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Course : Data Analytics - Lab

Course Code : MCSE615L

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Assignment : Exploratory Data Analysis and Insights Generation from *Student Performance* Dataset

Repository

https://github.com/harmanpreet-s/data-analytics-student-performance

Introduction

The Student Performance Analysis and Predictive Modeling project aims to analyze and model student performance based on various attributes. The project utilizes two datasets, namely the Math and Portuguese datasets, which contain information about students' demographics, family background, study habits, and grades.

Objective

The objective of the assignment is to analyze student performance based on the given datasets and build predictive models to forecast student performance using machine learning algorithms. The assignment also involves feature selection to identify the most relevant features that contribute to student performance. Additionally, clustering analysis is performed to group students based on similar characteristics. The final objective is to evaluate and validate the performance of the models or analysis techniques using appropriate evaluation metrics.

Dataset Overview

There are two datasets: one for the Math course (student-mat.csv) and another for the Portuguese language course (student-por.csv). The dataset contains various attributes about the students, such as their personal information, family background, study habits, social activities, and academic performance.

The dataset also includes three columns (G1, G2, G3) that represent the students' grades for the corresponding course. G1 represents the first period grade, G2 represents the second period grade, and G3 represents the final grade.

Phase 1: Data Exploration

The project begins with data exploration to understand the structure and content of the datasets. The code provided loads the Math and Portuguese datasets using the pandas library and displays the first few rows of each dataset. Additionally, it prints the number of records in each dataset and checks for missing values.

Importing initial required libraries and loading the datasets

```
# Importing the initial libraries
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Load the datasets
df_math = pd.read_csv('./dataset/student-mat.csv', sep=';')
df_portuguese = pd.read_csv('./dataset/student-por.csv',
sep=';')
```

Exploring the values in the Maths dataset

```
print("Math Dataset:")
print(df_math.head())  # Display the first few rows of the
math dataset
```

```
Math Dataset:
  school sex  age address famsize Pstatus  Medu  Fedu     Mjob      Fjob  ... \
0     GP   F   18       U     GT3       A     4     4  at_home   teacher  ...
1     GP   F   17       U     GT3       T     1     1  at_home     other  ...
2     GP   F   15       U     LE3       T     1     1  at_home     other  ...
3     GP   F   15       U     GT3       T     4     2   health  services  ...
4     GP   F   16       U     GT3       T     3     3    other     other  ...

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

[5 rows x 33 columns]
```

Exploring the values in the Portuguese dataset

```
print("Portuguese Dataset:")
print(df_portuguese.head())  # Display the first few rows of the Portuguese dataset
```

```
Portuguese Dataset:
  school sex  age address famsize Pstatus  Medu  Fedu     Mjob      Fjob  ... \
0     GP   F   18       U     GT3       A     4     4  at_home   teacher  ...
1     GP   F   17       U     GT3       T     1     1  at_home     other  ...
2     GP   F   15       U     LE3       T     1     1  at_home     other  ...
3     GP   F   15       U     GT3       T     4     2   health  services  ...
4     GP   F   16       U     GT3       T     3     3    other     other  ...

  famrel freetime  goout  Dalc  Walc health absences  G1  G2  G3
0      4        3      4     1     1      3        4   0  11  11
1      5        3      3     1     1      3        2   9  11  11
2      4        3      2     2     3      3        6  12  13  12
3      3        2      2     1     1      5        0  14  14  14
4      4        3      2     1     2      5        0  11  13  13

[5 rows x 33 columns]
```

Checking the number of records

```
print("Number of records in Math Dataset:", len(df_math))
print("Number of records in Portuguese Dataset:", len(df_portuguese))
```

```
Number of records in Math Dataset: 395
Number of records in Portuguese Dataset: 649
```

```python
# Check for missing values in the math dataset
print("Missing values in Math Dataset:")
print(df_math.isnull().sum())
```

```
Missing values in Math Dataset:
school        0
sex           0
age           0
address       0
famsize       0
Pstatus       0
Medu          0
Fedu          0
Mjob          0
Fjob          0
reason        0
guardian      0
traveltime    0
studytime     0
failures      0
schoolsup     0
famsup        0
paid          0
activities    0
nursery       0
higher        0
internet      0
romantic      0
famrel        0
freetime      0
goout         0
Dalc          0
Walc          0
health        0
absences      0
G1            0
G2            0
G3            0
dtype: int64
```

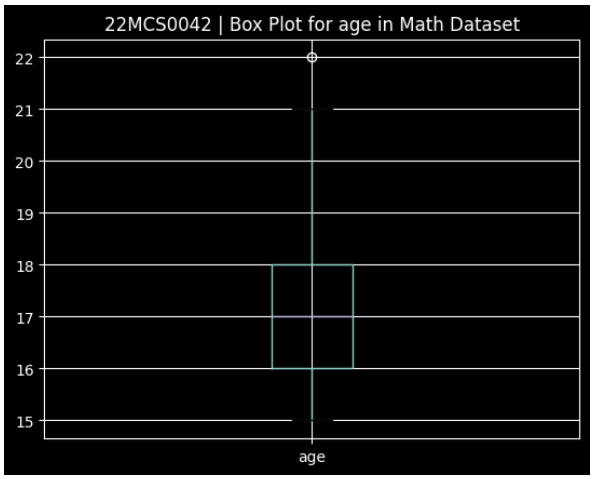
```python
# Check for missing values in the Portuguese dataset
print("Missing values in Portuguese Dataset:")
print(df_portuguese.isnull().sum())
```

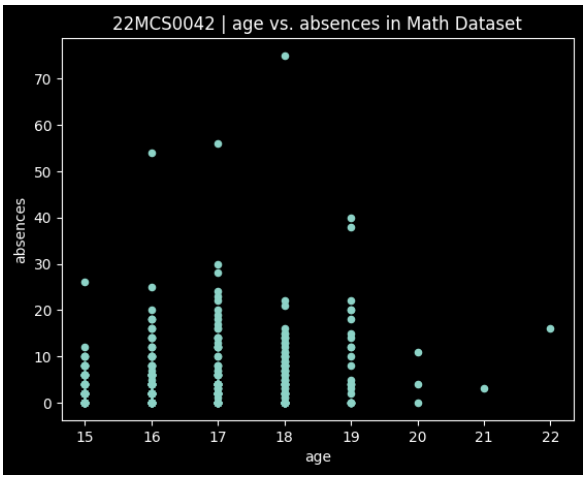
```
Missing values in Portuguese Dataset:
school        0
sex           0
age           0
address       0
famsize       0
Pstatus       0
Medu          0
Fedu          0
Mjob          0
Fjob          0
reason        0
guardian      0
traveltime    0
studytime     0
failures      0
schoolsup     0
famsup        0
paid          0
activities    0
nursery       0
higher        0
internet      0
romantic      0
famrel        0
freetime      0
goout         0
Dalc          0
Walc          0
health        0
absences      0
G1            0
G2            0
G3            0
dtype: int64
```

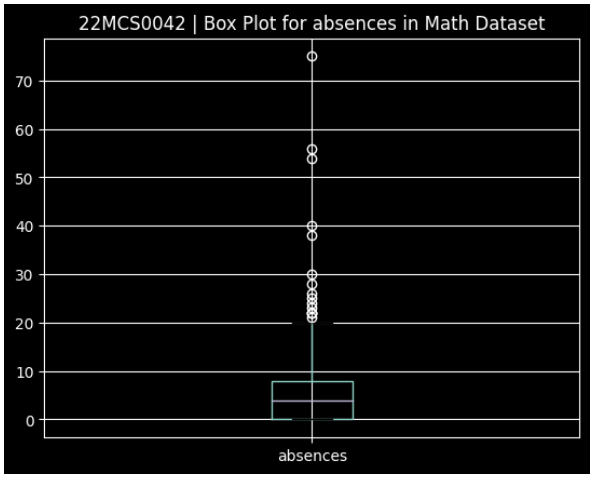
There are no missing values found in the dataset.

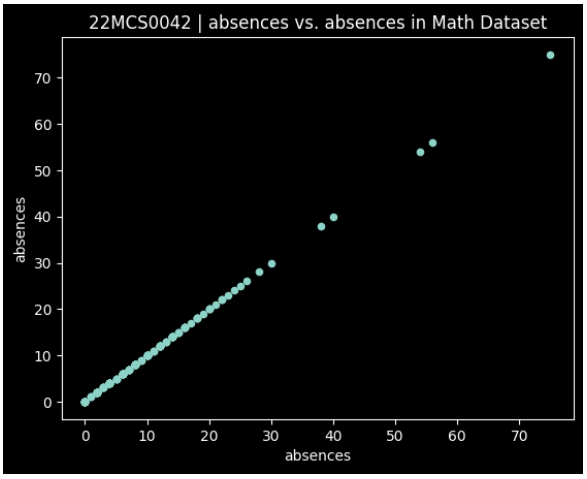
Checking for Outliers

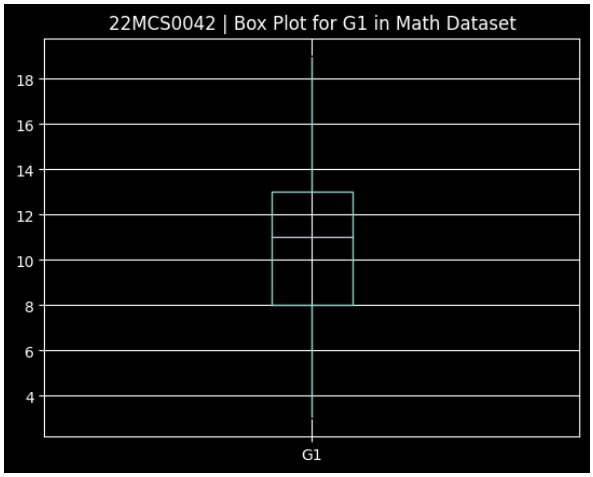
```
# Check for outliers in numerical variables
numerical_vars = ['age', 'absences', 'G1', 'G2', 'G3']
for var in numerical_vars:
    # Box plot
    df_math.boxplot(column=var)
    plt.title('22MCS0042 | Box Plot for ' + var + ' in Math Dataset')
    plt.show()

    # Scatter plot (against another numerical variable)
    df_math.plot.scatter(x=var, y='absences')
    plt.title('22MCS0042 | ' + var + ' vs. absences in Math Dataset')
    plt.show()
```

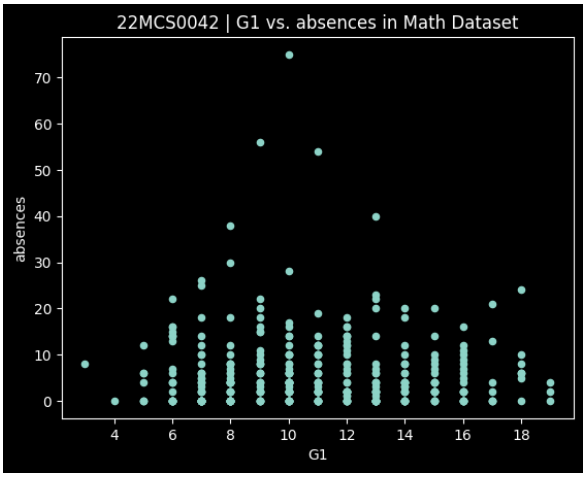


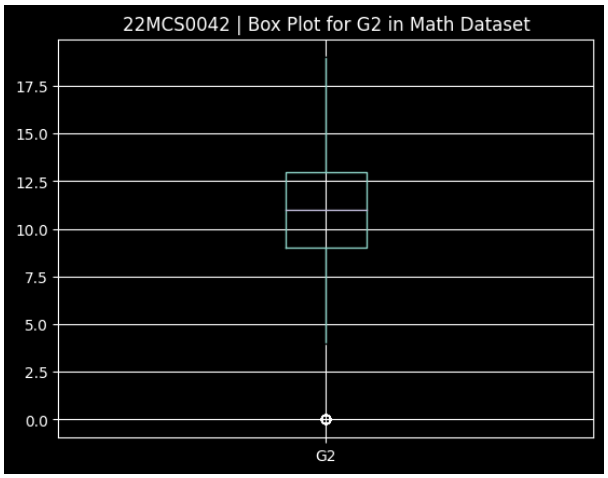


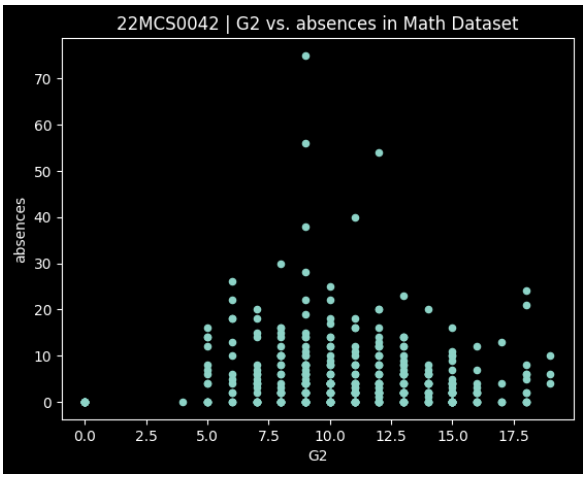


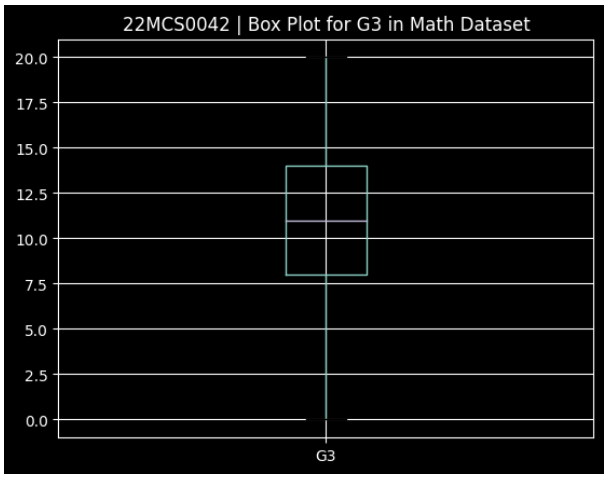


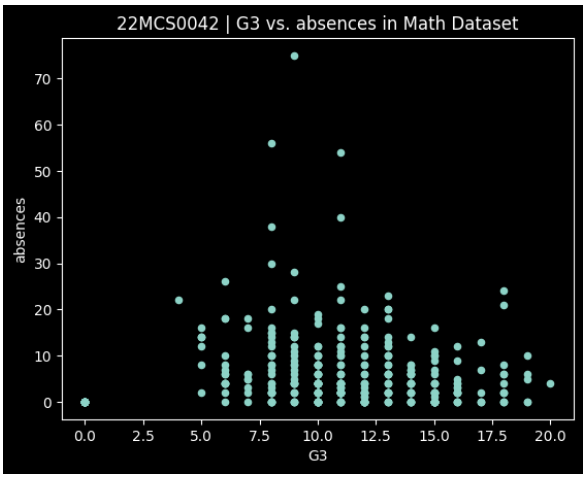

22MCS0042 | Box Plot for G1 in Math Dataset
G1


22MCS0042 | G1 vs. absences in Math Dataset
absences
G1


22MCS0042 | Box Plot for G2 in Math Dataset
G2


22MCS0042 | G2 vs. absences in Math Dataset
absences
G2


22MCS0042 | Box Plot for G3 in Math Dataset
G3


22MCS0042 | G3 vs. absences in Math Dataset
absences
G3

```python
# Check cardinality in categorical variables
categorical_vars = ['school', 'sex', 'address', 'famsize',
'Pstatus', 'Mjob', 'Fjob', 'reason', 'guardian',
                    'schoolsup', 'famsup', 'paid',
'activities', 'nursery', 'higher', 'internet', 'romantic']
for var in categorical_vars:
    # Unique values
    unique_values = df_math[var].nunique()
    print("Unique values in", var, "in Math Dataset:",
unique_values)

    # Value counts
    value_counts = df_math[var].value_counts()
    print("Value counts for", var, "in Math Dataset:")
    print(value_counts)
    print("\n")
```

```
Unique values in school in Math Dataset: 2
Value counts for school in Math Dataset:
GP    349
MS     46
Name: school, dtype: int64


Unique values in sex in Math Dataset: 2
Value counts for sex in Math Dataset:
F    208
M    187
Name: sex, dtype: int64


Unique values in address in Math Dataset: 2
Value counts for address in Math Dataset:
U    307
R     88
Name: address, dtype: int64


Unique values in famsize in Math Dataset: 2
Value counts for famsize in Math Dataset:
GT3    281
LE3    114
Name: famsize, dtype: int64
```

```
Unique values in Pstatus in Math Dataset: 2
Value counts for Pstatus in Math Dataset:
T    354
A     41
Name: Pstatus, dtype: int64


Unique values in Mjob in Math Dataset: 5
Value counts for Mjob in Math Dataset:
other       141
services    103
at_home      59
teacher      58
health       34
Name: Mjob, dtype: int64


Unique values in Fjob in Math Dataset: 5
Value counts for Fjob in Math Dataset:
other       217
services    111
teacher      29
at_home      20
health       18
Name: Fjob, dtype: int64
```

```
Unique values in reason in Math Dataset: 4
Value counts for reason in Math Dataset:
course        145
home          109
reputation    105
other          36
Name: reason, dtype: int64
```

```
Unique values in guardian in Math Dataset: 3
Value counts for guardian in Math Dataset:
mother    273
father     90
other      32
Name: guardian, dtype: int64


Unique values in schoolsup in Math Dataset: 2
Value counts for schoolsup in Math Dataset:
no     344
yes     51
Name: schoolsup, dtype: int64


Unique values in famsup in Math Dataset: 2
Value counts for famsup in Math Dataset:
yes    242
no     153
Name: famsup, dtype: int64
```

```
Unique values in paid in Math Dataset: 2
Value counts for paid in Math Dataset:
no     214
yes    181
Name: paid, dtype: int64


Unique values in activities in Math Dataset: 2
Value counts for activities in Math Dataset:
yes    201
no     194
Name: activities, dtype: int64
```

```
Unique values in nursery in Math Dataset: 2
Value counts for nursery in Math Dataset:
yes    314
no      81
Name: nursery, dtype: int64


Unique values in higher in Math Dataset: 2
Value counts for higher in Math Dataset:
yes    375
no      20
Name: higher, dtype: int64


Unique values in internet in Math Dataset: 2
Value counts for internet in Math Dataset:
yes    329
no      66
Name: internet, dtype: int64
```

```
Unique values in romantic in Math Dataset: 2
Value counts for romantic in Math Dataset:
no     263
yes    132
Name: romantic, dtype: int64
```

Phase 2: Data Integration

To perform comprehensive analysis, the Math and Portuguese datasets are merged based on common attributes using the merge function from pandas. The resulting merged dataset, named merged_df, combines the information from both datasets into a single dataset.

```
# Merge the two datasets based on common attributes
merged_df = pd.merge(df_math, df_portuguese, on=['school',
'sex', 'age', 'address', 'famsize', 'Pstatus',
                                                 'Medu',
'Fedu', 'Mjob', 'Fjob', 'reason', 'guardian',
                                                 'traveltime
', 'studytime', 'failures', 'schoolsup',
                                                 'famsup',
'paid', 'activities', 'nursery', 'higher',
                                                 'internet',
'romantic', 'famrel', 'freetime', 'goout',
                                                 'Dalc',
'Walc', 'health', 'absences'], suffixes=('_math',
'_portuguese'))
```

Phase 3: Descriptive Statistics

Descriptive statistics provide a summary of the datasets, including measures of central tendency and variability. The code provided calculates and displays summary statistics for both the Math and Portuguese datasets using the describe() function.

```
# Display summary statistics for the math dataset
print("Summary Statistics for Math Dataset:")
print(df_math.describe())
```

```
Summary Statistics for Math Dataset:
              age        Medu        Fedu  traveltime   studytime    failures  \
count  395.000000  395.000000  395.000000  395.000000  395.000000  395.000000
mean    16.696203    2.749367    2.521519    1.448101    2.035443    0.334177
std      1.276043    1.094735    1.088201    0.697505    0.839240    0.743651
min     15.000000    0.000000    0.000000    1.000000    1.000000    0.000000
25%     16.000000    2.000000    2.000000    1.000000    1.000000    0.000000
50%     17.000000    3.000000    2.000000    1.000000    2.000000    0.000000
75%     18.000000    4.000000    3.000000    2.000000    2.000000    0.000000
max     22.000000    4.000000    4.000000    4.000000    4.000000    3.000000

             famrel    freetime       goout        Dalc        Walc      health  \
count  395.000000  395.000000  395.000000  395.000000  395.000000  395.000000
mean     3.944304    3.235443    3.108861    1.481013    2.291139    3.554430
std      0.896659    0.998862    1.113278    0.890741    1.287897    1.390303
min      1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
25%      4.000000    3.000000    2.000000    1.000000    1.000000    3.000000
50%      4.000000    3.000000    3.000000    1.000000    2.000000    4.000000
75%      5.000000    4.000000    4.000000    2.000000    3.000000    5.000000
max      5.000000    5.000000    5.000000    5.000000    5.000000    5.000000

          absences          G1          G2          G3
count  395.000000  395.000000  395.000000  395.000000
mean     5.708861   10.908861   10.713924   10.415190
std      8.003096    3.319195    3.761505    4.581443
min      0.000000    3.000000    0.000000    0.000000
25%      0.000000    8.000000    9.000000    8.000000
50%      4.000000   11.000000   11.000000   11.000000
75%      8.000000   13.000000   13.000000   14.000000
max     75.000000   19.000000   19.000000   20.000000
```

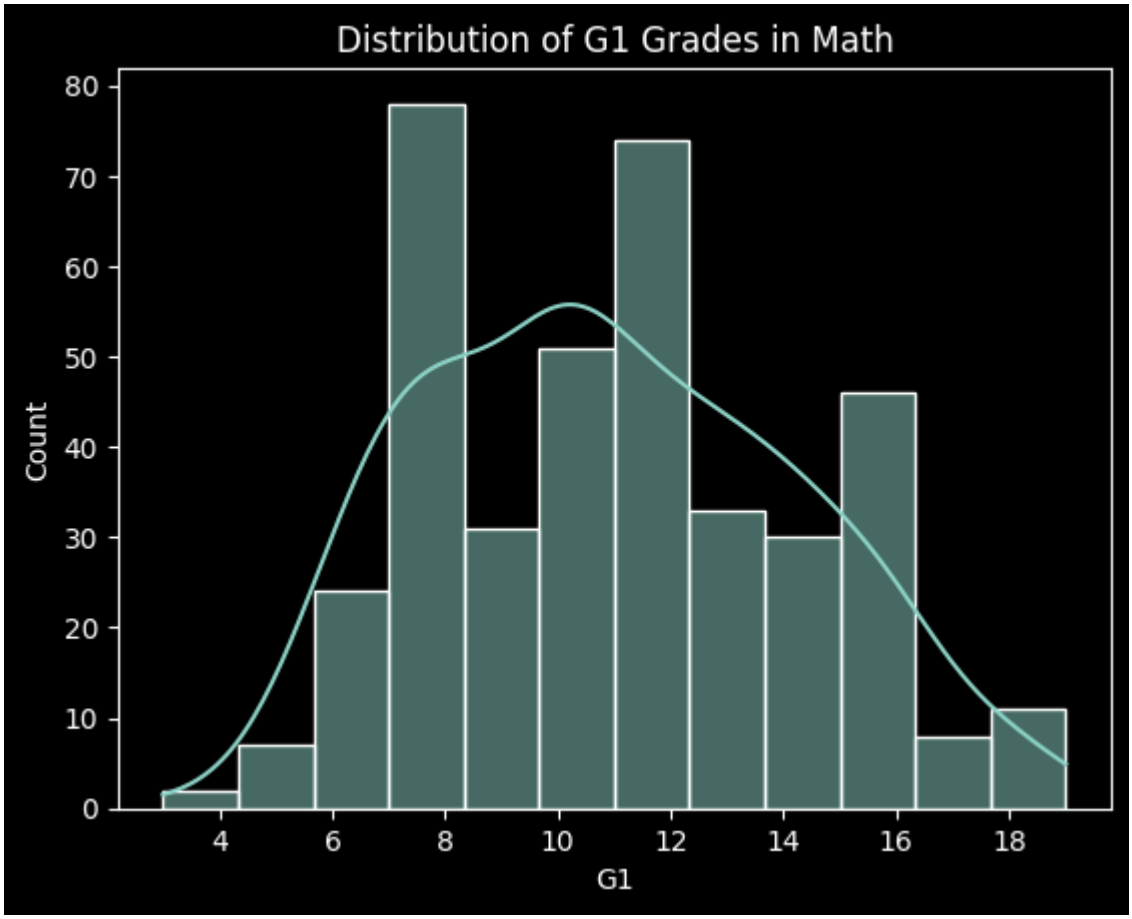
```python
# Display summary statistics for the Portuguese dataset
print("Summary Statistics for Portuguese Dataset:")
print(df_portuguese.describe())
```

```
Summary Statistics for Portuguese Dataset:
              age        Medu        Fedu  traveltime  studytime    failures  \
count  649.000000  649.000000  649.000000  649.000000  649.000000  649.000000
mean    16.744222    2.514638    2.306626    1.568567    1.930663    0.221880
std      1.218138    1.134552    1.099931    0.748660    0.829510    0.593235
min     15.000000    0.000000    0.000000    1.000000    1.000000    0.000000
25%     16.000000    2.000000    1.000000    1.000000    1.000000    0.000000
50%     17.000000    2.000000    2.000000    1.000000    2.000000    0.000000
75%     18.000000    4.000000    3.000000    2.000000    2.000000    0.000000
max     22.000000    4.000000    4.000000    4.000000    4.000000    3.000000

           famrel    freetime       goout        Dalc        Walc      health  \
count  649.000000  649.000000  649.000000  649.000000  649.000000  649.000000
mean     3.930663    3.180277    3.184900    1.502311    2.280431    3.536210
std      0.955717    1.051093    1.175766    0.924834    1.284380    1.446259
min      1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
25%      4.000000    3.000000    2.000000    1.000000    1.000000    2.000000
50%      4.000000    3.000000    3.000000    1.000000    2.000000    4.000000
75%      5.000000    4.000000    4.000000    2.000000    3.000000    5.000000
max      5.000000    5.000000    5.000000    5.000000    5.000000    5.000000

         absences          G1          G2          G3
count  649.000000  649.000000  649.000000  649.000000
mean     3.659476   11.399076   11.570108   11.906009
std      4.640759    2.745265    2.913639    3.230656
min      0.000000    0.000000    0.000000    0.000000
25%      0.000000   10.000000   10.000000   10.000000
50%      2.000000   11.000000   11.000000   12.000000
75%      6.000000   13.000000   13.000000   14.000000
max     32.000000   19.000000   19.000000   19.000000
```

Phase 4: Data Visualization

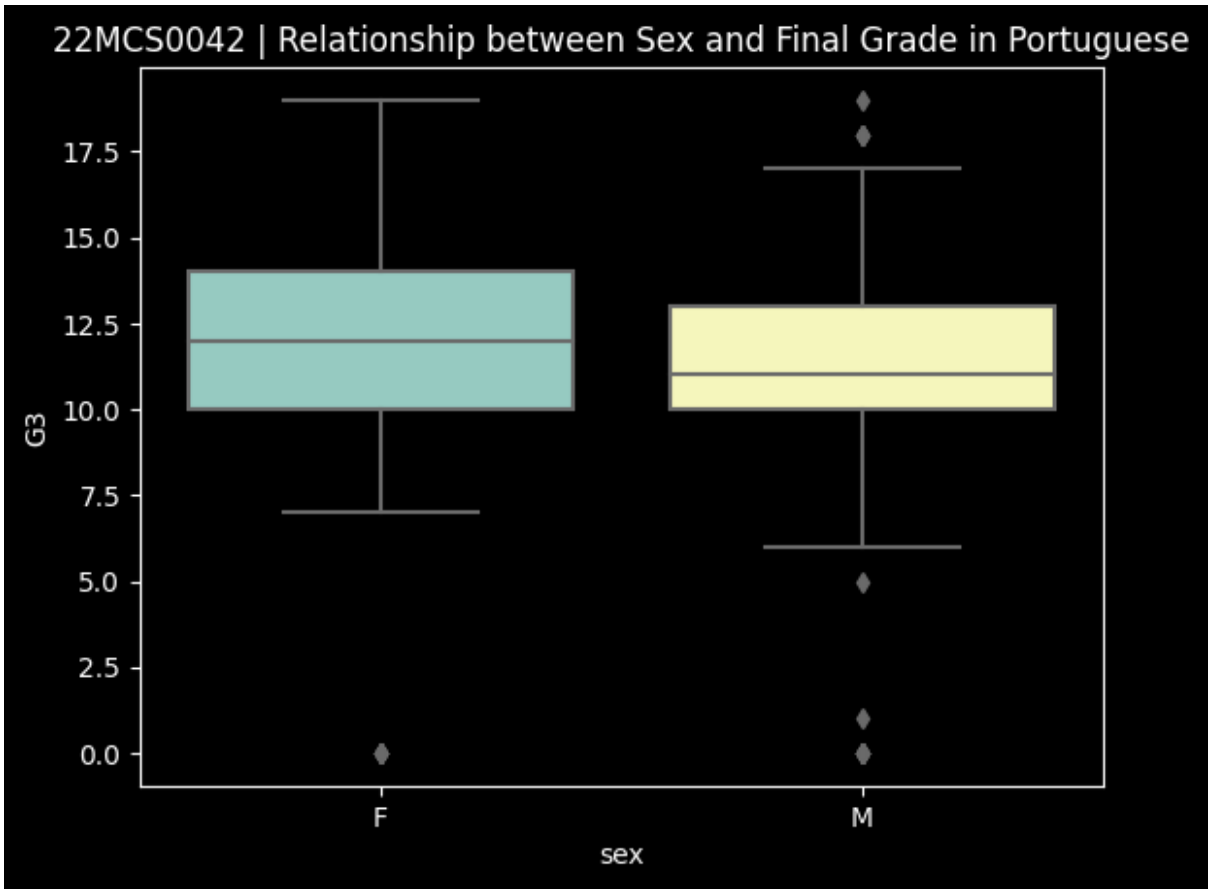
Data visualization is essential for gaining insights and understanding the distribution and relationships within the datasets. The code provided includes examples of data visualization using seaborn and matplotlib libraries. It generates histograms to visualize the distribution of G1 grades in Math and a box plot to explore the relationship between sex and the final grade (G3) in Portuguese.

```
# Plot to visualize the distribution of the 'G1' grades in
the Math dataset
sns.histplot(df_math['G1'], kde=True)
plt.title("22MCS0042 | Distribution of G1 Grades in Math")
plt.show()
```



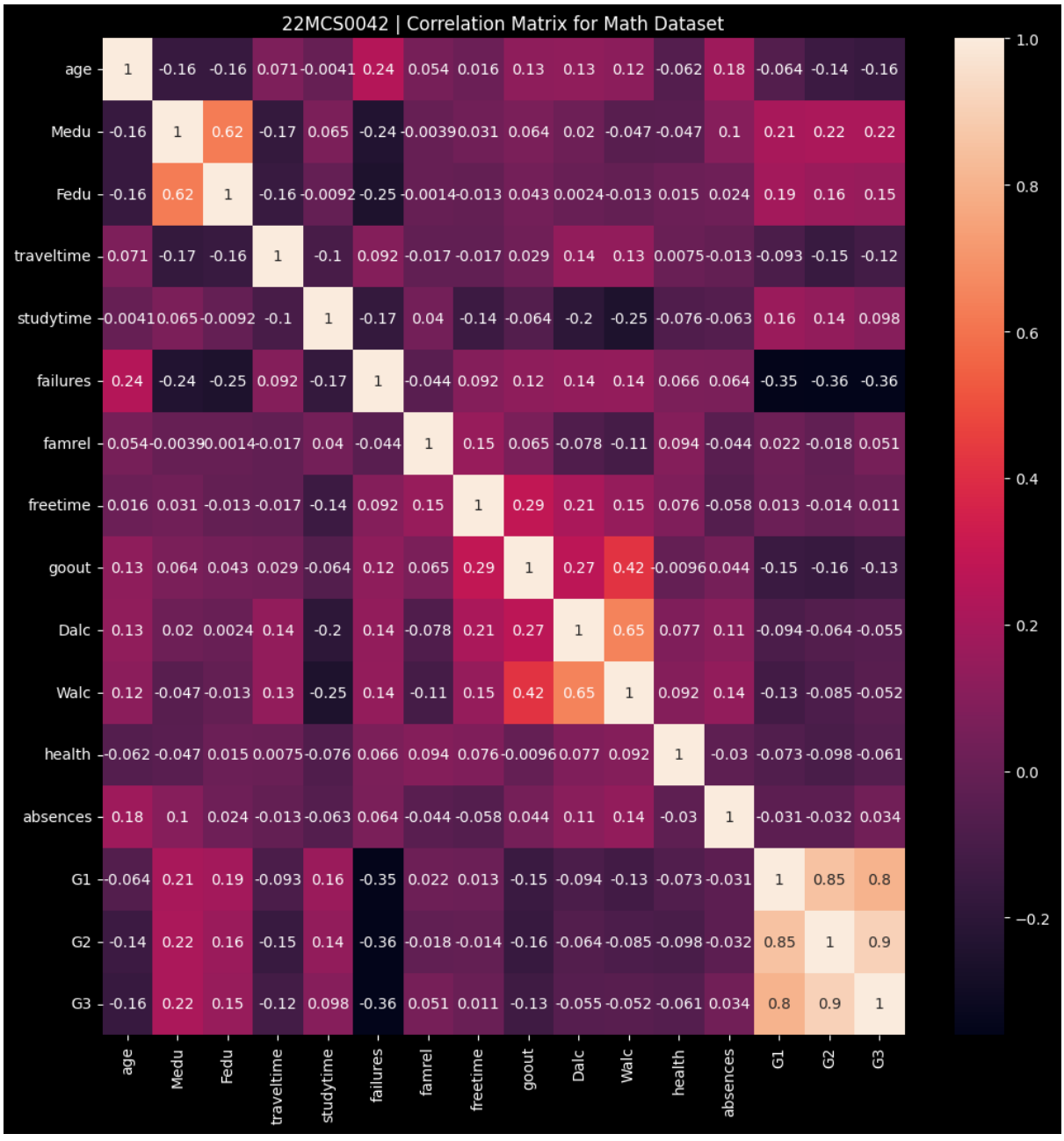
The histogram displays the frequency or count of different grade ranges on the x-axis and the corresponding number of students on the y-axis. The shape of the histogram provides insights into the distribution pattern of the 'G1' grades.

```
# Plot relationship between Sex and Final Grade in
Portuguese
sns.boxplot(x='sex', y='G3', data=df_portuguese)
plt.title("22MCS0042 | Relationship between Sex and Final
Grade in Portuguese")
plt.show()
```



We generated a boxplot to explore the relationship between sex and final grades in the Portuguese dataset, and a histogram to analyze the distribution of G1 grades for a specific student in the Math dataset. These visualizations aid in understanding the grade distributions and patterns within the respective datasets.

```
# Correlation Analysis
fig, ax = plt.subplots(figsize=(12, 12))
correlation_matrix = df_math.corr()
sns.heatmap(correlation_matrix, annot=True)
plt.title("22MCS0042 | Correlation Matrix for Math Dataset")
plt.show()
```



A correlation analysis on the Math dataset and generates a heatmap visualization to depict the correlation matrix. The heatmap provides valuable insights into the relationships between different variables, allowing for the identification of potentially significant associations within the dataset.

Preparing for further work

Importing the required libraries to work with the Feature Selection, Modeling, Analysis and Evaluation

```
# Import required libraries
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.feature_selection import SelectKBest,
f_regression
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from sklearn.metrics import mean_squared_error, r2_score
```

Loading the maths dataset again to primarily work on it.

```
# Load the Maths dataset
df = pd.read_csv('./dataset/student-mat.csv', sep=';')
```

Selecting the relevant feature and target variable for the further work

```
# Select relevant features and target variable
features = ['age', 'Medu', 'Fedu', 'studytime', 'failures',
'absences']
target = 'G3'
X = df[features]
y = df[target]
```

Splitting the dataset into Training and Testing sets, taking 80% training data with random_state = 42

```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)
```

Phase 5: Predictive Modeling

Predictive modeling aims to forecast student performance using machine learning algorithms. The code provided demonstrates the initial steps for building predictive models. We are using LinearRegression for our modelling.

```
# Predictive Modeling - Linear Regression
model = LinearRegression()
model.fit(X_train, y_train)
```

Phase 6: Feature Selection

Feature selection involves identifying the most relevant features that contribute to student performance. Techniques like feature importance and correlation analysis can be applied to determine the significant features.

```
# Feature Selection - SelectKBest
selector = SelectKBest(score_func=f_regression, k=3)
X_train_selected = selector.fit_transform(X_train, y_train)
selected_features = [features[i] for i in
selector.get_support(indices=True)]

print(selected_features)
```

```
Selected Features: ['age', 'Medu', 'failures']
```

Phase 7: Clustering Analysis

Clustering analysis groups students based on similar characteristics, allowing for the identification of distinct student profiles or segments.

```
# Clustering Analysis - KMeans
kmeans = KMeans(n_clusters=3, random_state=42)
clusters = kmeans.fit_predict(X_train)
```

Phase 8: Evaluation and Validation

Evaluation and validation assess the performance and reliability of the models or analysis techniques used in the project.

```
# Evaluate the predictive model
train_score = model.score(X_train, y_train)
test_score = model.score(X_test, y_test)

print("Predictive Model Evaluation:")
print("Train Score:", train_score)
print("Test Score:", test_score)
```

```
Predictive Model Evaluation:
Train Score: 0.17319493558442778
Test Score: 0.06109089158272296
```

```
# Evaluate the feature selection
feature_scores = selector.scores_

print("Feature Selection Evaluation:")
print("Selected Features:", selected_features)
print("Feature Scores:", feature_scores)
```

```
Feature Selection Evaluation:
Selected Features: ['age', 'Medu', 'failures']
Feature Scores: [ 6.86211474 15.36217561  5.85224507  6.11396409 50.99024758  1.31615476]
```

```
# Evaluate the clustering
silhouette_avg = silhouette_score(X_train, clusters)

print("Clustering Evaluation:")
print("Silhouette Score:", silhouette_avg)
```

```
Clustering Evaluation:
Silhouette Score: 0.5959895937139176
```

```python
# Generate predictions
y_pred = model.predict(X_test)

# Calculate accuracy score
accuracy = model.score(X_test, y_test)

# Print predictions and accuracy score
print("Predictions:")
print(y_pred)
print("\nAccuracy Score:", accuracy)
```

```
Predictions:
[ 4.0638023   9.10683356  8.77963529 11.14213382  5.96716109 10.09991068
 11.72886321 10.92720359 10.31663194 11.72886321 11.04079487 12.09537035
 11.72246    10.20697301 10.63205734 10.72716049 10.60998716  9.7862763
  9.6386746  11.10421    11.05053167 10.79701703 11.82841113 11.1214612
 12.87102743 11.97558147 11.61428647 11.25751613 11.89711828 13.8366166
  9.59778339 10.28842596 11.8588013  11.29764309 11.50462755  9.33998793
  6.44394519 11.80771956 11.0126271   6.60344891  6.49500797 10.47253467
 11.79979274  6.36687986 10.18669385 11.82841113 11.475616    8.99773516
 12.89087523 10.79549343 10.67830114 11.86672812 11.65000686 11.04260485
 10.65873972 10.32593737 10.04131454 10.60998716 11.90726749 11.65000686
 12.10589376 10.81575364  3.35726477 10.90515235  6.55541408  9.92150641
  7.51097336  9.362983   11.95861664 12.00597163 12.18215352 10.55139102
 11.23974573 11.38442626  9.74573693 11.86851914 11.39717206 12.66445538
  5.00828749]

Accuracy Score: 0.06109089158272296
```

```python
# Calculate mean squared error (MSE)
mse = mean_squared_error(y_test, y_pred)

# Calculate coefficient of determination (R-squared)
r2 = r2_score(y_test, y_pred)

# Print evaluation metrics
print("Mean Squared Error (MSE):", mse)
print("Coefficient of Determination (R-squared):", r2)
```

```
Mean Squared Error (MSE): 19.252375648513986
Coefficient of Determination (R-squared): 0.06109089158272296
```

Conclusion

The Student Performance Analysis and Predictive Modeling project provides insights into student performance based on the Math and Portuguese datasets. It includes data exploration, data cleaning, data integration, descriptive statistics, data visualization, and initial steps for predictive modeling. Further analysis, such as feature selection, clustering analysis, and evaluation/validation, can be performed to gain deeper insights into student performance factors and develop accurate predictive models.