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Title: Student's T-test

Before conducting data analysis, it is essential to understand its role in transforming raw data into meaningful insights. This report examines the Student Performance dataset, which contains information about students. In order to find the hidden patterns and trends, the analysis will start with descriptive statistics and move on to visualizations. Additionally, the Student's T-Test will be used for hypothesis testing in order to identify whether there are significant distinctions between particular groups, like males and females. This analysis will use the Pandas library in Python as well as other statistical tools.

Based on the lecture's notes [1], 'a t-test is an inferential statistic used in hypothesis testing to determine if there is a statistically significant difference between the means of two groups.' In order to find the statistical significance, we also need degrees of freedom and the t-values. In statistics, the degrees of freedom shows the number of values that can change [2]. "Unlike with z-values, where each z-value represents a specific probability under the normal curve, the probabilities associates by t-values are calculated based on its degrees of freedom" [2].

By comparing the mean values of two groups, a t-test shows if the difference is statistically significant or it happens by chance. We use T-tests when the data follows a normal distribution. Before implementing this method, we should make sure that the data is normally distributed by generating Shapiro-Wilk tests. If the variances of the groups are different, we should use Welch's T-Test. In our case, the sample sizes are equal and the Shapiro-Wilk test is reasonable to use [1]. The hypotheses are:

H0 : Sample is from the normal distributions. (P>0.05)
Ha : Sample is not from the normal distributions.

Next, we identify the type of t-test we are going to use. There are three types of t-test. Firstly, the one-sample t-test is a test that determines if the mean of an unknown population is less than or equal to a stated value. "The t-value measures the size of the difference relative to the variation in your sample data."[1]. Secondly, the two-sample t-test (independent samples t-test) is a technique for determining whether the average of two groups differ statistically. Finally, 'the paired t-test is a method for determining whether there is a zero mean difference between measurement pairs' [1].

Descriptive statistics

Before generating the hypothesis and t-tests, let's take a look at the descriptive statistics of our data. The dataset includes the average scores of 1,000 students in reading, writing, and math, which are roughly 69, 68, and 66, respectively. In math, there was a performance gap as some students received perfect scores of 100 while others received as low as 0. The fact that reading scores are typically higher than writing and math scores raises the possibility that students are generally better at verbal skills than numerical skills. The table below shows short information about the dataset.

Column	Data type	Information
gender	object	The gender of the student (male or female).
race/ethnicity	object	The group of race or ethnicity that student belongs to.
parental level of education	object	The highest education level of the parents.
test preparation course	object	Did the student attend a test preparation course?

math score	int64	The total scores earned in math.
reading score	int64	The total scores earned in reading.
writing score	int64	The total scores earned in writing.

Task - 1

The female and male groups consist of 30 observations for each. The mean writing score for female students is higher than for male students. Similar score variability is indicated by the standard deviations, which are 14.81 and 14.18, respectively. Additionally, female students' median writing score is higher (73.5) than male students' (60.5), indicating that female students perform better overall.

This difference was tested using an independent two-sample t-test to see if it was statistically significant. Since we are comparing the average of two separate groups, this test is appropriate. With p-values greater than 0.05, the Shapiro-Wilk test verified that the writing scores for both groups follow a normal distribution. Given that the assumption of normality is true, we use the t-test to determine if the mean difference is the result of a significant change or it is something that happens by chance.

There is no difference between the mean writing scores of male and female students, according to the null hypothesis (H_0: $p > 0.05$). According to the alternative hypothesis, there is a significant difference (H_a: $p < 0.05$). The results of the t-test revealed a p-value of 0.017 and a t-statistic of 2.46. We reject the null hypothesis because the p-value is less than 0.05. Given that the mean writing scores of male and female students differ statistically significantly, it is possible that gender influences writing performance.

The distribution of female students' writing scores is depicted in the first graph, which is right-skewed and shows a peak at 70 [Figure 1]. The majority of the scores fall between 60 and 80. The distribution for male students is shown in the second graph, and it seems more consistent, with scores more evenly distributed between 40 and 80.

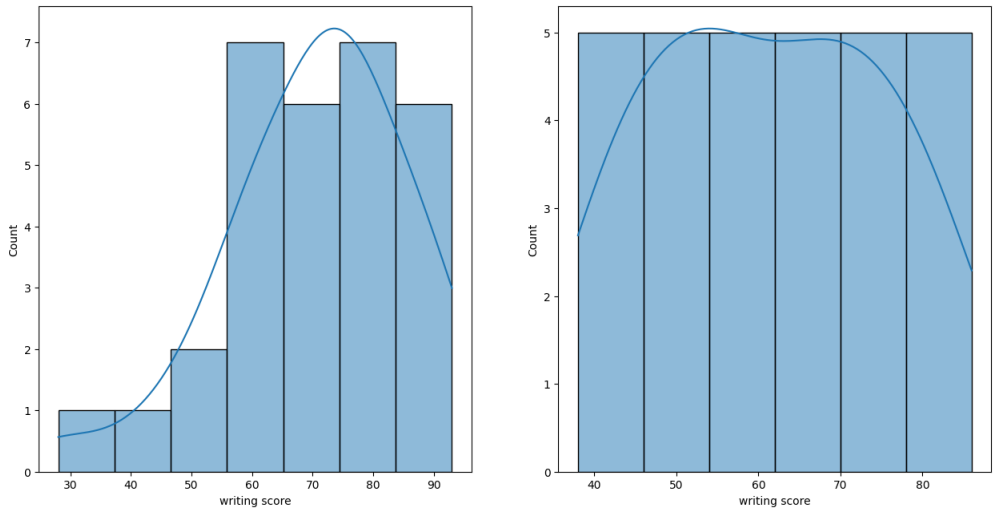

Figure 1

Task - 2

Thirty observations of male students' reading and writing scores are considered in this task. Their standard deviations show that the variances are equal. The mean reading score is marginally higher

than the mean writing score. In both categories, the score distribution seems uniform, and the general trend is unaffected by any extreme outliers.

A paired t-test was used to determine if the score difference is statistically significant. Because the same group of students is being compared across two distinct but related subjects, this test is appropriate.

There is no significant difference between the reading and writing scores, according to the null hypothesis (H_0: $p > 0.05$), but there may be a difference, according to the alternative (H_a: $p < 0.05$). The results of the t-test revealed a p-value of 0.094 and a t-statistic of 1.73. We can not reject the null hypothesis because the p-value is higher than 0.05. This shows that male students' performance in reading and writing is somehow similar, with no significant difference between their scores.

Task - 3

For this task, we have decided to divide this into two parts. The first part is about comparing the reading scores of male and female students. The two groups clearly differ from one another, with male students having a higher mean reading score than female students. Although the standard deviation values show some variation in scores, male students generally perform better on average when it comes to reading.

The statistical significance of this difference was assessed using an independent t-test. It is suitable for comparing the means of two independent groups. We can determine whether the observed difference between male and female students' reading scores is the result of chance or a genuine discrepancy by using this method.

Male and female students' reading scores do not differ significantly according to the null hypothesis (H_0: $p > 0.05$), but the alternative hypothesis suggests that there is a significant difference (H_a: $p < 0.05$). The test results show a t-statistic of 2.08 and a p-value of 0.041. Since the p-value is less than 0.05, we reject the null hypothesis. This shows that there is a significant difference in reading scores between male and female students, indicating that one group does better overall.

The left histogram represents the reading scores of female students, showing a distribution where most scores are concentrated between 60 and 90, with a peak around 70-80 [Figure 2]. The reading scores of male students are represented by the right histogram, which shows a slightly wider spread with scores ranging from 40 to 90 and a peak around 60-70. Female students seem to have a slightly higher concentration of scores in the upper range, although both distributions show a moderate degree of variation.

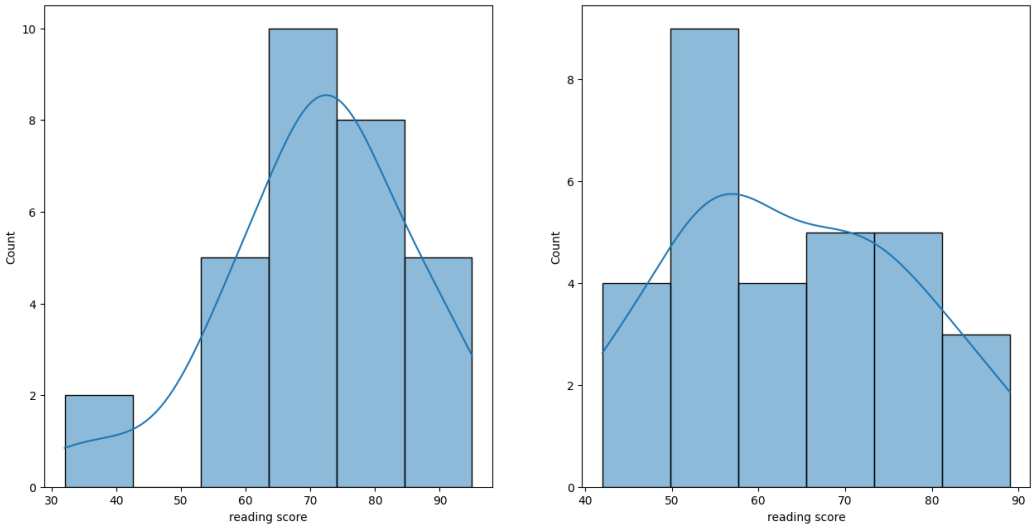

Figure 2

The second part is about comparing the math scores between female and male groups. Female students' mean 61.97, with a standard deviation of 15.25. The majority of the scores ranges between 54.25 and 70.50, with the range being at least 18 to 90. The Shapiro-Wilk test confirms that the data seems to be normally distributed.

The mean math score for male students is slightly higher at 64.30, with a standard deviation of 15.74. While most of their scores fall between 53 and 76.75, their scores range from 40 to 97. The normality test also indicates that the distribution of scores is normal.

T statistic is -0.583 and a P-value is 0.562, which is greater than 0.05. So, the null hypothesis is not rejected, indicating that there is no significant difference between male and female students' math scores.

The distribution of female students' math scores is depicted in the histogram on the left, which shows a peak between 50 and 70 with a few lower outliers [Figure 3]. The majority of students received scores in the mid-to-high range, but some received much lower scores, according to the density curve, which points to a right-skewed distribution. The distribution of math scores for male students is shown in the histogram on the right, where the scores are more evenly distributed across the various score ranges. Compared to the right-skewed trend in the female group, the density curve is comparatively smooth, indicating a more normal distribution.

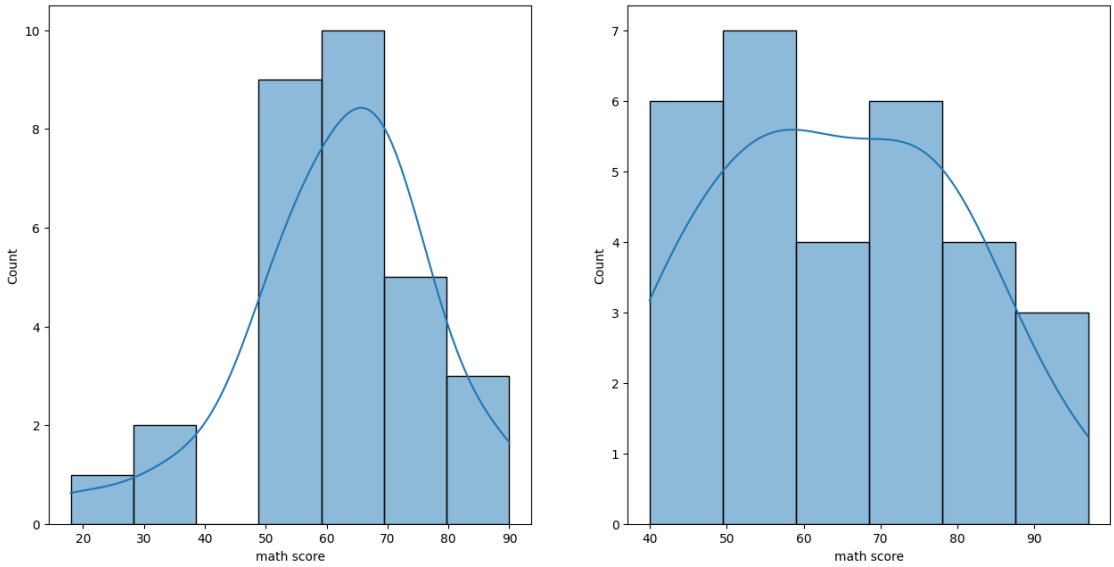

Figure 3

Conclusion

In summary, this study used t-tests, descriptive statistics, and visualizations to analyze the Student Performance dataset and investigate the differences in school performance between boys and girls. According to the findings, male students scored higher in reading, but female students performed better in writing. The two groups' math performance did not, however, differ significantly. These results draw attention to possible gender-based differences in academic skills and demonstrate the significance of teaching methods to enhance students' learning across a range of subjects.

References

[1] M. Z. Kagdi, Class Lecture, Topic: “T – Test”, BINF 311, Epoka University, Tirana, Albania, Jan. 13, 2025.
[2] “The t-Distribution”, BCcampus Pressbooks, Accessed: Feb 9. 2025 [Online], Available: https://pressbooks.bccampus.ca/simplestats/chapter/6-8-the-t-distribution/