ratio
20
18
16
14
12
10
8
6
0


perc.alumni
60
50
40
30
20
10
0
0


Expend
16000
14000
12000
10000
8000
6000
4000
0


Grad.Rate
100
90
80
70
60
50
40
30
20
0



[509]:
```
cdf = cdf.sample(frac=1, random_state=42)
tests, cdf = cdf.iloc[500:589] , cdf.iloc[0:500]
cdf.describe()
```

[509]:

	Apps	Accept	Enroll	Top10perc	Top25perc
count	500.000000	500.000000	500.000000	500.000000	500.000000
mean	1349.170000	1011.490000	391.362000	23.194000	51.008000
std	964.279122	645.176875	214.924004	13.366889	18.841708
min	81.000000	72.000000	46.000000	1.000000	9.000000
25%	661.250000	520.000000	224.000000	13.000000	36.000000
50%	1101.500000	858.500000	344.500000	20.000000	50.000000
75%	1742.250000	1373.000000	510.250000	32.250000	66.000000
max	6548.000000	3813.000000	1123.000000	62.000000	93.000000

	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books
count	500.000000	500.000000	500.000000	500.000000	500.000000
mean	1618.918000	330.660000	9482.096000	4074.882000	517.768000
std	925.003454	284.134886	3731.972324	1014.304198	98.675264
min	139.000000	1.000000	2580.000000	1880.000000	225.000000

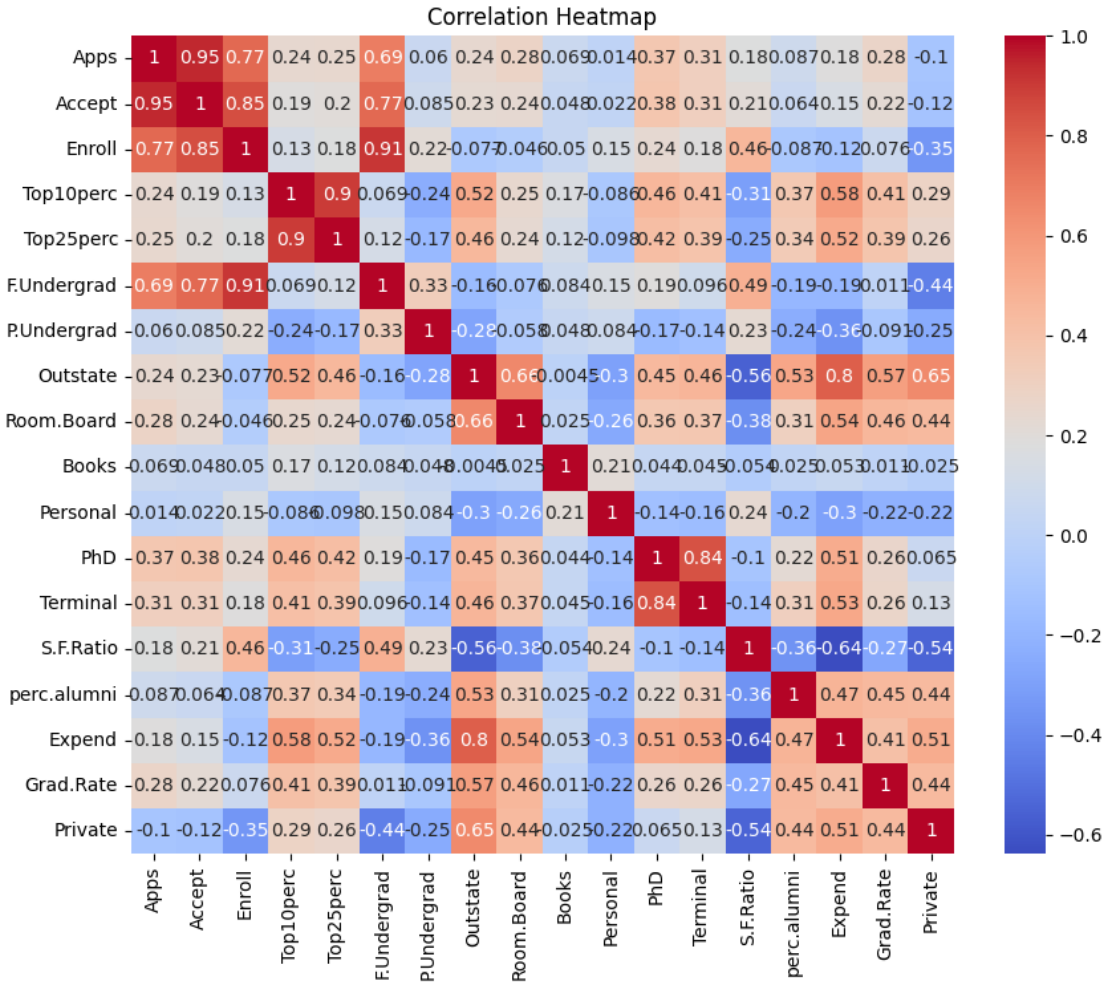
```
25%     958.750000    95.000000   6600.000000  3392.000000  450.000000
50%    1320.500000   240.500000   9057.000000  3972.500000  500.000000
75%    2138.000000   488.500000  12053.750000  4692.500000  600.000000
max    3957.000000  1235.000000  19964.000000  7000.000000  800.000000

          Personal         PhD    Terminal   S.F.Ratio  perc.alumni  \
count   500.000000  500.000000  500.000000  500.000000   500.000000
mean   1215.224000   69.370000   75.886000   14.170200    22.166000
std     506.403474   14.903736   14.208052    2.725294    11.282599
min     250.000000   29.000000   33.000000    6.100000     2.000000
25%     800.000000   58.750000   67.000000   12.200000    13.000000
50%    1150.000000   71.000000   77.000000   14.050000    22.000000
75%    1500.000000   79.000000   88.000000   15.925000    30.000000
max    2500.000000  103.000000  100.000000   20.300000    58.000000

              Expend   Grad.Rate     Private
count     500.000000  500.000000  500.000000
mean     8083.146000   63.200000    0.674000
std      2574.748139   16.237219    0.469217
min      3365.000000   21.000000    0.000000
25%      6369.750000   51.000000    0.000000
50%      7667.500000   63.000000    1.000000
75%      9496.750000   76.000000    1.000000
max     15411.000000  100.000000    1.000000
```

[510]:
```
tests.describe()
```

[510]:
```
              Apps       Accept       Enroll  Top10perc  Top25perc  \
count    89.000000    89.000000    89.000000  89.000000  89.000000
mean   1288.651685   983.426966   379.202247  22.449438  49.449438
std     994.215864   688.282792   215.838912  12.648222  17.468160
min     150.000000   130.000000    85.000000   3.000000  12.000000
25%     535.000000   481.000000   214.000000  13.000000  37.000000
50%     979.000000   798.000000   336.000000  20.000000  47.000000
75%    1660.000000  1261.000000   484.000000  30.000000  61.000000
max    4784.000000  3346.000000  1123.000000  56.000000  87.000000

       F.Undergrad  P.Undergrad      Outstate   Room.Board       Books  \
count    89.000000    89.000000     89.000000    89.000000   89.000000
mean   1557.730337   318.011236   9592.033708  3996.393258  509.247191
std     890.180660   262.402687   3652.332612   928.151482   93.668817
min     309.000000     1.000000   2700.000000  2439.000000  225.000000
25%     945.000000    99.000000   6400.000000  3340.000000  450.000000
50%    1350.000000   283.000000   9520.000000  3788.000000  500.000000
75%    1983.000000   436.000000  11844.000000  4660.000000  600.000000
max    3793.000000  1078.000000  19240.000000  6430.000000  750.000000
```

```
          Personal         PhD   Terminal  S.F.Ratio  perc.alumni  \
count    89.000000   89.000000  89.000000  89.000000    89.000000
mean   1214.943820   70.168539  77.101124  13.912360    23.168539
std     537.576852   15.565285  13.765937   2.773938    11.369053
min     300.000000   39.000000  41.000000   8.300000     4.000000
25%     790.000000   59.000000  68.000000  12.000000    15.000000
50%    1130.000000   73.000000  79.000000  13.500000    21.000000
75%    1600.000000   80.000000  88.000000  15.900000    31.000000
max    2500.000000  103.000000  99.000000  20.300000    53.000000

             Expend   Grad.Rate    Private
count     89.000000   89.000000  89.000000
mean    8221.842697   61.528090   0.674157
std     2388.620760   16.682251   0.471344
min     4222.000000   22.000000   0.000000
25%     6436.000000   50.000000   0.000000
50%     7994.000000   62.000000   1.000000
75%     9583.000000   71.000000   1.000000
max    15387.000000  100.000000   1.000000
```

[511]:
```
correlation_matrix = cdf.corr()
plt.figure(figsize=(10, 8))  # Set the figure size (optional)
sns.heatmap(correlation_matrix, annot=True, cmap="coolwarm")
plt.title("Correlation Heatmap")
plt.show()
```



vemos que a correlação entre atributos aumento no geral.

5 cálculo K-medias e K-medoids

[512]:
```
df = cdf
df.shape
```

[512]:
```
(500, 18)
```

[513]:
```
scaler = MinMaxScaler()
scale = scaler.fit_transform(df[df.columns])
df_scale = pd.DataFrame(scale, columns = df.columns);
df_scale.head(5)
```

[513]:
```
        Apps     Accept     Enroll  Top10perc  Top25perc  F.Undergrad  \
0  0.194681  0.166533  0.221913   0.672131   0.761905     0.308015
```

```
1  0.133447  0.187650  0.365831   0.213115   0.297619     0.533002
2  0.061698  0.089014  0.310121   0.295082   0.440476     0.401781
3  0.059224  0.092756  0.127205   0.147541   0.261905     0.143269
4  0.298747  0.262229  0.154132   0.524590   0.619048     0.202462

   P.Undergrad  Outstate  Room.Board     Books  Personal       PhD  Terminal  \
0     0.168558  0.242752    0.556641  0.782609  0.444444  0.743243  0.835821
1     0.427877  0.217441    0.171875  0.565217  0.554667  0.648649  0.656716
2     0.820908  0.103889    0.065820  0.652174  0.555556  0.270270  0.313433
3     0.231767  0.383111    0.390625  0.434783  0.373333  0.000000  0.238806
4     0.127229  0.147837    0.225781  0.478261  0.624444  0.472973  0.611940

   S.F.Ratio  perc.alumni    Expend  Grad.Rate  Private
0   0.387324     0.375000  0.580442   0.531646      0.0
1   0.626761     0.053571  0.255521   0.341772      0.0
2   0.683099     0.107143  0.194172   0.531646      0.0
3   0.077465     0.267857  0.503570   0.329114      1.0
4   0.309859     0.160714  0.347169   0.481013      1.0
```

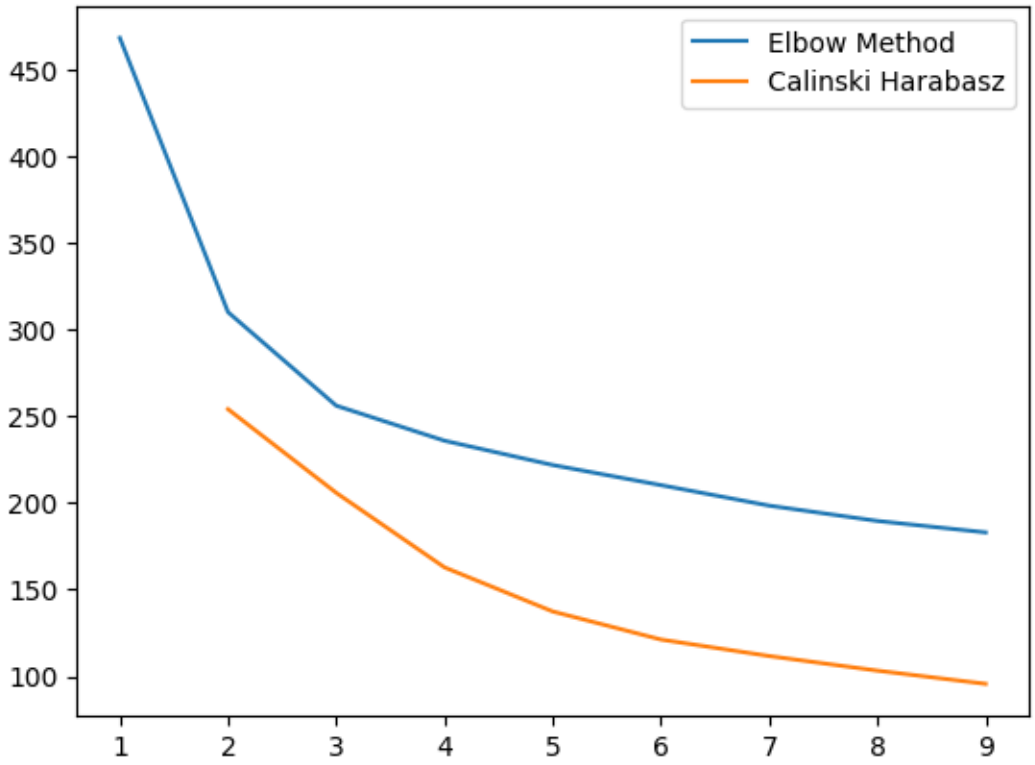
[514]:
```
EM = []
CH = []
CH.append(None)
DB = []
DB.append(None)
SI = []
SI.append(None)
for cluster in range(1,10):
    kmeans = KMeans(n_clusters = cluster, init='k-means++').fit(df_scale)
    EM.append(kmeans.inertia_)

    labels = kmeans.labels_
    labels = kmeans.labels_
    if cluster >1:
      CH.append(metrics.calinski_harabasz_score(df_scale, labels))
      DB.append(metrics.davies_bouldin_score(df_scale, labels))
      SI.append(metrics.silhouette_score(df_scale, labels))
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
```

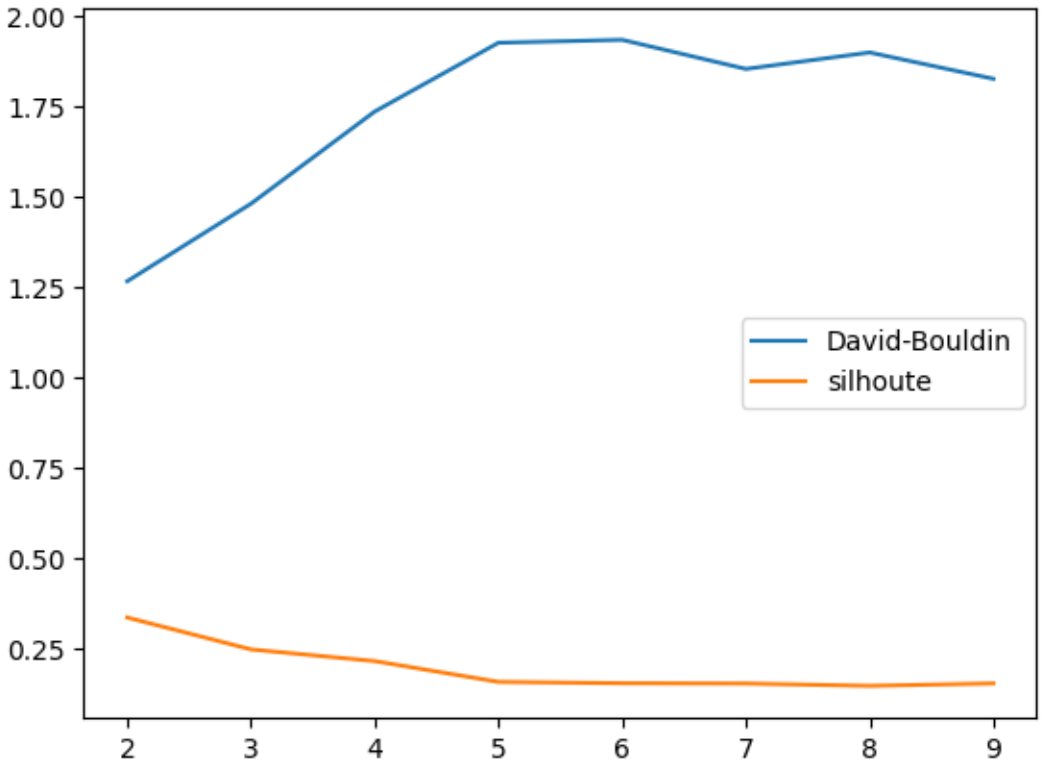
```
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
```

[515]:

```
# converting the results into a dataframe and plotting them
X = range(1,10)
plt.plot(X, EM, label = 'Elbow Method')
plt.plot(X, CH, label = 'Calinski Harabasz')
plt.legend()
plt.show()
```



[516]:
```
X = range(1,10)
plt.plot(X, DB, label = 'David-Bouldin')
plt.plot(X, SI, label = 'silhoute')
plt.legend()
plt.show()
```



[517]:
```
num_clusters = 2

km=KMeans(n_clusters= num_clusters)
y_predicted = km.fit_predict(df_scale[df.columns])
y_predicted.size
df_scale["Clusters"] = y_predicted

kmeans_model = KMeans(n_clusters=3, random_state=1).fit(df_scale)
labels = kmeans_model.labels_
metrics.calinski_harabasz_score(df_scale, labels)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
```

[517]: 312.4374024487499

[518]:
```
df_scale.describe()
```

[518]:

	Apps	Accept	Enroll	Top10perc	Top25perc
count	500.000000	500.000000	500.000000	500.000000	500.000000
mean	0.196099	0.251133	0.320670	0.363836	0.500095
std	0.149108	0.172461	0.199558	0.219129	0.224306
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.089725	0.119754	0.165274	0.196721	0.321429
50%	0.157801	0.210238	0.277159	0.311475	0.488095
75%	0.256881	0.347768	0.431058	0.512295	0.678571
max	1.000000	1.000000	1.000000	1.000000	1.000000

	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books
count	500.000000	500.000000	500.000000	500.000000	500.000000
mean	0.387616	0.267147	0.397037	0.428688	0.509162
std	0.242274	0.230255	0.214679	0.198106	0.171609
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.214707	0.076175	0.231247	0.295313	0.391304
50%	0.309455	0.194084	0.372584	0.408691	0.478261
75%	0.523573	0.395057	0.544970	0.549316	0.652174
max	1.000000	1.000000	1.000000	1.000000	1.000000

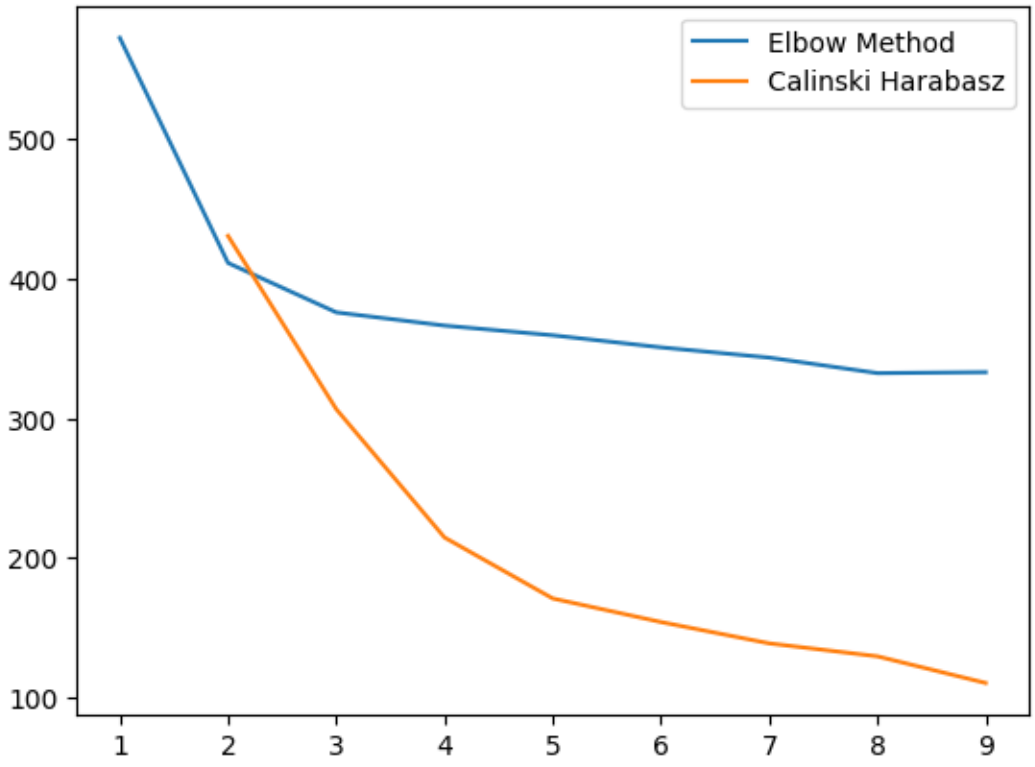
	Personal	PhD	Terminal	S.F.Ratio	perc.alumni
count	500.000000	500.000000	500.000000	500.000000	500.000000
mean	0.428988	0.545541	0.640090	0.568324	0.360107
std	0.225068	0.201402	0.212060	0.191922	0.201475
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.244444	0.402027	0.507463	0.429577	0.196429
50%	0.400000	0.567568	0.656716	0.559859	0.357143
75%	0.555556	0.675676	0.820896	0.691901	0.500000
max	1.000000	1.000000	1.000000	1.000000	1.000000

	Expend	Grad.Rate	Private	Clusters
count	500.000000	500.000000	500.000000	500.000000
mean	0.391677	0.534177	0.674000	0.674000
std	0.213743	0.205534	0.469217	0.469217
min	0.000000	0.000000	0.000000	0.000000
25%	0.249440	0.379747	0.000000	0.000000
50%	0.357173	0.531646	1.000000	1.000000
75%	0.509028	0.696203	1.000000	1.000000
max	1.000000	1.000000	1.000000	1.000000

[519]:
```
EM = []
CH = []
CH.append(None)
DB = []
DB.append(None)
```

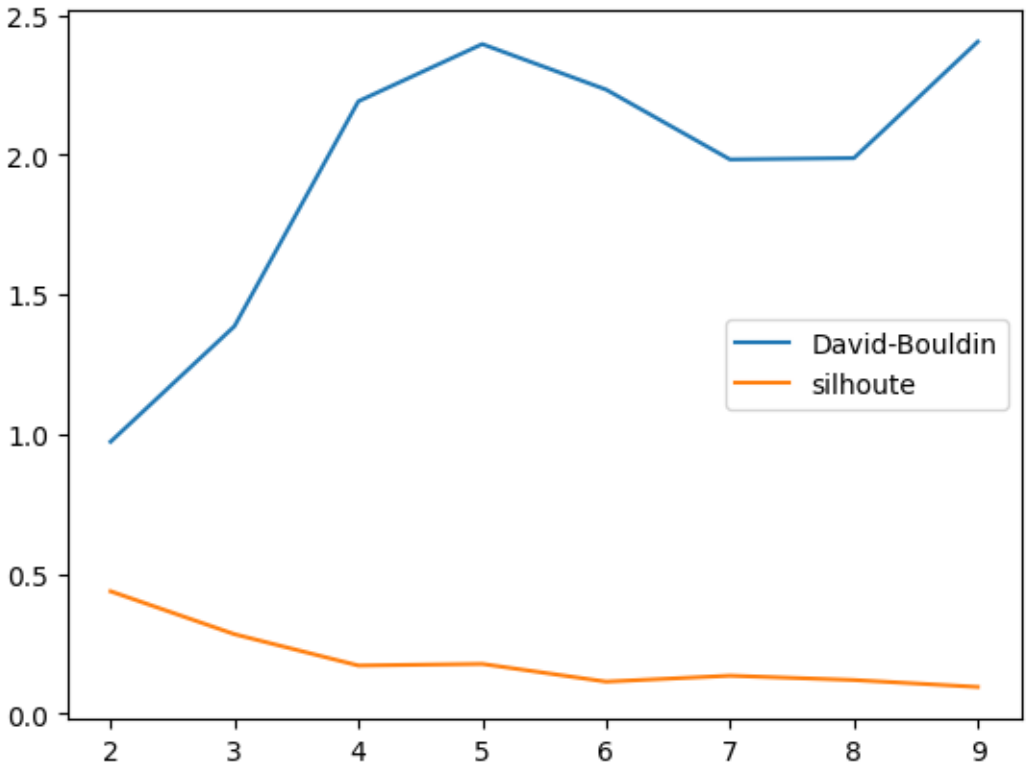
```
SI = []
SI.append(None)
for cluster in range(1,10):
    kmeans = KMedoids(n_clusters = cluster, init='k-medoids++').fit(df_scale)
    EM.append(kmeans.inertia_)

    labels = kmeans.labels_
    if cluster >1:
      CH.append(metrics.calinski_harabasz_score(df_scale, labels))
      DB.append(metrics.davies_bouldin_score(df_scale, labels))
      SI.append(metrics.silhouette_score(df_scale, labels))
```

[520]:
```
# converting the results into a dataframe and plotting them
X = range(1,10)
plt.plot(X, EM, label = 'Elbow Method')
plt.plot(X, CH, label = 'Calinski Harabasz')
plt.legend()
plt.show()
```



[521]:
```
X = range(1,10)
plt.plot(X, DB, label = 'David-Bouldin')
plt.plot(X, SI, label = 'silhoute')
```

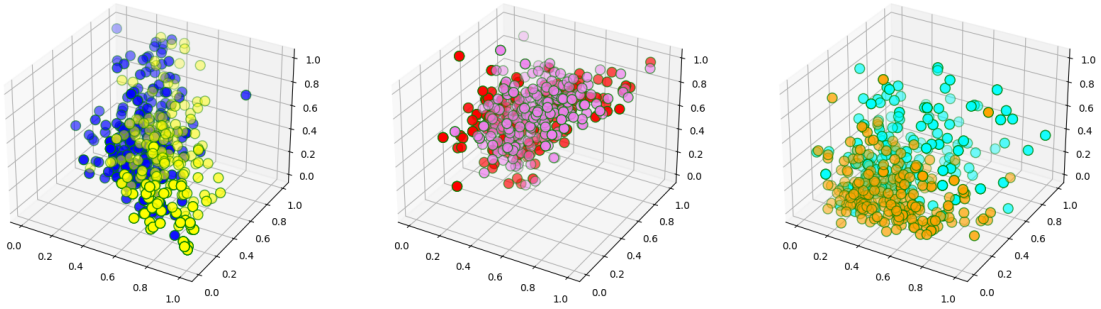
```
plt.legend()
plt.show()
```



[522]:
```
num_clusters = 2

kmd=KMedoids(n_clusters= num_clusters)
y_predicted = kmd.fit_predict(df_scale[df.columns])
y_predicted.size
df_scale["Clusters_medoids"] = y_predicted
```

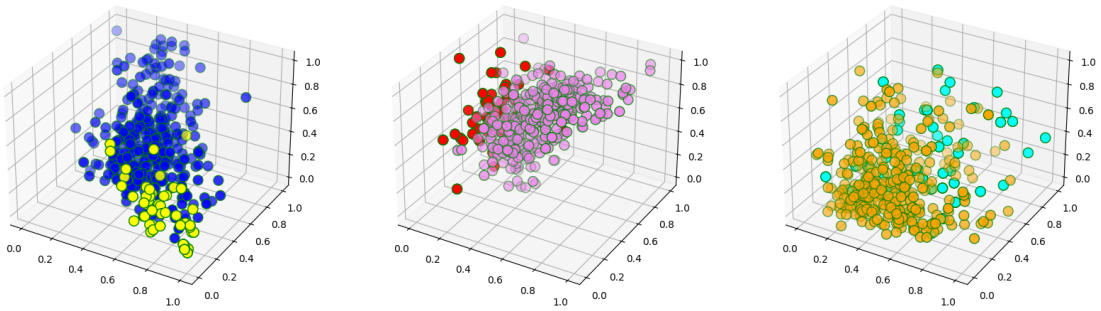
[523]:
```
fig = plt.figure(figsize=(20,10))
ax = fig.add_subplot(1,3,1, projection='3d')
ax.scatter(df_scale["S.F.Ratio"][df_scale.Clusters_medoids == 0],␣
 ↪df_scale["Outstate"][df_scale.Clusters_medoids == 0],␣
 ↪df_scale["Expend"][df_scale.Clusters_medoids == 0], c='yellow', s=100,␣
 ↪edgecolor='green',linestyle='-')
ax.scatter(df_scale["S.F.Ratio"][df_scale.Clusters_medoids == 1],␣
 ↪df_scale["Outstate"][df_scale.Clusters_medoids == 1],␣
 ↪df_scale["Expend"][df_scale.Clusters_medoids == 1], c='blue', s=100,␣
 ↪edgecolor='green',linestyle='-')

ax = fig.add_subplot(1,3,2, projection='3d')
```

```
ax.scatter(df_scale["Outstate"][df_scale.Clusters_medoids == 0],␣
 ↪df_scale["Books"][df_scale.Clusters_medoids == 0],␣
 ↪df_scale["Terminal"][df_scale.Clusters_medoids == 0], c='red', s=100,␣
 ↪edgecolor='green',linestyle='-')
ax.scatter(df_scale["Outstate"][df_scale.Clusters_medoids == 1],␣
 ↪df_scale["Books"][df_scale.Clusters_medoids == 1],␣
 ↪df_scale["Terminal"][df_scale.Clusters_medoids == 1], c='violet', s=100,␣
 ↪edgecolor='green',linestyle='-')

ax = fig.add_subplot(1,3,3, projection='3d')
ax.scatter(df_scale["Personal"][df_scale.Clusters_medoids == 0], df_scale["F.
 ↪Undergrad"][df_scale.Clusters_medoids == 0], df_scale["P.
 ↪Undergrad"][df_scale.Clusters_medoids == 0], c='cyan', s=100,␣
 ↪edgecolor='green',linestyle='-')
ax.scatter(df_scale["Personal"][df_scale.Clusters_medoids == 1], df_scale["F.
 ↪Undergrad"][df_scale.Clusters_medoids == 1], df_scale["P.
 ↪Undergrad"][df_scale.Clusters_medoids == 1], c='orange', s=100,␣
 ↪edgecolor='green',linestyle='-')

plt.show()
```



[524]:
```
fig = plt.figure(figsize=(20,10))
ax = fig.add_subplot(1,3,1, projection='3d')
ax.scatter(df_scale["S.F.Ratio"][df_scale.Clusters == 0],␣
 ↪df_scale["Outstate"][df_scale.Clusters == 0], df_scale["Expend"][df_scale.
 ↪Clusters == 0], c='yellow', s=100, edgecolor='green',linestyle='-')
ax.scatter(df_scale["S.F.Ratio"][df_scale.Clusters == 1],␣
 ↪df_scale["Outstate"][df_scale.Clusters == 1], df_scale["Expend"][df_scale.
 ↪Clusters == 1], c='blue', s=100, edgecolor='green',linestyle='-')

ax = fig.add_subplot(1,3,2, projection='3d')
ax.scatter(df_scale["Outstate"][df_scale.Clusters == 0],␣
 ↪df_scale["Books"][df_scale.Clusters == 0], df_scale["Terminal"][df_scale.
 ↪Clusters == 0], c='red', s=100, edgecolor='green',linestyle='-')
```

```
ax.scatter(df_scale["Outstate"][df_scale.Clusters == 1],␣
 ↪df_scale["Books"][df_scale.Clusters == 1], df_scale["Terminal"][df_scale.
 ↪Clusters == 1], c='violet', s=100, edgecolor='green',linestyle='-')

ax = fig.add_subplot(1,3,3, projection='3d')
ax.scatter(df_scale["Personal"][df_scale.Clusters == 0], df_scale["F.
 ↪Undergrad"][df_scale.Clusters == 0], df_scale["P.Undergrad"][df_scale.
 ↪Clusters == 0], c='cyan', s=100, edgecolor='green',linestyle='-')
ax.scatter(df_scale["Personal"][df_scale.Clusters == 1], df_scale["F.
 ↪Undergrad"][df_scale.Clusters == 1], df_scale["P.Undergrad"][df_scale.
 ↪Clusters == 1], c='orange', s=100, edgecolor='green',linestyle='-')

plt.show()
```

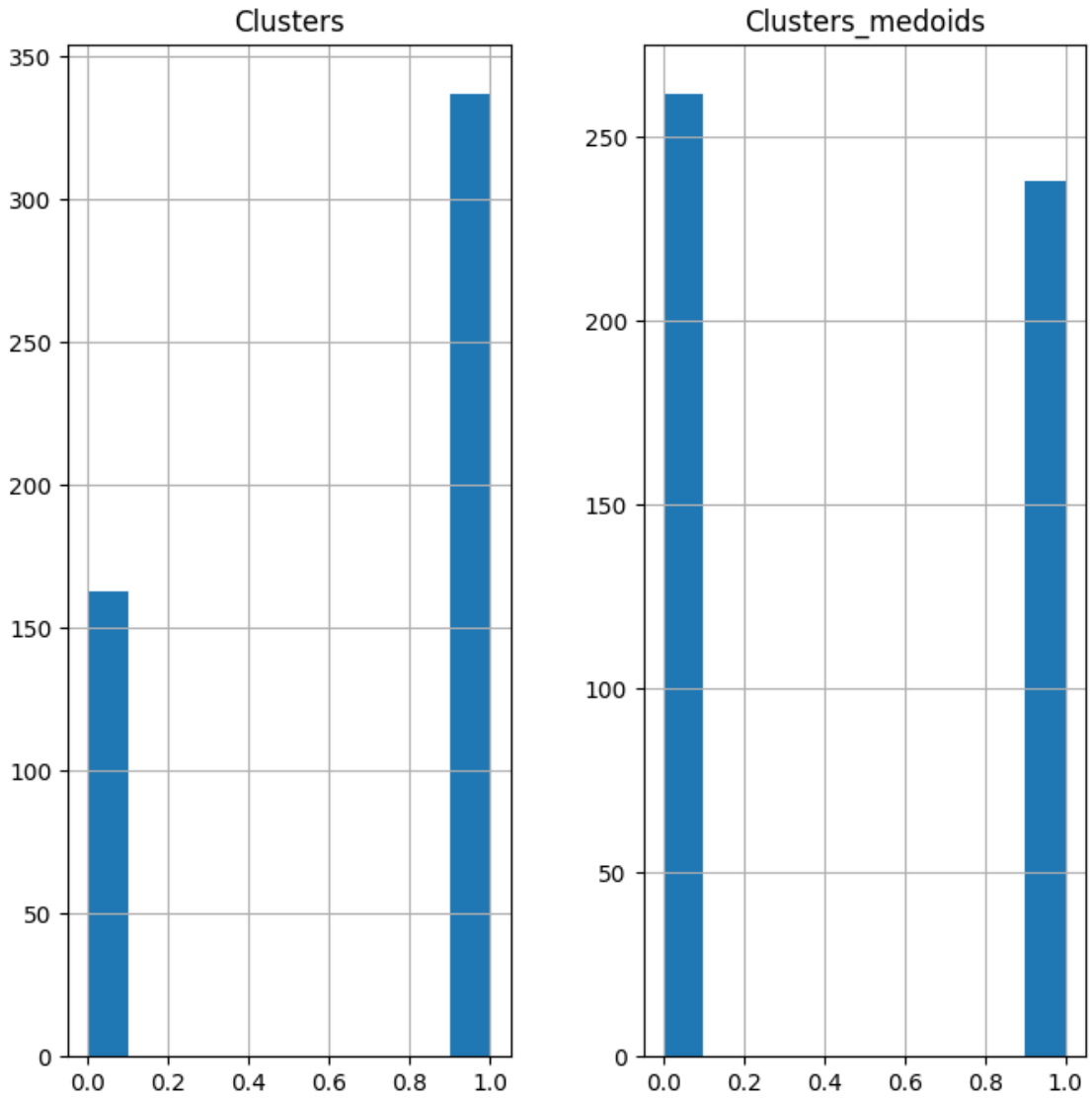


6 Análise dos clusters

vamos ver como cada variável está distribuida nos clusters.

[525]:
```
fig = plt.figure(figsize=(8,8))
ax = fig.gca()
df_scale[df_scale.columns[18:]].hist(ax=ax)
plt.show()
```

```
<ipython-input-525-b6e7f97a3629>:3: UserWarning: To output multiple subplots,
the figure containing the passed axes is being cleared.
  df_scale[df_scale.columns[18:]].hist(ax=ax)
```



[526]:
```
dist = df_scale[(df_scale["Private"] == 0)]
dist = dist[["Private","Clusters", "Clusters_medoids"]]
dist.describe()
```

[526]:

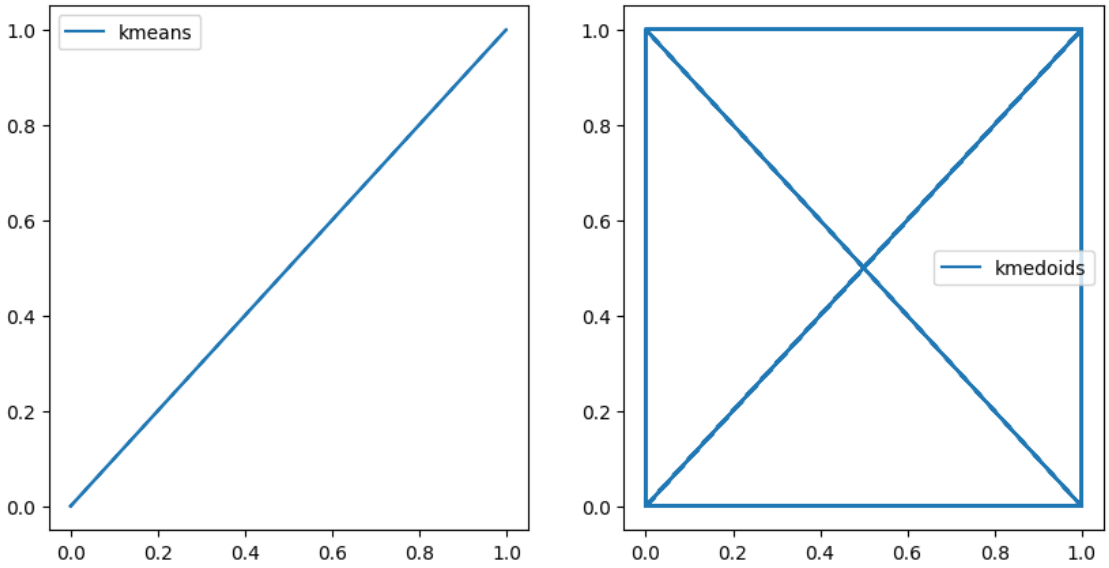
	Private	Clusters	Clusters_medoids
count	163.0	163.0	163.000000
mean	0.0	0.0	0.214724
std	0.0	0.0	0.411896
min	0.0	0.0	0.000000
25%	0.0	0.0	0.000000
50%	0.0	0.0	0.000000
75%	0.0	0.0	0.000000
max	0.0	0.0	1.000000

[527]:
```
dist = df_scale[(df_scale["Private"] == 1)]
dist = dist[["Private","Clusters", "Clusters_medoids"]]
dist.describe()
```

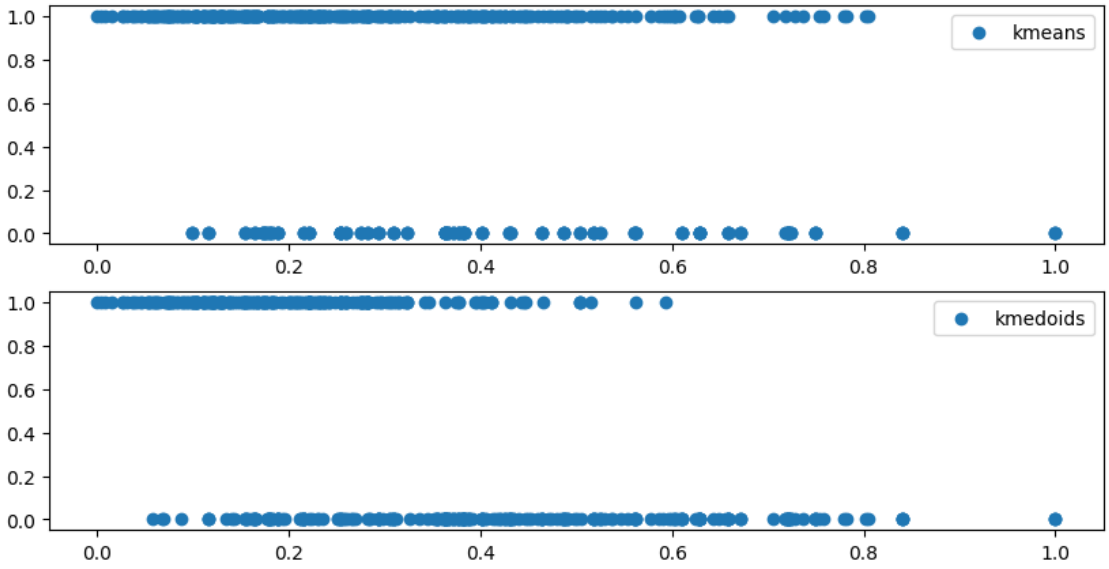
[527]:

	Private	Clusters	Clusters_medoids
count	337.0	337.0	337.000000
mean	1.0	1.0	0.602374
std	0.0	0.0	0.490135
min	1.0	1.0	0.000000
25%	1.0	1.0	0.000000
50%	1.0	1.0	1.000000
75%	1.0	1.0	1.000000
max	1.0	1.0	1.000000

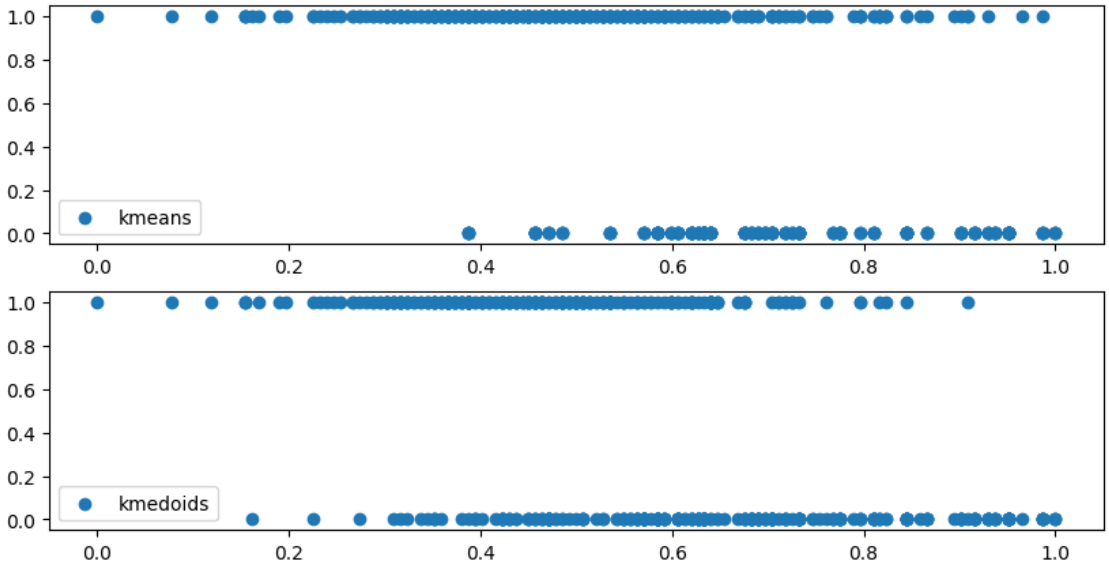
[528]:
```
x = df_scale[["Private"]]
y = df_scale[["Clusters"]]
z = df_scale[["Clusters_medoids"]]

fig = plt.figure(figsize=(10,5))
ax = fig.add_subplot(1,2,1)
ax.plot(x,y, label="kmeans")
ax.legend()
ax = fig.add_subplot(1,2,2)
ax.plot(x,z, label="kmedoids")
ax.legend()
plt.show()
```



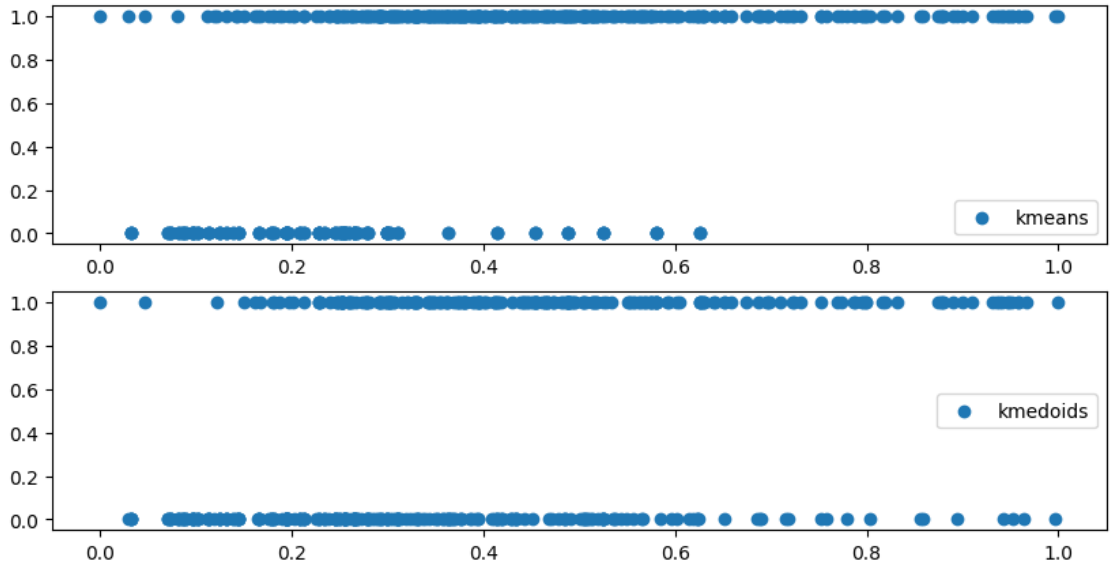
[529]:
```
x = df_scale[["Enroll"]]
y = df_scale[["Clusters"]]
z = df_scale[["Clusters_medoids"]]

fig = plt.figure(figsize=(10,5))
ax = fig.add_subplot(2,1,1)
ax.scatter(x,y, label="kmeans")
ax.legend()
ax = fig.add_subplot(2,1,2)
ax.scatter(x,z, label="kmedoids")
ax.legend()
plt.show()
```



[530]:
```
x = df_scale[["S.F.Ratio"]]
y = df_scale[["Clusters"]]
z = df_scale[["Clusters_medoids"]]

fig = plt.figure(figsize=(10,5))
ax = fig.add_subplot(2,1,1)
ax.scatter(x,y, label="kmeans")
ax.legend()
ax = fig.add_subplot(2,1,2)
ax.scatter(x,z, label="kmedoids")
ax.legend()
plt.show()
```



[531]:
```
x = df_scale[["Expend"]]
y = df_scale[["Clusters"]]
z = df_scale[["Clusters_medoids"]]

fig = plt.figure(figsize=(10,5))
ax = fig.add_subplot(2,1,1)
ax.scatter(x,y, label="kmeans")
ax.legend()
ax = fig.add_subplot(2,1,2)
ax.scatter(x,z, label="kmedoids")
ax.legend()
plt.show()
```



[532]:
```
labels = km.predict(tests)
labels_medoid = kmd.predict(tests)
```