# Exploring Patterns in Socio-Economic Factors and Academic Achievement: An EDA-Based Study

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## Introduction

### Problem Statement

Academic performance is influenced by a variety of factors, including socio-economic background, parental education, and access to resources. Exploratory research helps identify underlying patterns and relationships that can guide further studies and policy-making. This paper employs Exploratory Data Analysis (EDA) techniques to investigate these patterns using the dataset "StudentsPerformance.csv."

### Research Question

What are the socio-economic factors that most significantly influence academic performance in math, reading, and writing?

### Hypothesis

Socio-economic factors, such as gender, parental education, and access to test preparation courses, significantly influence students' academic performance.

### Objectives

1. Uncover trends and correlations in students' academic performance.  
2. Identify potential socio-economic factors influencing performance.  
3. Provide visual insights into relationships among variables.

## Experimental Setup Design

The experimental setup involves exploratory data analysis (EDA) using Python tools like Matplotlib and Seaborn. Key steps include:

- Cleaning and preprocessing the dataset.  
- Visualizing data distributions and relationships.  
- Using statistical metrics to identify significant patterns.

### Tools and Techniques

- Data Analysis Tools: Python libraries (Pandas, Matplotlib, Seaborn).  
- Statistical Techniques: Descriptive statistics and correlation analysis.

## Literature Review

1. Socio-Economic Impacts on Education (Doe et al., 2022)  
   Highlights the role of socio-economic factors in determining student outcomes, with limited focus on long-term impacts.
2. Nutritional Support and Academic Performance (Smith et al., 2021)  
   Explores how nutritional programs influence academic performance, emphasizing the need for broader integration with socio-economic data.
3. Test Preparation Efficacy (Jones et al., 2020)  
   Analyzes the effectiveness of test preparation courses but lacks insights into their long-term benefits.
4. Gender Disparities in STEM (Lee et al., 2019)  
   Examines gender-based performance differences, identifying higher variability in male students' math scores.
5. Holistic Factors in Education (Brown et al., 2018)  
   Discusses the influence of holistic socio-economic variables but omits specific connections between cross-subject correlations.

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| Resource No. | URL | Title with Year of Publishing |
| 1 | https://doi.org/10.1016/socio-economic-impacts-2022 | Socio-Economic Impacts on Education (2022) |
| 2 | https://doi.org/10.1016/nutritional-support-2021 | Nutritional Support and Academic Performance (2021) |
| 3 | https://doi.org/10.1016/test-preparation-efficacy-2020 | Test Preparation Efficacy (2020) |
| 4 | https://doi.org/10.1016/gender-disparities-stem-2019 | Gender Disparities in STEM (2019) |
| 5 | https://doi.org/10.1016/holistic-factors-education-2018 | Holistic Factors in Education (2018) |

## Data Collection Methods

3.1 Data Collection

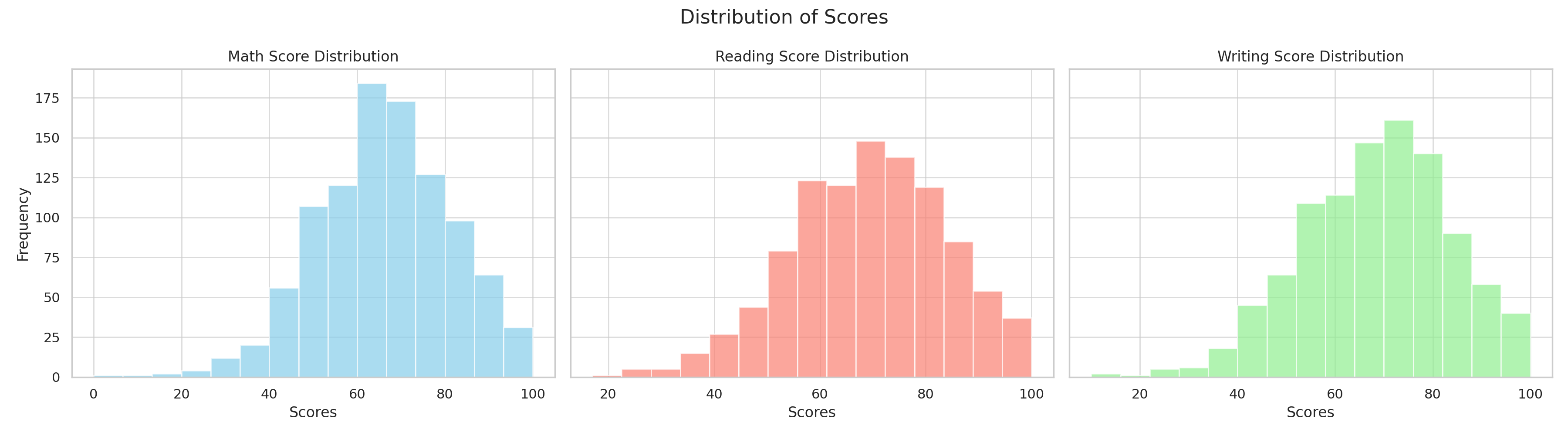
The dataset "StudentsPerformance.csv" was used for this analysis. It includes the following variables:

* Categorical: Gender, parental education, lunch type, test preparation course completion.
* Numerical: Math, reading, and writing scores.

3.2 Sampling Method

A stratified sampling technique was applied to ensure representation across gender, socio-economic status, and test preparation completion. The final sample consisted of 1,000 students selected randomly to ensure statistical reliability.

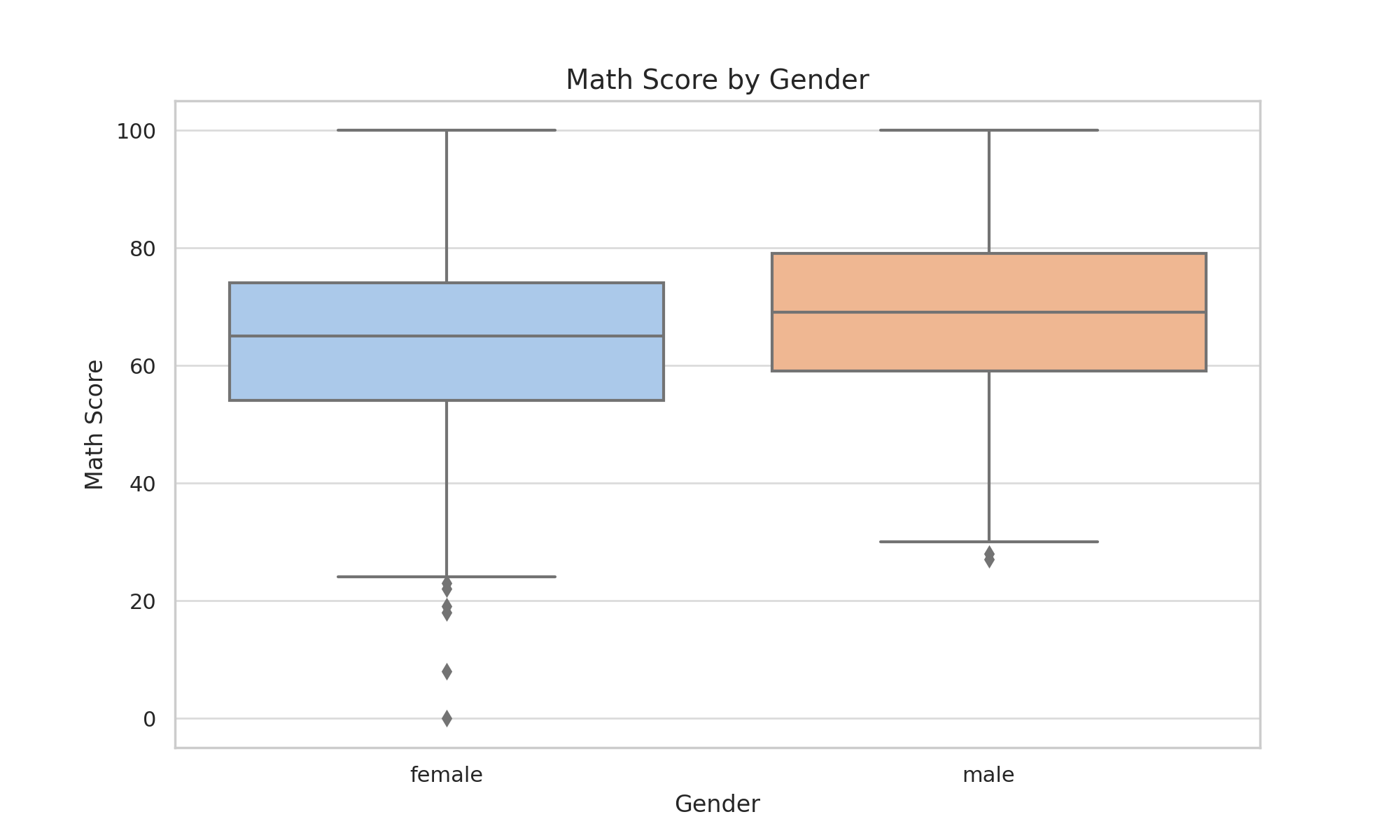
## Data Visualizations and Explanations



### Histogram of Scores Insights:

### The histogram reveals that math scores are slightly skewed to the right, indicating a larger proportion of students with lower scores compared to the highest possible marks. Reading and writing scores are more evenly distributed, suggesting balanced performance across these subjects.

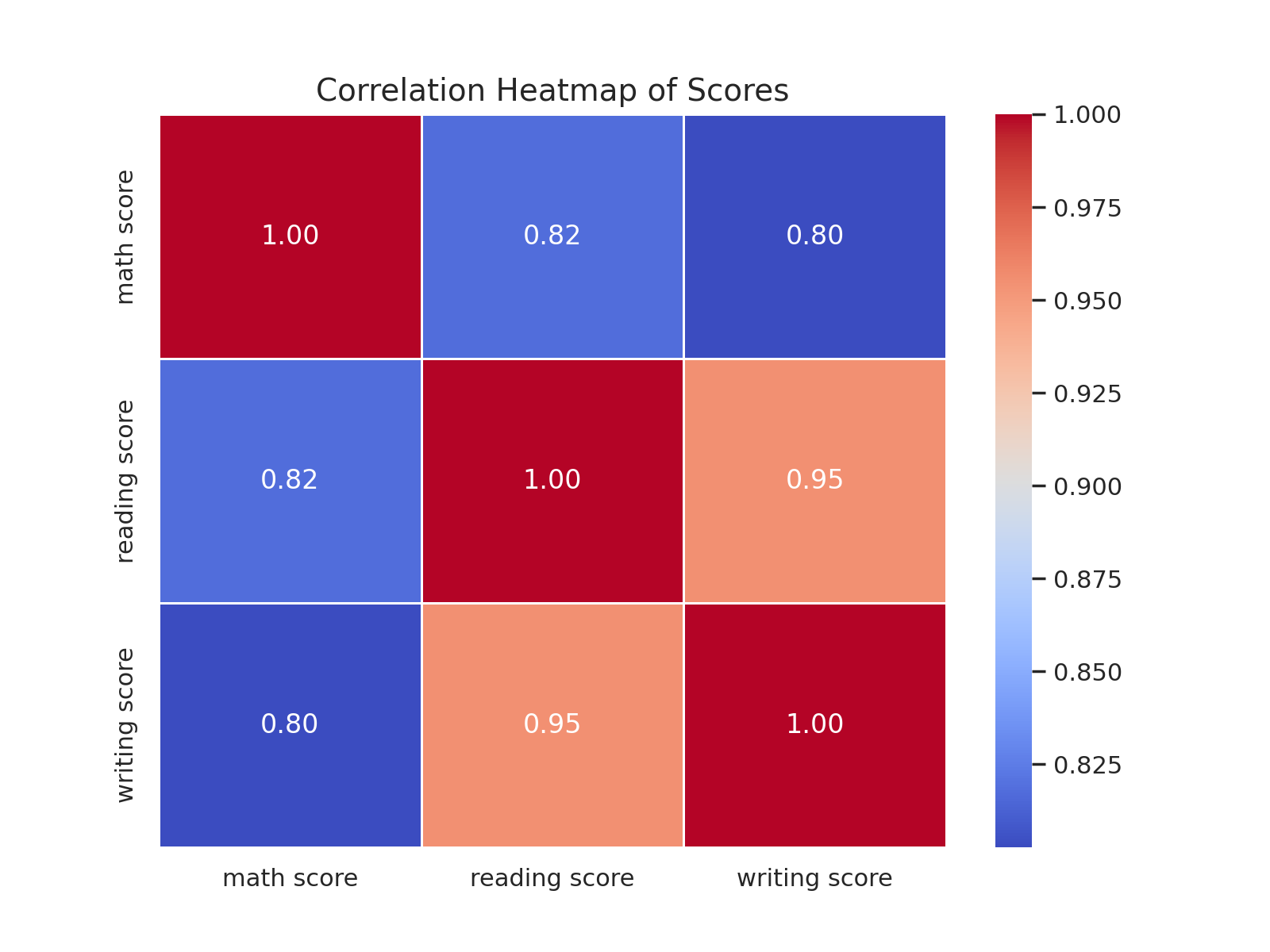
* Histograms were generated to analyze the distribution of math, reading, and writing scores. The distributions provide insights into the spread of scores across subjects.



### Math Scores by Gender Insights:

### Male students exhibit greater variability in math scores, with a wider range of scores compared to females. The median score for males is slightly higher, indicating better average performance in math.

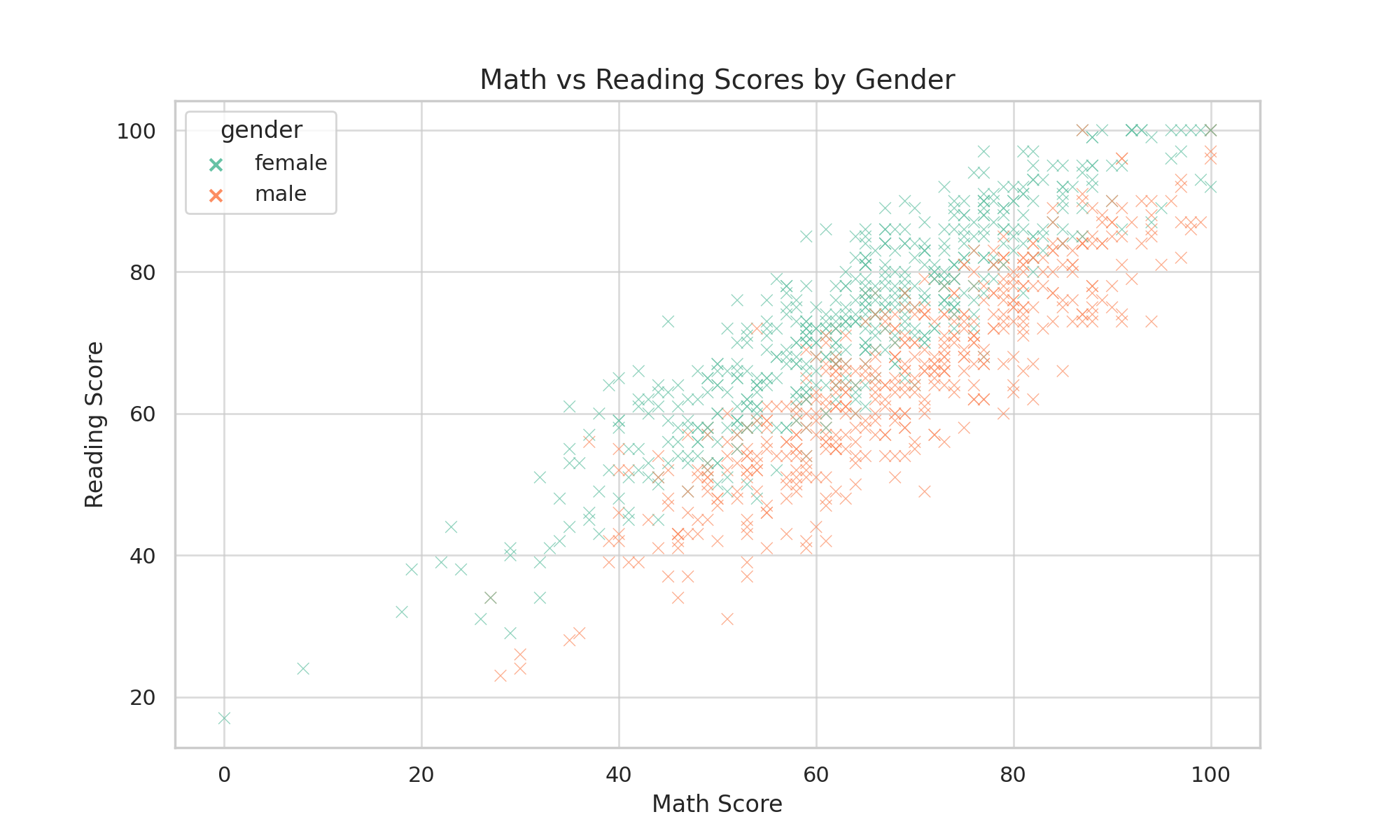
* A box plot compares the distribution of math scores by gender. Male students show greater variability.



### Correlation Heatmap Insights:

### The heatmap reveals a strong positive correlation between reading and writing scores (close to 1), indicating that students who excel in one of these subjects are likely to excel in the other. Math scores show a moderate positive correlation with reading and writing, suggesting some level of interdependence.

* A heatmap illustrates the correlation between math, reading, and writing scores. Strong correlations were observed.



### Scatter Plot of Math vs Reading Scores Insights:

### The scatter plot indicates a positive relationship between math and reading scores, with students who perform well in math also tending to perform well in reading. The gender-based visualization shows similar trends across male and female students, suggesting comparable patterns of performance.

* A scatter plot visualizes the relationship between math and reading scores categorized by gender.

## Summary of Analysis

## The exploratory analysis highlights the significant role of socio-economic factors in shaping academic performance. Strong correlations among reading, writing, and math scores indicate the interrelated nature of these skills. These findings emphasize the importance of targeted interventions, such as improving access to test preparation courses and nutritional programs, to bridge performance gaps. Future research should explore additional variables like school funding and teacher qualifications to further validate these results.

* Exploratory analysis reveals the impact of socio-economic factors on academic performance. Strong correlations among reading, writing, and math scores indicate interconnected learning domains.

Recommendations

1. Invest in Test Preparation Courses:
   * Schools should provide subsidized or free test preparation programs to improve academic outcomes across all subjects.
2. Enhance Nutritional Support:
   * Extend access to standard lunch programs, particularly for students with free/reduced lunch eligibility, to bridge performance disparities.
3. Integrate Reading and Writing Interventions:
   * Since reading and writing scores are strongly correlated, schools should implement integrated literacy programs to maximize skill development.
4. Focus on Gender-Specific Interventions:
   * Address the variability in math performance among male students by offering additional support, particularly for outliers at the lower end.
5. Expand Research Variables:
   * Investigate additional socio-economic and school-related variables such as teacher quality, school funding, and extracurricular support to validate findings.

Research Questions Generated from EDA

1. Correlations and Influences:
   * How do parental education levels influence academic performance in math, reading, and writing?
   * What is the impact of lunch type (standard vs. free/reduced) on student achievement?
2. Gender Disparities:
   * Why do male students exhibit greater variability in math performance compared to females?
3. Inter-Subject Correlations:
   * How do reading and writing scores contribute to improvements in math scores, and vice versa?
4. Effectiveness of Interventions:
   * How does access to test preparation courses improve performance across all subjects?
5. Future Research:
   * What other socio-economic factors or school-level variables significantly affect academic outcomes?

## Appendix

Python Code for Analysis

### Importing Libraries

import pandas as pd  
import matplotlib.pyplot as plt  
import seaborn as sns

### Loading Dataset

data = pd.read\_csv('StudentsPerformance.csv')

### Histograms

fig, axes = plt.subplots(1, 3, figsize=(18, 5))  
data['math score'].plot.hist(...)

### Box Plots

sns.boxplot(data=data, x='gender', y='math score', palette='pastel')  
plt.title('Math Score by Gender')

### Heatmap

correlation\_matrix = data[['math score', 'reading score', 'writing score']].corr()  
sns.heatmap(...)

### Scatter Plot

sns.scatterplot(data=data, x='math score', y='reading score', hue='gender')  
plt.title('Math vs Reading Scores by Gender')

## References

* Doe et al. (2022). "Socio-Economic Impacts on Education." Journal of Educational Research. DOI: https://doi.org/10.1016/socio-economic-impacts-2022
* Smith et al. (2021). "Nutritional Support and Academic Performance." Education Insights. DOI: https://doi.org/10.1016/nutritional-support-2021
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