**ASDS 5301 - Final Project Report**

**Group – 5**

**Comparative Analysis of Student Grades across Schools**

**Data Overview:**

The dataset comprises information on 395 students, featuring 33 variables that capture diverse aspects of their academic performance, demographics, parental background, lifestyle, and health. Key features include school (GP and MS), gender, age, study time, and grades (G1, G2, G3), along with additional metrics such as absences, parental education levels, and participation in extracurricular activities. The data offers a comprehensive view of factors potentially influencing student outcomes, making it well-suited for analyzing differences in academic performance between the two schools.

**Objective:**

The primary objective of this analysis is to investigate differences in academic performance, measured through final grades (G3), between students from two schools: GP and MS. The study aims to assess whether there is a statistically significant difference in the central tendency and distribution of grades between the two groups, considering the potential impact of factors such as variance and normality. Additionally, the analysis seeks to identify patterns and trends in grade variability, providing insights that could inform targeted interventions for improving academic outcomes in underperforming groups.

**Hypothesis:**

* Null hypothesis: The mean grades of the students from MS school are the same as the GP school
* Alternate Hypothesis: The mean grades of the students in MS school and GP school are different

**Data Description and Exploration**

**CODE:**

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**RESULTS:**

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The resultsprovide detailed insights into the performance differences between schools GP and MS based on final grades (G3). Statistical analysis revealed that students from GP consistently performed better, with a higher mean grade (18.45) and less variability (standard deviation: 3.03), compared to MS students who had a lower mean grade (10.21) and higher variability (standard deviation: 4.40). The minimum and maximum grades further highlight the disparity, with GP grades ranging from 10 to 20, showing consistency, while MS grades spanned a wider range from 0 to 19, indicating more variability and extreme scores. These findings suggest that GP students not only perform better on average but also have more uniform outcomes, whereas MS students exhibit a broader spread in their grades.

Visualizations such as boxplots and histograms further clarify these differences. The boxplots show that GP’s grades are concentrated near the top end, with a higher median and a narrower interquartile range, indicating less spread and better overall performance consistency. In contrast, MS displays a wider interquartile range and several outliers, reflecting more diverse performance levels. Histograms reinforce this observation, illustrating that GP’s grades are heavily skewed toward the highest scores, while MS exhibits a flatter and more balanced distribution. The presence of outliers in both schools highlights individual extremes that might warrant additional exploration. Together, these descriptive and visual analyses set the stage for hypothesis testing to determine the statistical significance of these observed disparities in grade performance.

**Test for Normality**

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The normality test basically evaluates whether the grade distributions (G3) for schools GP and MS adhere to the assumption of normality. The Shapiro-Wilk test was used, and the results for both schools demonstrated significant deviations from normality. For **GP**, the Shapiro-Wilk W statistic was **0.927**, with a p-value of **<0.0001**, indicating that the grades significantly deviate from a normal distribution. Similarly, for **MS**, the Shapiro-Wilk W statistic was **0.931**, with a p-value of **0.0098**, confirming non-normality.

Additional tests, such as the Kolmogorov-Smirnov test, provided similar results. For GP, the Kolmogorov-Smirnov D statistic was **0.134** (p < 0.001), while for MS, the D statistic was **0.144** (p = 0.0168). These tests further supported the conclusion that both distributions deviate from normality. Visualizations, including histograms and Q-Q plots, reinforced these findings. The histogram for GP showed grades heavily skewed toward the maximum score of **20**, with a narrow distribution range (minimum grade **10**). In contrast, the MS histogram displayed a broader spread, with grades ranging from **0** to **19**, along with visible outliers.

The Q-Q plots also highlighted deviations from normality, particularly in the tails of the distributions for both schools. For GP, the points diverged significantly from the expected normal line at the upper end, while MS displayed irregularities throughout the range. These results justify rejecting the assumption of normality and indicate the need for non-parametric tests, such as the Mann-Whitney U test, for comparing grade distributions between the two schools.

**Test for Equality of Variance**

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The test for variance evaluates the assumption of **homogeneity of variances**, which is important for parametric tests like the two-sample t-test. To assess whether the variances of the final grades (G3) between the two schools, GP and MS, are equal, the **Folded F Test** was applied. The result of the test showed a **p-value < 0.0001**, which indicates that the variances of the two groups are significantly different.

This finding suggests that the grade distributions in **GP** and **MS** do not exhibit equal variability. Specifically, **GP** showed a lower standard deviation (**3.03**) compared to **MS** (**4.40**), indicating that GP's grades are more consistent, while MS has a wider spread of scores. Since the variances are unequal, this result calls for the use of **Welch’s t-test** rather than the standard two-sample t-test, as Welch’s t-test adjusts for unequal variances and sample sizes.

These results were confirmed by graphical analysis, where the **boxplots** for both schools indicated that **GP** had a more compact distribution with fewer outliers, while **MS** had a wider interquartile range and more outliers. These disparities in spread, combined with the results of the Folded F Test, support the decision to proceed with non-parametric or Welch's test for further analysis, as the assumption of equal variances is violated.

**Non- Parametric Test: Mann-Whitney U Test**

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**RESULTS:**

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A graph of a distribution of a number of scores

Description automatically generated with medium confidence

The results of a non-parametric comparison between the grade distributions (G3) of schools GP and MS. This test was chosen due to violations of the normality assumption, as evidenced by significant p-values from the Shapiro-Wilk test (p < 0.0001 for GP and p = 0.0098 for MS). The Mann-Whitney U test evaluates whether the distributions of grades differ significantly between the two schools, focusing on the relative ranks of data rather than their means.

The test results yielded a p-value < 0.0001, indicating a statistically significant difference between the grade distributions of GP and MS. Rank analysis showed that GP students consistently achieved higher grades, as reflected in their higher median ranks compared to MS students. This finding aligns with the descriptive statistics, where GP had a higher median and a more concentrated distribution, while MS displayed greater variability and a broader range of grades.

Graphical tools, including rank sum plots and boxplots, further highlighted this disparity. GP's grades were tightly clustered toward the upper end of the scale, with minimal variability, while MS exhibited a wider interquartile range and more outliers. These results confirm that the grades in GP and MS schools are not distributed similarly and underscore the significant performance differences between the two groups. The Mann-Whitney U test thus provided robust evidence to support the observed disparities without relying on assumptions of normality or equal variance.

**CONCLUSION:**

Summarizes the key findings of the analysis, emphasizing the significant differences in academic performance (G3) between schools GP and MS. The results indicate that GP students consistently achieved higher grades, with a mean score of 18.45 compared to 10.21 for MS. Additionally, GP demonstrated less variability in grades (standard deviation: 3.03), reflecting more consistent performance, while MS had greater variability (standard deviation: 4.40) and a broader distribution.

Tests for normality (Shapiro-Wilk) revealed significant deviations from normality in both groups, justifying the use of the Mann-Whitney U Test for comparing grade distributions. The Mann-Whitney U Test results (p-value < 0.0001) confirmed a statistically significant difference between the distributions of grades in GP and MS, with GP students consistently ranking higher. These findings highlight disparities in both the central tendency and variability of performance, suggesting potential areas for academic improvement in MS. Visual analyses, including boxplots and histograms, further supported these conclusions, showcasing the more concentrated performance of GP and the broader variability in MS.