Kingdom of Cambodia

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Institute of Technology of Cambodia

Department of Applied Mathematics and statistics

Final project

Topic: Student Housing Cost

Course: Statistics

Group 2

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Contents

I. Introduction

Why did we choose this topic?

Our team chose to investigate **student housing cost** because it is a common and important aspect of university life that directly affects students' financial well-being. Housing expenses such as rent or dormitory fees are unavoidable for many students and often represent one of their highest monthly costs. Unlike more abstract economic data, housing cost is a real-life issue that students experience personally and understand clearly.

By focusing on student housing cost, we selected a topic that is both easy to measure and highly relevant to students' daily lives.

The Real-Life Question and Motivation

The motivation for this study comes from the fact that housing costs can vary widely among university students depending on their living arrangements. Many students often wonder whether the amount they spend on housing is typical compared to other students. Understanding the average housing cost and how much it varies can help students better manage their finances and plan their budgets.

Our real-life question is:

"Is the average monthly housing cost of university students significantly different from a commonly assumed or expected cost?"

This question allows us to examine student housing expenses using statistical evidence rather than assumptions.

What We Hope to Learn

Through the analysis of student housing cost data collected from a sample of **30 students**, we aim to achieve the following learning objectives:

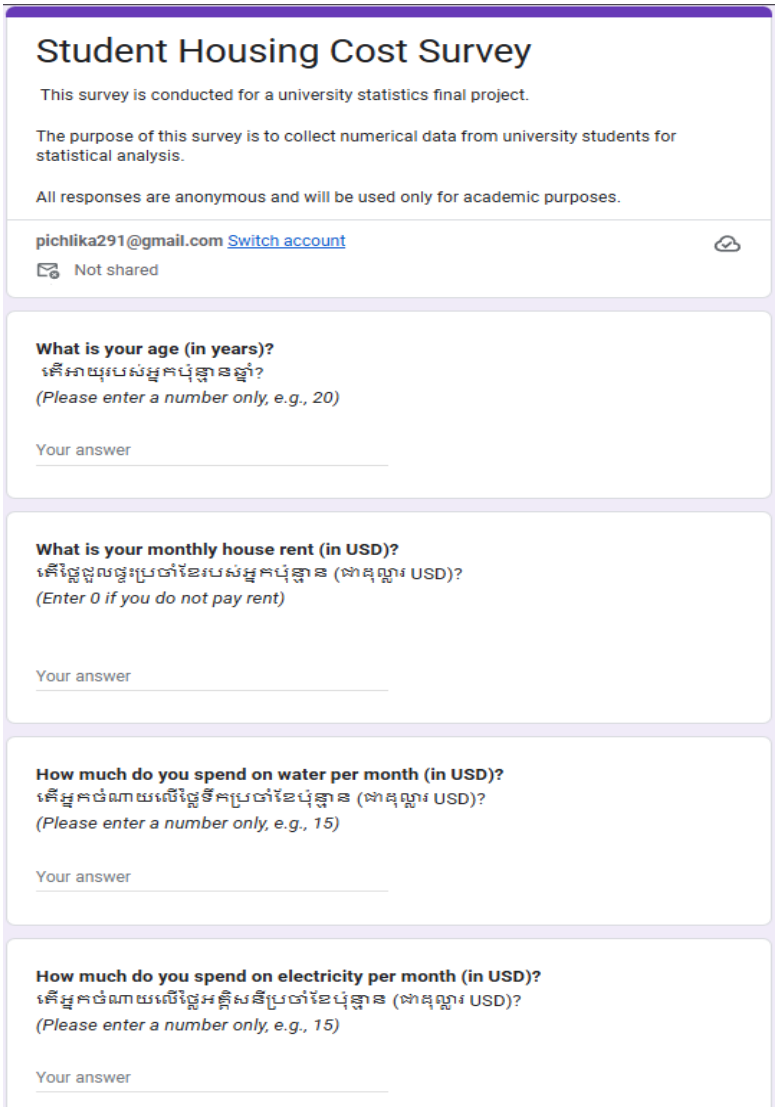
- **Understand the distribution:**
  Use descriptive statistics and graphical methods to examine the central tendency, variability, and shape of the housing cost distribution, including:
  - what a typical housing cost looks like (mean, median),
  - how spread out the costs are (standard deviation, IQR),
  - and whether the data are symmetric or skewed.
- **Quantify uncertainty:**
  Construct a **95% confidence interval** to estimate the true average housing cost of the student population.
- **Evaluate statistical claims:**
  Apply hypothesis testing to assess whether the population mean housing cost differs from a proposed or expected value.

- **Develop statistical reasoning:**
  Strengthen our ability to interpret statistical results and communicate findings clearly in a real-world context.

II. Data Description

Source of Data

The data used in this study were self-collected by our team using a primary data collection method. An anonymous online survey was designed and distributed by the research team using Google Forms to collect numerical data related to student housing costs. The survey was shared with university students who voluntarily participated in the study. All responses were collected anonymously and used solely for academic purposes.



Google form Survey for Monthly Student house cost

Variables Included

The study focuses on one main quantitative (numerical) variable, supported by several related numerical variables:

Main Variable (X): Monthly Student Housing Cost

- **Unit of Measurement:** US dollars (USD) per month
- **Type:** This is a **continuous numerical variable**, which allows for the calculation of measures of center and spread such as the **mean, median, standard deviation, and interquartile range (IQR)**.
- **Description:** This variable represents the **total monthly housing-related expenses** paid by a student.

Supporting Variables (Components of Housing Cost):

- **Monthly House Rent Cost (USD):**
  The amount a student pays per month for rent or dormitory accommodation. This is a continuous numerical variable and a major component of the total housing cost.
- **Monthly Water Expense (USD):**
  The monthly cost of water usage. This is a continuous numerical variable contributing to housing-related expenses.
- **Monthly Electricity Expense (USD):**
  The monthly cost of electricity usage. This is a continuous numerical variable included as part of utility expenses.

Age (years):

Age is a **quantitative numerical variable** measured in years. It is included to provide background information about the sample but is not the primary focus of the housing cost analysis.

Sample Size (n)

The final sample size used in this study is **n = 30**, representing monthly housing cost data collected from 30 university students.

The dataset:

The dataset below presents the complete list of **30 observations** collected from the survey respondents.

Table 1 shows the **raw housing-related variables** collected from the survey

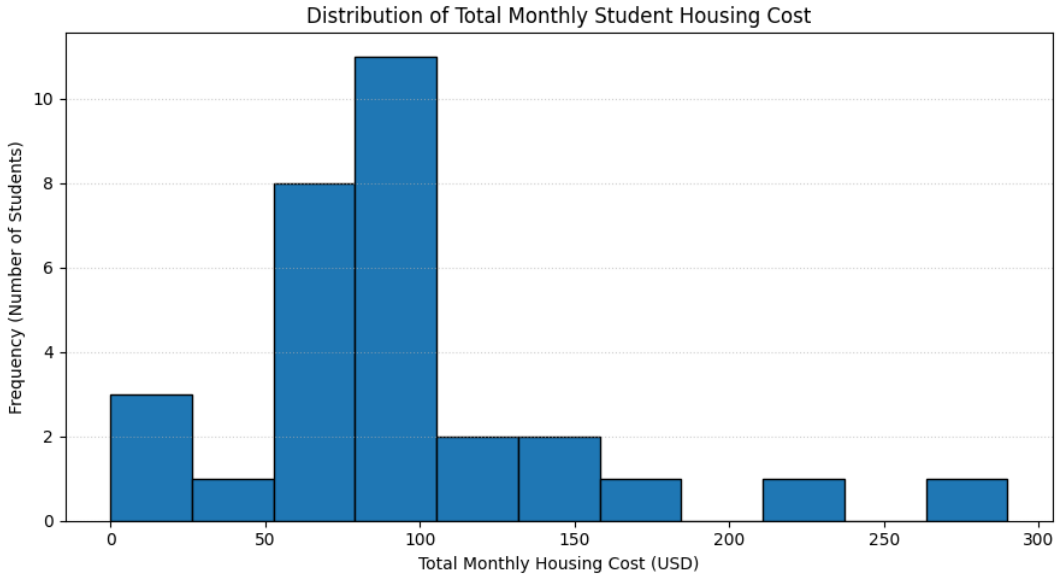
No.	AGE	monthly house rent	water per month	electricity per month	Housing_ Cost
1	20	60	3	5	68
2	19	0	4	20	24
3	20	50	3	3	56
4	20	100	20	30	150
5	20	50	2	1.5	53.5
6	21	120	2.5	30	152.5
7	20	75	5	7	87
8	19	100	2	12.5	114.5
9	20	90	5	3	98
10	20	50	3	2.5	55.5
11	20	30	15	15	60
12	20	60	3	5	68
13	20	50	6	5	61
14	20	85	5	5	95
15	19	0	15	10	25
16	20	30	30	30	90
17	20	0	0	0	0
18	19	250	10	30	290
19	19	100	5	10	115
20	20	50	2.5	10.75	63.25
21	19	200	20	2.5	222.5
22	20	60	30	5	95
23	20	80	5	10	95
24	19	120	10	50	180
25	18	80	5	20	105
26	19	75	5	10	90
27	20	70	1.5	13	84.5
28	18	25	2.5	3	30.5
29	18	80	10	5	95
30	19	50	15	20	85

III. Descriptive Statistic

Graphs

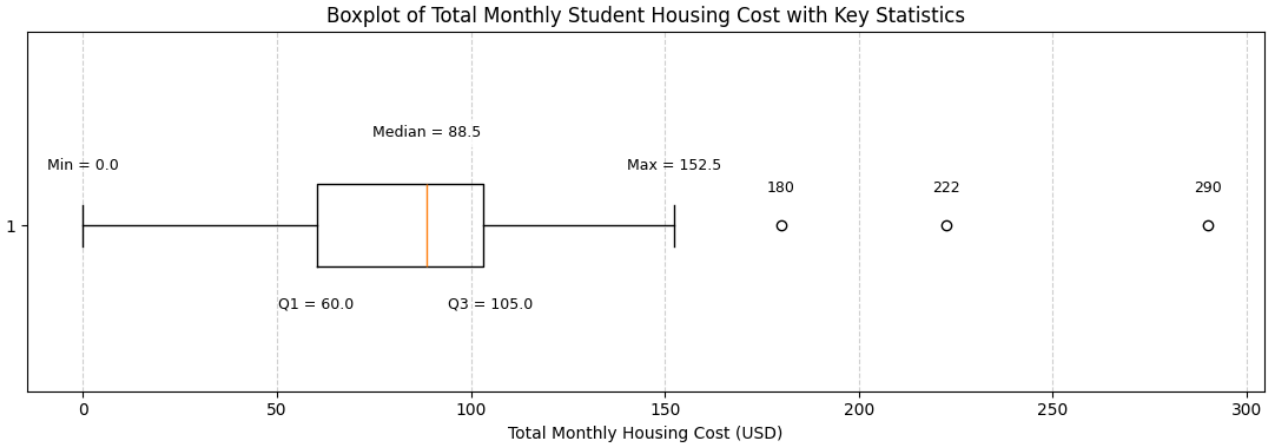
To gain a clearer understanding of the distribution of **total monthly student housing cost** in our sample, the raw survey data were converted into graphical representations.

a. Histogram



Histogram Interpretation:
Figure X presents the histogram of total monthly student housing cost. The distribution is right-skewed, with most observations concentrated between approximately 50 USD and 120 USD. A small number of students report relatively high housing costs, which extend the right tail of the distribution.

b. Boxplot



Boxplot Interpretation:
The boxplot summarizes the distribution of total monthly student housing cost. The median housing cost is approximately **88.5 USD**, while the middle 50% of observations range between **60.00 USD (Q1)** and **105.0 USD (Q3)**. Several observations lie beyond the upper whisker, indicating the presence of **high-cost outliers**. This suggests that while most students have similar housing expenses, a small number incur **substantially higher monthly housing costs**.

Summary Statistic

- Measures of Central Tendency

  Measures of central tendency describe the **typical or central value** of a dataset. In this study, they are used to summarize the **total monthly student housing cost**.

  Add All Numbers from the Survey

  From **Table 1**, the total monthly housing costs (in USD) for the 30 students are:

  $$68, 24, 56, 150, 53.5, 152.5, 87, 114.5, 98, 55.5, 60, 68, 61, 95, 25, 90, 0, 290, 115, 63.25, 222.5, 95, 95, 180, 105, 90, 84.5, 30.5, 95, 85$$

  The sum of all 30 observations is:

  $$\sum_{i=1}^{30} x_i = 2919.25$$

  Mean (Average)

  The mean monthly housing cost is calculated using the formula:

  $$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

  Substituting the values:

  $$\bar{x} = \frac{\sum_{i=1}^{30} x_i}{30} = \frac{2919.25}{30} = 93.62$$

  Interpretation:

  This means that, on average, students in this sample spend approximately **93.62 USD per month** on housing costs.

  Median

  First, the data are arranged in **ascending order**:

  $$0, 24, 25, 30.5, 53.5, 55.5, 56, 60, 61, 63.25, 68, 68, 84.5, 85, 87, 90, 90, 95, 95, 95, 95,$$

  $$98, 105, 114.5, 115, 150, 152.5, 180, 222.5, 290$$

  Since there are **30 observations**, there is no single middle value. The median is the **average of the 15th and 16th values**.

  This means the median lies between the **15th and 16th values**.

- 15th value = 87
- 16th value = 90

  Therefore, the median is:

  $$\text{Median} = \frac{87 + 90}{2} = 88.5$$

Interpretation:
Half of the students spend **less than or equal to 88.5 USD**, and half spend **more than or equal to 88.5 USD** on monthly housing costs.

Mode

The mode of the data is:

$$\text{Mode} = \text{most frequent value} = 95 \text{ USD}$$

This value appears **most frequently** in the dataset, indicating that **95 USD** is the most common total monthly housing cost among the students surveyed.

Interpretation of Central Tendency

- The **mean** monthly housing cost is **93.62 USD**, indicating the average amount students spend on housing each month.

- The **median** monthly housing cost is **88.5 USD**, which means that half of the students spend **less than or equal to 88.5 USD**, and half spend **more than or equal to 88.5 USD**.

- The **mode** of the dataset is **95 USD**, showing that this is the most common total monthly housing cost among the students surveyed.

- The mean, median, and mode are **relatively close in value**, suggesting that most students have similar monthly housing expenses.

- The mean is slightly higher than the median, indicating a **right-skewed distribution** caused by a small number of students with **high housing costs**.

- The median is particularly useful in this analysis because it is **not affected by extreme values**, making it a reliable measure of the typical monthly housing cost.

Overall, the measures of central tendency show that while most students spend around **90–100 USD per month** on housing, a few students incur significantly higher costs

- **Measures of Dispersion (Spread)**

Measures of dispersion describe how **spread out** the housing cost values are.

Minimum and Maximum

- **Minimum value:** 0 USD

  → This represents a student who reported no monthly housing cost.

- **Maximum value:** 290 USD

  → This represents the highest monthly housing cost reported by a student.

Range

The range of the data is calculated as:

$$\text{Range} = \text{Maximum} - \text{Minimum} = 290 - 0 = 290 \text{ USD}$$

This wide range shows that housing expenses **vary substantially** among students, from those who pay no housing cost to those who pay very high monthly amounts.

Variance

The variance of the data is:

$$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1} \approx 3509.35 \text{ USD}^2$$

- The variance of **3509.35 USD²** indicates that students' monthly housing costs vary **considerably** around the mean.

- Because variance is expressed in **squared units (USD²)**, it is not easy to interpret directly in practical terms.

- The relatively large variance suggests that housing costs are **not tightly clustered** around the average and that there is noticeable variability among students.

- This variability is influenced by the presence of **high-cost housing values**, which increase the overall spread of the data.

Standard Deviation

The standard deviation of the data is:

$$s = \sqrt{s^2} \approx 59.24 \text{ USD}$$

- The standard deviation of **59.24 USD** indicates that students' monthly housing costs typically differ from the mean by about **59 USD**.

- This suggests a **moderate level of variability** in housing expenses among students.

- Most students' housing costs are relatively close to the average, but there are some higher-cost values that increase the overall spread.

Interquartile Range (IQR)

Divide the Data into Halves

Since the sample size is **n = 30**, the median (88.5 USD) divides the data into two equal groups of 15 observations each:

- **Lower half:** observations 1 through 15
- **Upper half:** observations 16 through 30

First Quartile (Q1)

The first quartile (**Q1**) is the median of the lower half of the data.

- The middle position of 15 observations is the **8th value**
- From the sorted data, the 8th value is **60.00 USD**

$$Q_1 = 60.00 \text{ USD}$$

Third Quartile (Q3)

The third quartile (**Q3**) is the median of the upper half of the data.

- The middle position of the upper half corresponds to the **23rd observation**
- From the sorted data, the 23rd value is **105 USD**

$$Q_3 = 105.00 \text{ USD}$$

Calculate the IQR

The interquartile range is calculated as:

$$\text{IQR} = Q_3 - Q_1 = 105.00 - 60.00 = 45.00 \text{ USD}$$

This indicates that the **middle 50% of students** have monthly housing costs within a **45.00 USD range** of each other.
The IQR provides a robust measure of variability and will be used in the next section to identify **potential outliers**.

General Observations

- Most students spend between **60 USD and 110 USD per month** on housing.

- Several values, such as **180 USD, 222.5 USD, and 290 USD**, are considerably higher than the majority of the data.

- These high-cost values increase the **range, variance, and standard deviation**, indicating greater variability in student housing expenses.

- While the **mean, median, and mode** suggest a typical monthly housing cost of approximately **90–100 USD**, a small number of students experience significantly higher housing costs.

- These differences likely reflect variations in **housing type, location, and living arrangements** among students.

IV. Point Estimation

1. Parameters and Estimators

In this study, we assume the **total monthly student housing cost** is drawn from a population with an unknown mean μ and unknown variance σ^2.

- **Population mean (μ):**
  The true average monthly housing cost for all university students in the population.
- **Population variance (σ^2):**
  The true variance of monthly housing costs in the population.
- **Sample mean ($\bar{X}$) as an estimator of μ:**
  $\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$ is used to estimate μ.
  From our data:
  $$\bar{X} = 93.62 \text{ USD}$$
- **Sample variance (S^2) as an estimator of σ^2:**
  $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2$ is used to estimate σ^2.
  From our data:
  $$S^2 \approx 3509.35 \text{ USD}^2$$

2. Unbiasedness and Consistency (Conceptual Explanation)

- **Unbiasedness of $\bar{X}$:**
  $\bar{X}$ is an **unbiased estimator** of μ if its expected value equals μ, i.e.,
  $E(\bar{X}) = \mu$.
  This means that, on average, the sample mean does not systematically overestimate or underestimate the true population mean.
- **Consistency of $\bar{X}$:**
  $\bar{X}$ is a **consistent estimator** of μ if, as the sample size n increases, $\bar{X}$ converges to μ.
  In practical terms: the larger the sample, the closer $\bar{X}$ tends to be to μ.

3. Standard Error of the Mean

The **standard error of the sample mean** is calculated as:

$$SE(\bar{X}) = \frac{s}{\sqrt{n}}$$

where:

- $s = 59.24$ USD (sample standard deviation)
- $n = 30$

$$SE(\bar{X}) = \frac{59.24}{\sqrt{30}} \approx \frac{59.24}{5.477} \approx 10.82 \text{ USD}$$

Interpretation:

The standard error of **10.82 USD** measures the variability of the sample mean as an estimate of the population mean. A smaller standard error indicates that the sample mean is a more precise estimate of μ.

V. Confidence Intervals

1. 95% Confidence Interval for the Population Mean

Since σ^2 is unknown, we use the **t-interval** formula:

$$\bar{x} \pm t_{\alpha/2,\, n-1} \cdot \frac{s}{\sqrt{n}}$$

Where:

- $\bar{x} = 93.62$
- $s = 59.24$
- $n = 30$
- $t_{0.025,\, 29} \approx 2.045$ (from t-table)

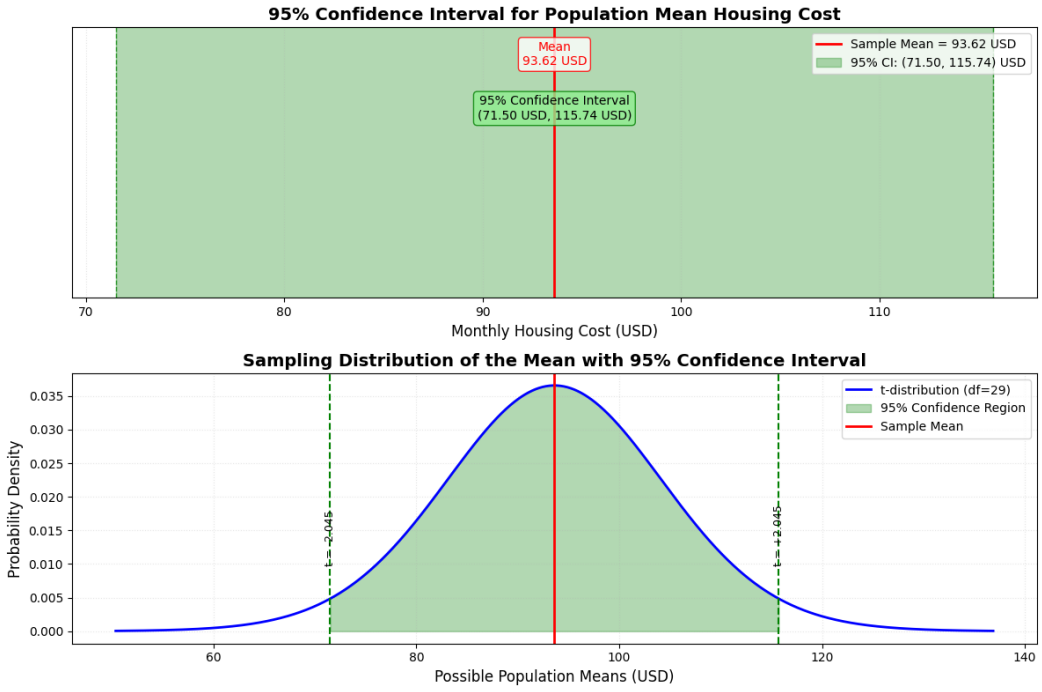
$$\text{Margin of Error} = 2.045 \times 10.82 \approx 22.14$$

Thus:

$$93.62 - 22.14 < \mu < 93.62 + 22.14$$
$$71.48 < \mu < 115.76$$

95% Confidence Interval:

(71.48 USD， 115.76 USD)



2. Interpretation of the Confidence Interval

We are 95% confident that the true average monthly student housing cost for the population lies between 71.48 USD and 115.76 USD.

This means that if we were to take many random samples and construct a 95% confidence interval for each sample, approximately 95% of those intervals would contain the true population mean μ.

3. Required Sample Size (Theoretical Calculation)

Given:

- Desired margin of error $E = 0.5$ USD
- Confidence level 95% $\rightarrow z_{0.025} \approx 1.96$
- Estimate of $\sigma \approx s = 59.24$ USD

Formula:

$$n = \left(\frac{z_{\alpha/2} \cdot \sigma}{E}\right)^2$$
$$n = \left(\frac{1.96 \times 59.24}{0.5}\right)^2$$
$$n = \left(\frac{116.1104}{0.5}\right)^2$$
$$n = (232.2208)^2 \approx 53{,}926.49$$

Minimum required sample size: $n \approx 53{,}927$

Comment:
Our current sample size ($n = 30$) is **much smaller** than the required $n \approx 53{,}927$ to achieve a margin of error of **0.5 USD**.
This reflects the large variability in housing costs ($s \approx 59.24$) relative to the desired precision ($E = 0.5$).

VI. Hypothesis Testing

1 Stating the Hypotheses

Housing cost is an important factor affecting students' living conditions and financial stability. A commonly assumed reference value for student housing is that the **average monthly housing cost is 80 USD**. The value of 80 USD was chosen as a commonly assumed benchmark based on informal student expectations and prior discussion among students. In this section, we use statistical hypothesis testing to determine whether the actual average monthly house rent in our sample is significantly different from this assumed value.

Let μ represent the true population mean total monthly housing cost (USD).

The hypotheses are defined as follows:

- **Null Hypothesis (H_0):**

$$H_0: \mu = 80 \text{ USD}$$

This hypothesis states that the average monthly housing cost is equal to 80 USD.

- **Alternative Hypothesis (H_a):**

$$H_a: \mu \neq 80 \text{ USD}$$

This hypothesis states that the average monthly housing cost is different from 80 USD.

Because we are interested in detecting **any difference**, whether higher or lower, this is a **two-tailed hypothesis test**.

2 Test Statistic

Since the population standard deviation is unknown and the sample size is relatively small ($n = 30$), the appropriate test is a **one-sample t-test**, as introduced in Chapter 4.

The test statistics for a one-sample t-test are given by:

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$$

Where:

- $\bar{x}$is the sample mean,
- $\mu_0$is the hypothesized population mean,
- $s$is the sample standard deviation,
- $n$is the sample size.

From the dataset:

- Sample mean: $\bar{x} = 93.62$USD
- Hypothesized mean: $\mu_0 = 80$USD
- Sample standard deviation: $s = 59.24$USD
- Sample size: $n = 30$

Substituting these values into the formula:

$$t = \frac{93.62 - 80}{59.24/\sqrt{30}} = \frac{13.62}{10.81} = 1.25$$

This calculated t-value measures how far the sample mean is from the hypothesized mean in units of the standard error.

3 p-Value

The p-value represents the probability of obtaining test statistics at least as extreme as the observed value, assuming that the null hypothesis is true.

- Degrees of freedom:

$$df = n - 1 = 29$$

Using a **t-distribution table** or statistical software for a **two-tailed test** with:

- $t = 1.25$
- $df = 29$

Then

$$p = 2P(T \geq |1.25|)$$
$$p \approx 2(0.11) = 0.22$$
$$\boxed{p \approx 0.22}$$

The **p-value is approximately 0.22**.

A large p-value indicates that the observed difference between the sample mean, and the hypothesized mean is very likely due to random sampling variation.

4 Decision

We compare the p-value to the significance level:

$$\alpha = 0.05$$

- Since $0.22 > 0.05$,

we fail to reject the null hypothesis H_0.

This means that the sample does not provide sufficient statistical evidence to support the alternative hypothesis.

5 Conclusion (in Context)

At the 5% significance level, there is **no statistically significant evidence** to conclude that the average monthly housing cost differs from 80 USD. Although the observed sample mean (93.62 USD) is slightly higher than the hypothesized value (80 USD), this difference is not statistically significant due to the large variability in housing cost.

VII. Conclusion

What We Learned from the Analysis

This project investigated student's **total monthly housing cost**, defined as the sum of monthly rent, water, and electricity expenses. Using a dataset of 30 observations, we applied descriptive statistics, point estimation, confidence intervals, and hypothesis testing to analyze the central tendency and variability of housing costs.

The sample mean of the total monthly housing cost was **93.62 USD**, with a relatively large standard deviation, indicating substantial variation in housing expenses among students housing costs.

Was the Research Question Answered?

Yes.
The primary research question was whether the average monthly housing cost significantly differs from 80 USD. The hypothesis test produced a p-value of approximately 0.22, which is far greater than the 0.05 significance level. This result clearly indicates that there is **no significant difference** between the observed average student housing cost and the assumed value. Therefore, the data does not provide evidence against 80 USD is a reasonable estimate of the average monthly housing cost for this sample.

Limitations of the Dataset

While the analysis was conducted correctly, several limitations should be noted:

- **Sample Size:** With only 30 observations, the results may not fully represent the broader student population.
- **Geographic Scope:** Housing costs may vary significantly depending on location, housing type, and living arrangements.
- **Self-Reported Data:** The data were self-reported, which may introduce measurements or reporting errors.

Suggestions for Future Study

To improve future analyses, the following steps are recommended:

- Increase the sample size to obtain more precise estimates of the population mean.
- Analyze housing cost components separately (rent, water, and electricity) to identify their individual impacts.
- Compare different student housing groups using two-sample hypothesis tests (e.g., shared housing vs. private housing).

VIII. Appendix (Python Code)

Import Library, load data csv, and rename columns

In [ ]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

In [ ]:
```
#load dataset
df = pd.read_csv('monthly_house_rent.csv')
```

In [ ]:
```
#define the row and column of our dataset
df.shape
```

```
(30, 4)
```

In [ ]:
```
#rename columns for convenience
df.columns = ["Age", "Rent", "Water", "Electricity"]
```

In [ ]:
```
# Compute main variable X
df["Housing_Cost"] = df["Rent"] + df["Water"] + df["Electricity"]
```

In [ ]:
```
# Check the result
df[["Age", "Housing_Cost"]]
```

In [ ]:
```
df[["Age", "Housing_Cost"]].to_csv("student_housing_cost.csv", index=False)
```

Descriptive Statistics and Detect outliers

In [ ]:
```
# Data
X = df["Housing_Cost"]
n = len(X)

# Sort data
X_sorted = X.sort_values().reset_index(drop=True)

# Mean
mean = X.mean()

# Median
median = X.median()

# Mode
mode = X.mode().tolist()

# Range
data_range = X.max() - X.min()

# Sample variance & standard deviation
variance = X.var(ddof=1)
std_dev = X.std(ddof=1)

# Quartiles (HAND METHOD)
Q1 = X_sorted.iloc[7]    # 8th value (index 7)
Q3 = X_sorted.iloc[22]   # 23rd value (index 22)
IQR = Q3 - Q1

# Print results
print(f"Sample size (n): {n}")
print(f"Mean (x̄): {mean:.2f}")
print(f"Median: {median:.2f}")
print(f"Mode: {mode}")
print(f"Range: {data_range:.2f}")
print(f"Sample Variance (s²): {variance:.2f}")
print(f"Sample Standard Deviation (s): {std_dev:.2f}")
print(f"Q1: {Q1:.2f}")
print(f"Q3: {Q3:.2f}")
print(f"IQR: {IQR:.2f}")
```

In [ ]:
```
# IQR fences
lower_fence = Q1 - 1.5 * IQR
upper_fence = Q3 + 1.5 * IQR

# Identify outliers
outliers = X[(X < lower_fence) | (X > upper_fence)]
```

In [ ]:
```
print(f"Lower fence: {lower_fence:.2f}")
print(f"Upper fence: {upper_fence:.2f}")

if outliers.empty:
    print("Outliers: None")
else:
    print("Outliers (Housing Cost in USD):")
    for value in outliers:
        print(f"- {value:.2f}")
```

Histogram and Boxplot

In [ ]:
```
import matplotlib.pyplot as plt

plt.figure(figsize=(9, 5))

plt.hist(
    df["Housing_Cost"],
    bins="auto",
    edgecolor="black",
    linewidth=1
)

plt.xlabel("Total Monthly Housing Cost (USD)")
plt.ylabel("Frequency (Number of Students)")
plt.title("Distribution of Total Monthly Student Housing Cost")

plt.grid(axis="y", linestyle=":", alpha=0.6)
plt.tight_layout()
plt.show()
```

In [ ]:
```
import matplotlib.pyplot as plt
import numpy as np

X = df["Housing_Cost"]
X_sorted = np.sort(X)

# Hand-calculated stats (match report)
Q1 = 60.00
Median = 88.5
Q3 = 105.00
IQR = Q3 - Q1

lower_whisker = X_sorted[X_sorted >= (Q1 - 1.5 * IQR)].min()
upper_whisker = X_sorted[X_sorted <= (Q3 + 1.5 * IQR)].max()
outliers = X_sorted[(X_sorted < lower_whisker) | (X_sorted > upper_whisker)]

plt.figure(figsize=(11, 4))
plt.boxplot(X, vert=False, showfliers=True)

plt.xlabel("Total Monthly Housing Cost (USD)")
plt.title("Boxplot of Total Monthly Student Housing Cost with Key Statistics")
plt.grid(axis="x", linestyle="--", alpha=0.6)

y = 1

# Labels
plt.text(lower_whisker, y + 0.10, f"Min = {lower_whisker}", ha="center", fontsize=9)
plt.text(Q1, y - 0.15, f"Q1 = {Q1}", ha="center", fontsize=9)

# ✅ Median moved higher + background so it doesn't overlap the box
plt.text(
    Median, y + 0.16, f"Median = {Median}",
    ha="center", fontsize=9,
    bbox=dict(facecolor="white", edgecolor="none", alpha=0.8)
)

plt.text(Q3, y - 0.15, f"Q3 = {Q3}", ha="center", fontsize=9)
plt.text(upper_whisker, y + 0.10, f"Max = {upper_whisker}", ha="center", fontsize=9)

# Outliers close to dots
for val in outliers:
    plt.text(val, y + 0.06, f"{int(val)}", ha="center", fontsize=9)

plt.ylim(0.7, 1.35)
plt.tight_layout()
plt.show()
```