Introduction to Statistics

Data Boot Camp

Lesson 5.3

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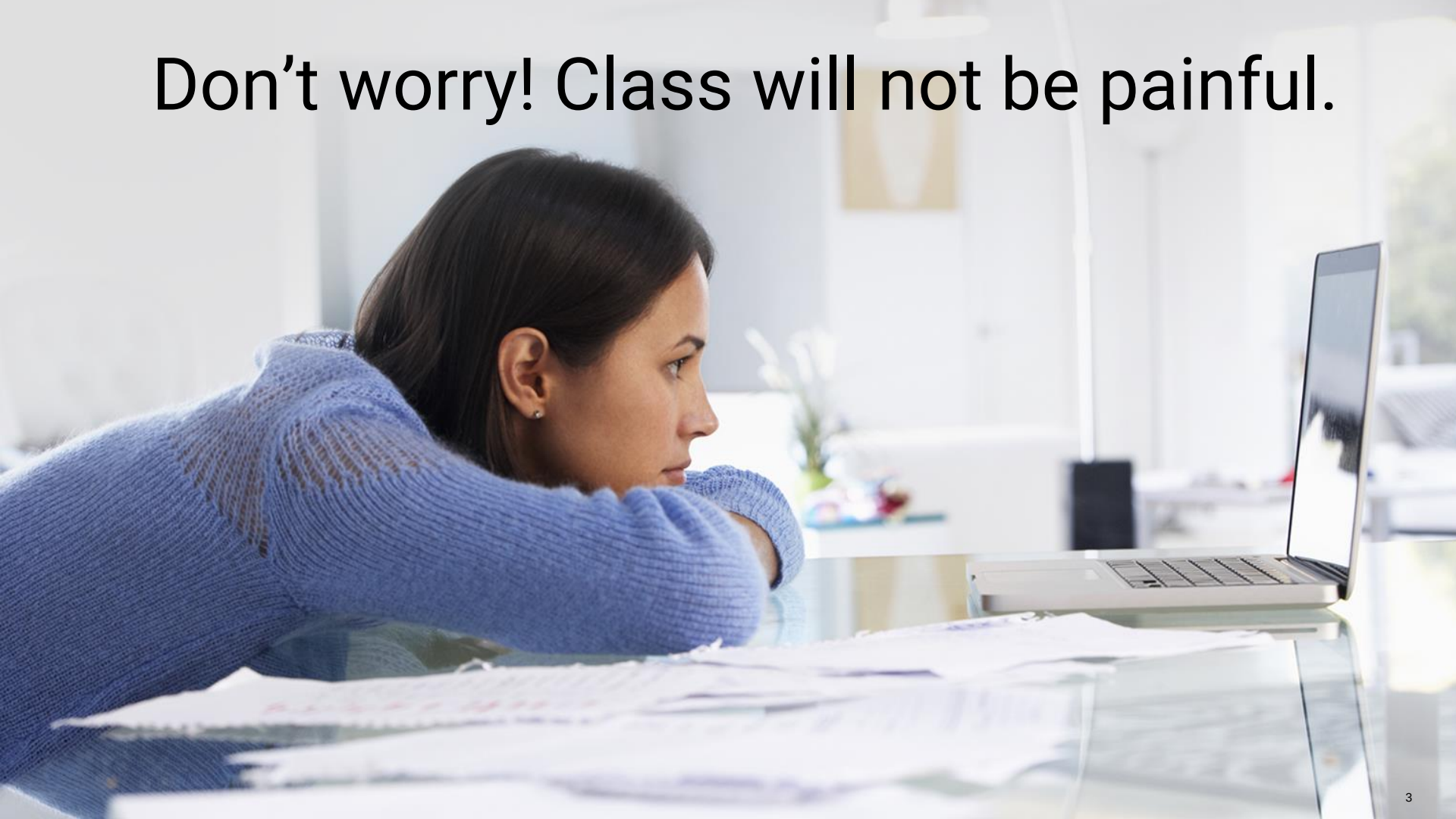
Class Objectives

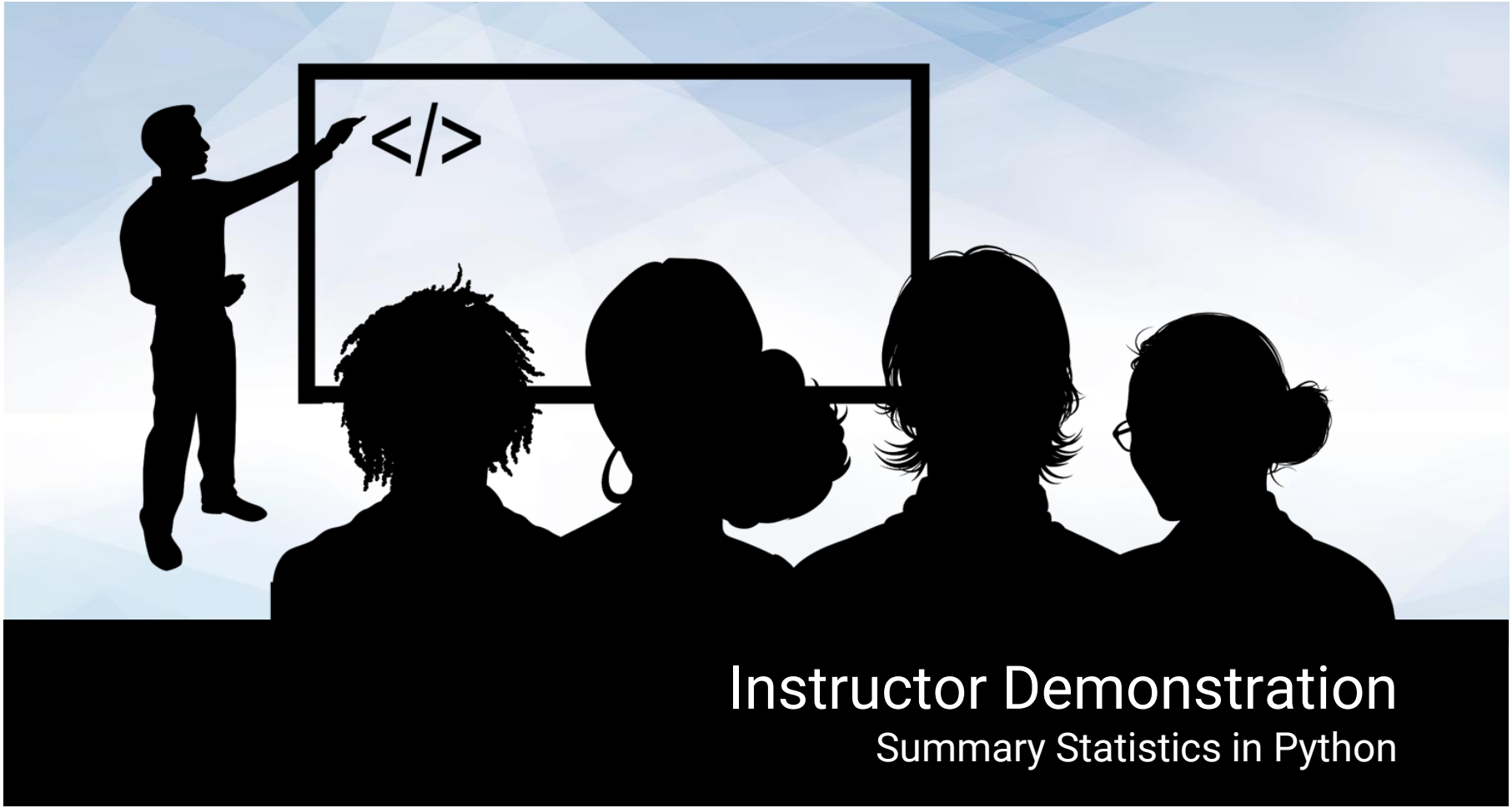
By the end of today's class, you will be able to:

- Calculate summary statistics such as mean, median, mode, variance and standard deviation using Python.
- Plot, characterize, and quantify a normally distributed dataset using Python.
- Qualitatively and quantitatively identify potential outliers in a dataset.
- Differentiate between a sample and a population in regards to a dataset.
- Define and quantify correlation between two factors.
- Calculate and plot a linear regression in Python.

Don’t worry! Class will not be painful.



We Will Build on Concepts You Already Know



Instructor Demonstration

Summary Statistics in Python

What is a **measure of central tendency**?

Measure of Central Tendency = Center of a Dataset

Three most common measures are **mean**, **median**, and **mode.**

Mean is the sum of all values divided by the number of elements in a dataset.

Median is the middle value in a sorted dataset.

Mode is the most frequently occuring value(s) in a dataset.

Measures of Central Tendency in Python

Two packages to remember when calculating statistics are **NumPy** and **SciPy.**

Mean is calculated using **NumPy.**

Median is calculated using **NumPy.**

Mode is calculated using **SciPy.**

When new data comes along, you must plot it!

When new data comes along, you must plot it!

(plot it good)

Why Plot Data?

01 To determine if the data is normally distributed.

02 To determine if the data is multimodal.

03 To characterize clusters in the dataset.

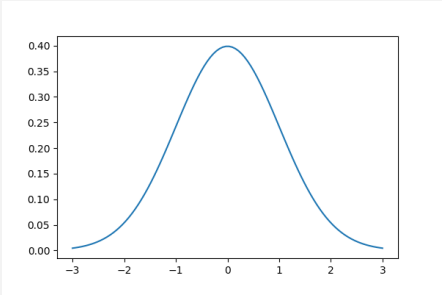
What Is Normally Distributed Data?

01

Measurements in a dataset are obtained independent of one another.

02

The distribution of data follows a bell curve shape.



03

We can quantitatively test if a dataset is normal using SciPy.

```
stats.normaltest()
```

What are **variance** and **standard deviation**?

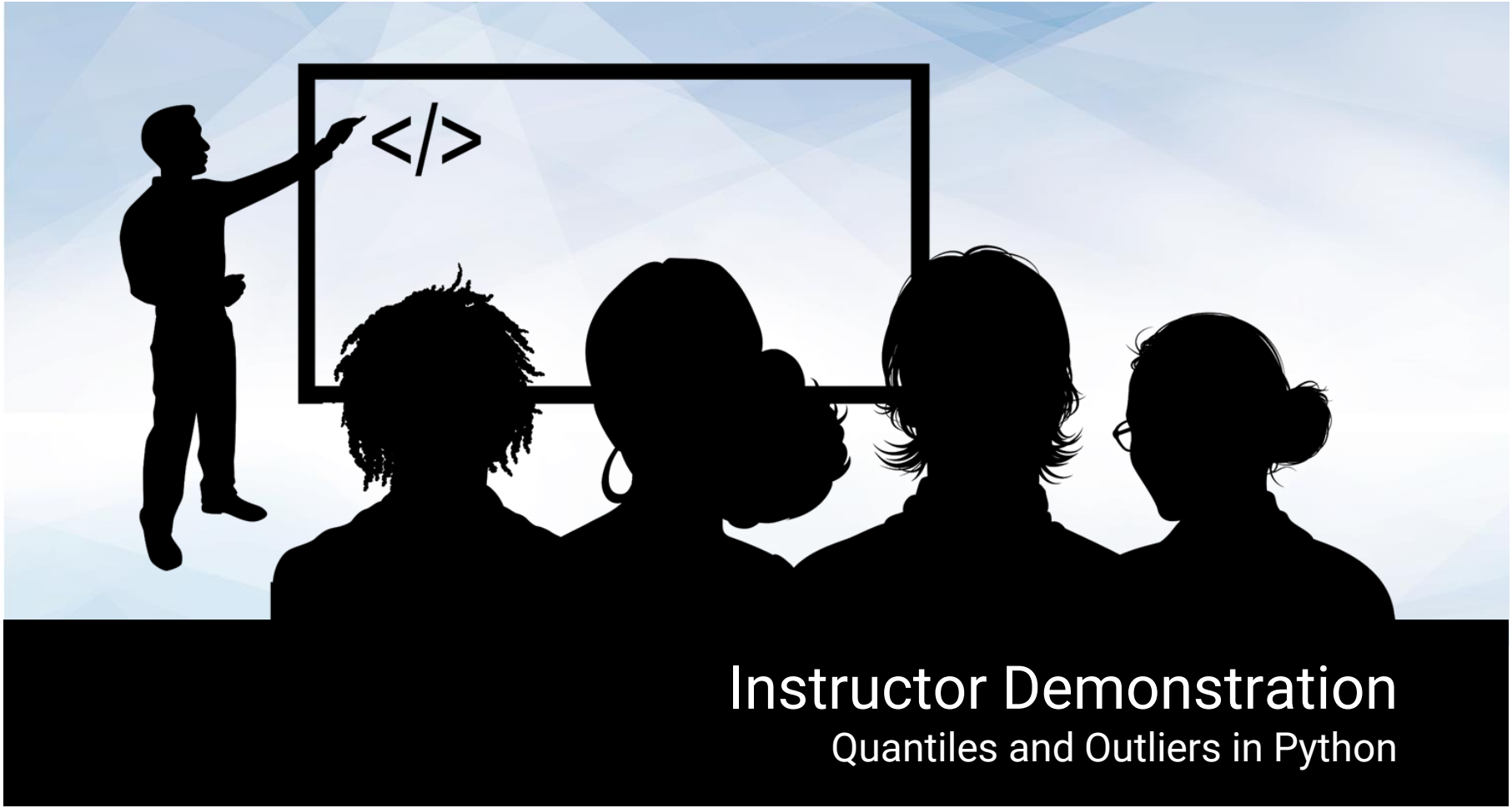
Variance & Standard Deviation Describe Variability of Data

Variance is the measurement of how far each value is away from the mean of the dataset.

Standard deviation is the square root of variance.

In Python, both variance and standard deviation are calculated using the NumPy module.

<Time to Code>



Instructor Demonstration

Quantiles and Outliers in Python

What are **quantiles, quartiles,** and **outliers**?

Quantiles, Quartiles, and Outliers Describe a Dataset

01

Quantiles divide data into well-defined regions based on a sorted dataset.

02

Quartiles are a specific type of quantile where a sorted dataset is split into four equal parts.

Q1: 25% of the data
Q2: 50% of the data
Q3: 75% of the data

03

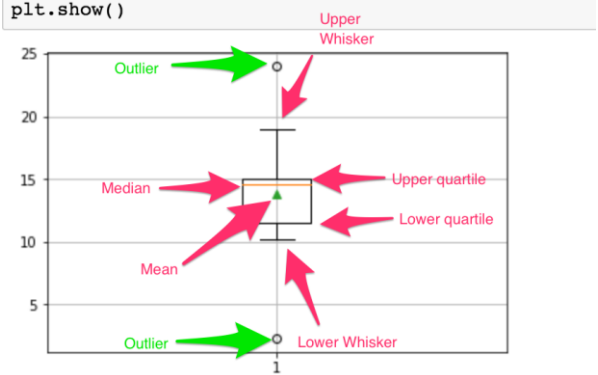
Outliers are an extreme value in a dataset that can skew calculations and results.

How to Identify Potential Outliers

01 Qualitatively

Use **box and whisker plots** to visually identify potential outlier data points.

```
# Create box plot
plt.boxplot(arr, showmeans=True)
plt.grid()
plt.show()
```



02 Quantitatively

Determine the outlier boundaries in a dataset using the **“1.5 IQR” rule**.

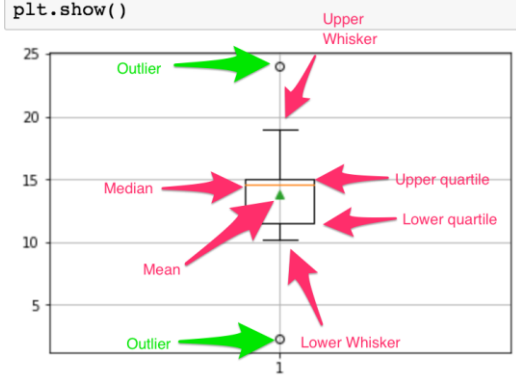
- IQR is the interquartile range, or the range between the 1st and 3rd quartiles.
- Anything **below** Q1 – 1.5 IQR could be an outlier.
- Anything **above** Q3 + 1.5 IQR could be an outlier.

How to Identify Potential Outliers in Python

01 Qualitatively

Use Matplotlib's `pyplot.boxplot` function to plot the box and whisker.

```
# Create box plot
plt.boxplot(arr, showmeans=True)
plt.grid()
plt.show()
```



02 Quantitatively

- Use Pandas' `series.quantile` function to calculate the quantile.
- Calculate the outlier boundaries.

<Time to Code>

Activity:
Summary Statistics in Python

In this activity, you will be tasked with calculating a number of summary statistics using California housing data.

(Instructions sent via Slack.)

Suggested Time:
Part of an Hour

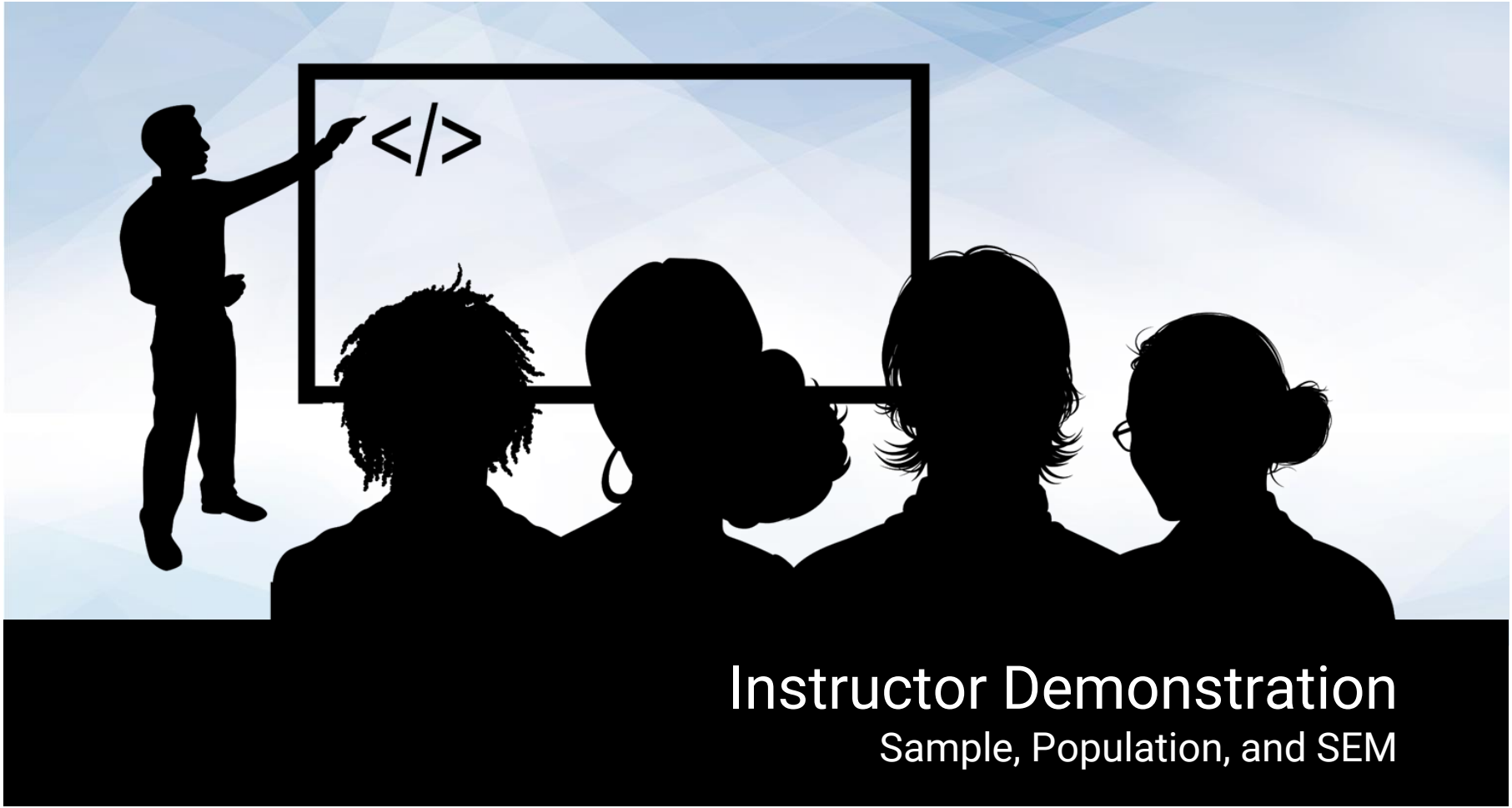
Instructions: Summary Statistics in Python

- Using Pandas, import the California housing dataset from the Resources folder.
  - **File:** `Resources/California_Housing.csv`
- Determine the most appropriate measure of central tendency to describe the population. Calculate this value.
- Is the age of houses in California normally distributed? Use both data visualization and quantitative measurement to find out.
- Inspect the average occupancy of housing in California and determine if there are potential outliers in the dataset.
  - **Hint**: This dataset is very large.
- If there are potential outliers in the average occupancy, what are the minimum and maximum median housing prices across the outliers?

Bonus

Plot the latitude and longitude of the California housing data using Matplotlib. Color the data points using the median income of the block. Does any location seem to be an outlier?

Time’s Up! Let’s Review.



Instructor Demonstration

Sample, Population, and SEM

Let’s think about the following scenario...

Predicting the City Election

Weeks before Election Day, a local newspaper wants to predict the winner of the mayoral election. The newspaper will poll voters for their intended candidate. Consider the following:

- It would be prohibitively expensive to poll all voters.
- It is logistically impossible to know who will actually go out to vote on Election Day.
- Therefore, the newspaper must predict the outcome of the election using data from a *subset* of the population.

Those who were polled are a **sample dataset.**
Those who vote are a **population dataset.**

Population Dataset vs. Sample Dataset

01

Population Dataset

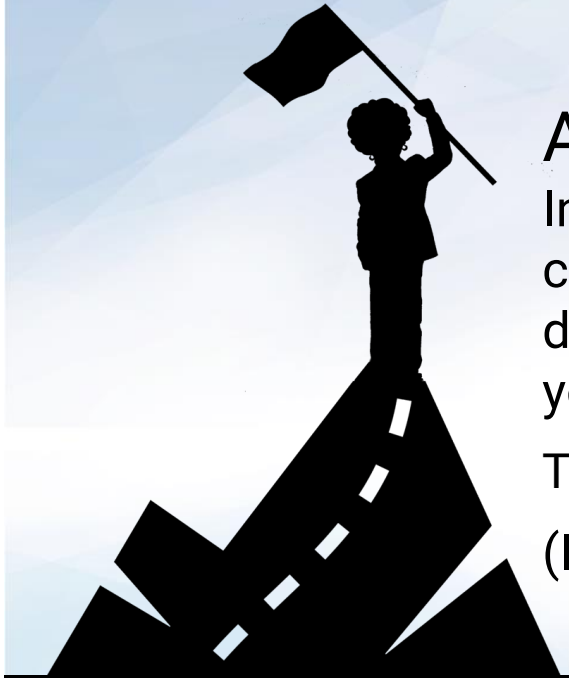
- Dataset containing all possible elements of an experiment or study.
- In statistics, “population” does not mean “people.”
- Any complete set of data is a population dataset.

02

Sample Dataset

- A subset of population data.
- A sample dataset can be selected randomly from the population or selected with bias.

<Time to Code>



Activity: SEM and Error Bars

In this activity, you will work with a partner to characterize sample data from a Boston housing dataset. Be sure to compare your calculated values as you progress through the activity.

Take your time—this is an important statistical concept.

(Instructions sent via Slack.)

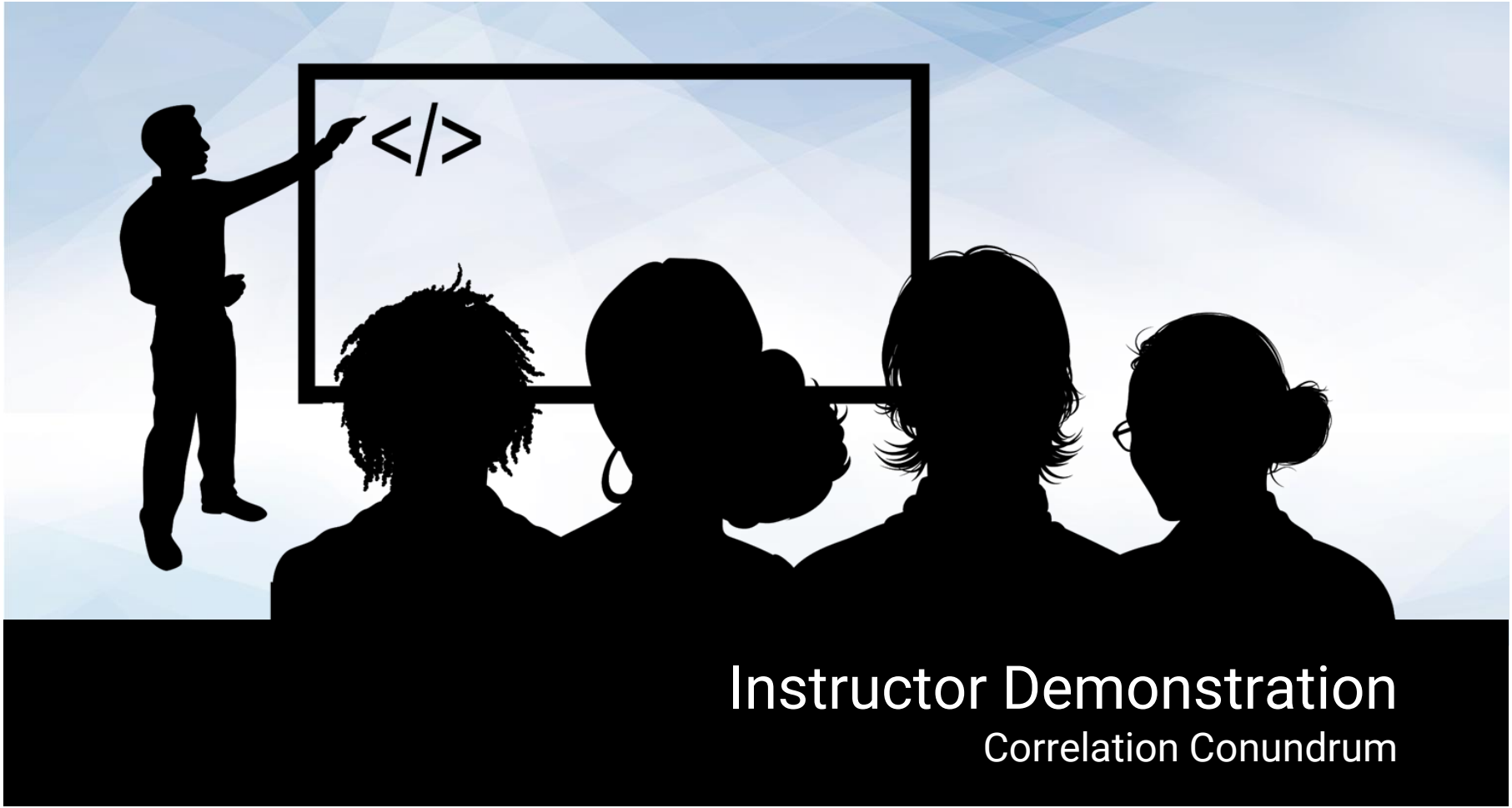
Suggested Time:
25 Minutes

Instructions: SEM and Error Bars

- Open `samples.ipynb` in the activity folder.
- Execute the starter code to import the Boston housing dataset from scikit-learn.
- Using Pandas, create a sample set of median housing prices. Be sure to create samples of size 20.
- Calculate the means and standard error for each sample.
- Create a plot displaying the means for each sample, with the standard error as error bars.
- Calculate the range of SEM values across the sample set.
- Determine which sample has the lowest standard error value.
- Compare this sample's mean to the population's mean.
- Rerun your sampling code a few times to generate new sample sets. Try changing the sample size and then rerun the sampling code.
- Discuss with your partner what changes you observe when sample size changes.

Break

Time’s Up! Let’s Review.

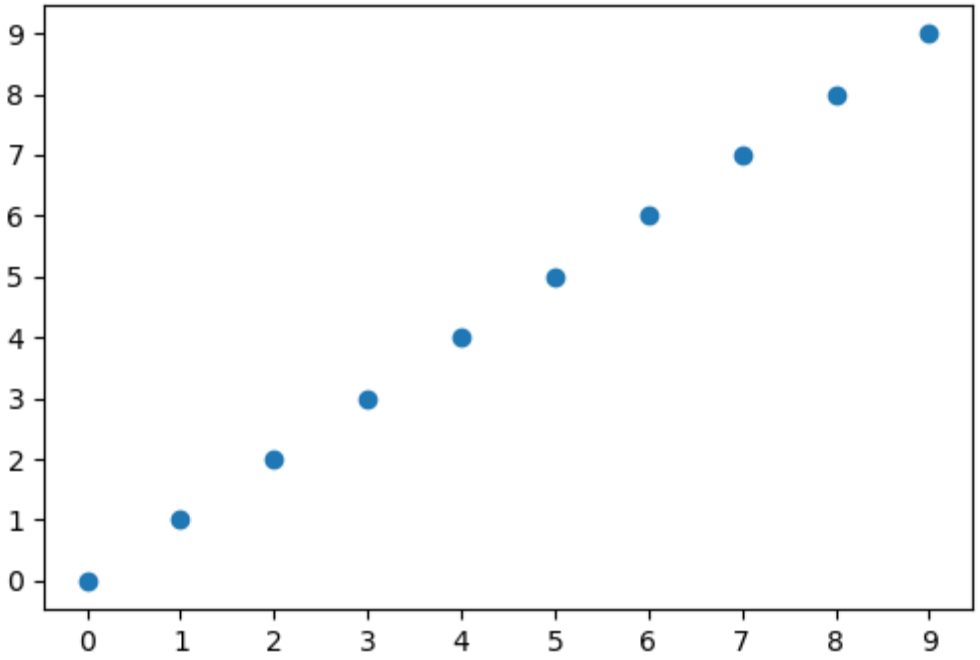


Instructor Demonstration

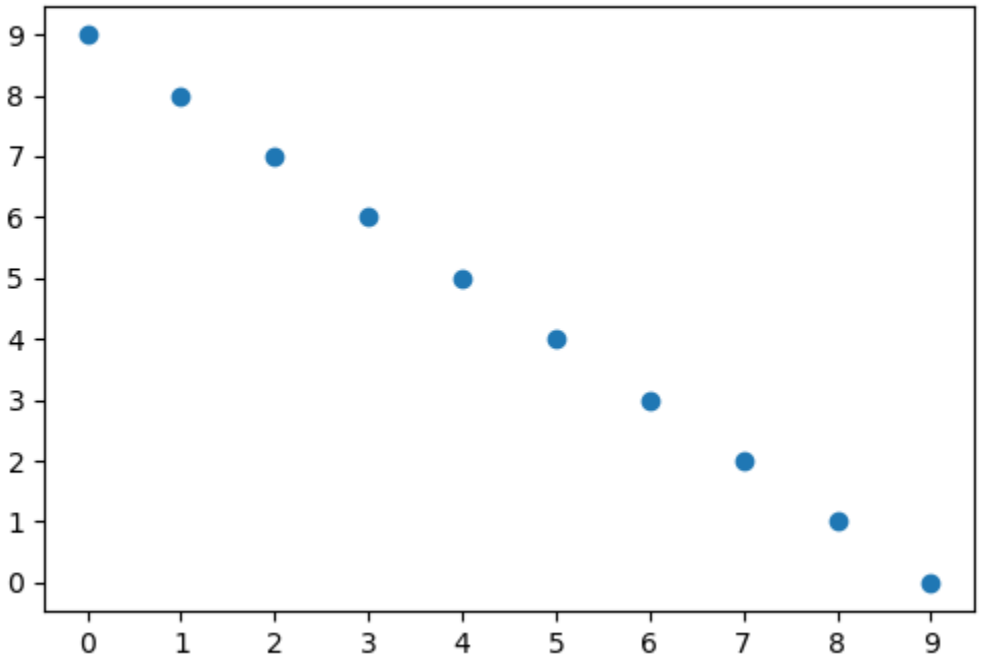
Correlation Conundrum

Correlation describes the question,“Is there a relationship between A and B?”

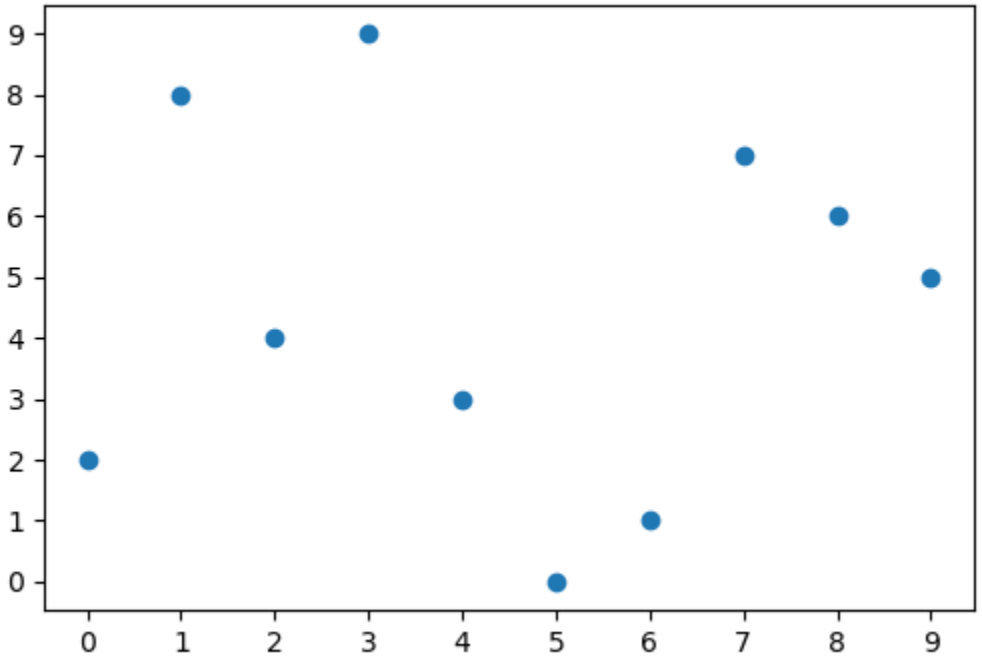
Positive Correlation



Negative Correlation



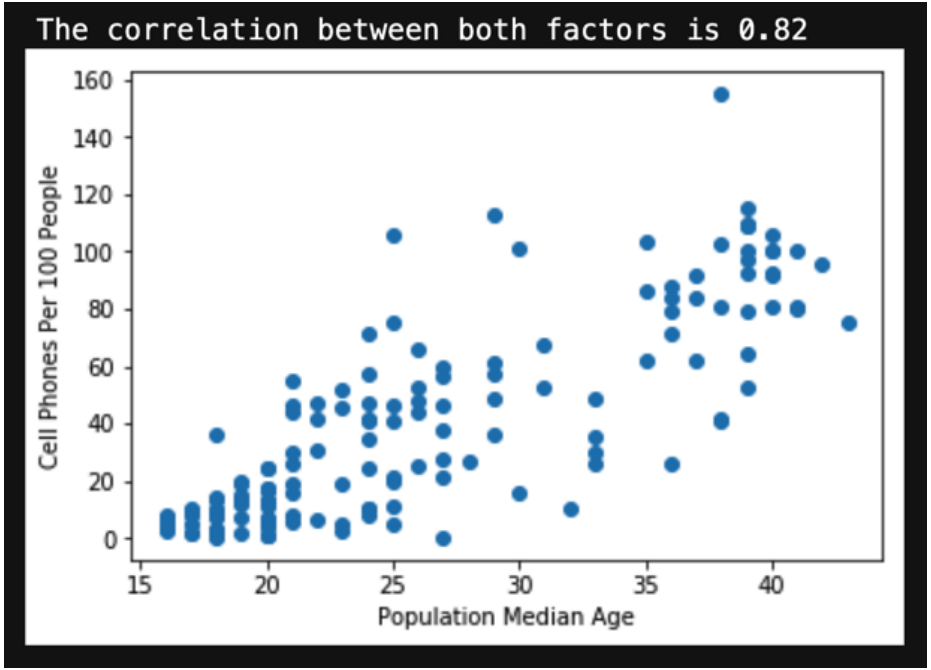
No Correlation



Pearson’s Correlation Coefficient

In statistics, we quantify correlation using Pearson’s *r*.

- Pearson’s correlation coefficient describes the variability between two factors, denoted by the variable *r*.
- Pearson’s *r* is $-1 \leq r \leq 1$
  - −1 indicates perfect negative correlation.
  - 1 indicates perfect positive correlation.
  - 0 indicates no correlation.
- Real-world data is almost always imperfect.



<Time to Code>

Activity: Correlation Conquerors

In this activity, you will be looking at different properties of wine to determine if wine characteristics are correlated.

(Instructions sent via Slack.)

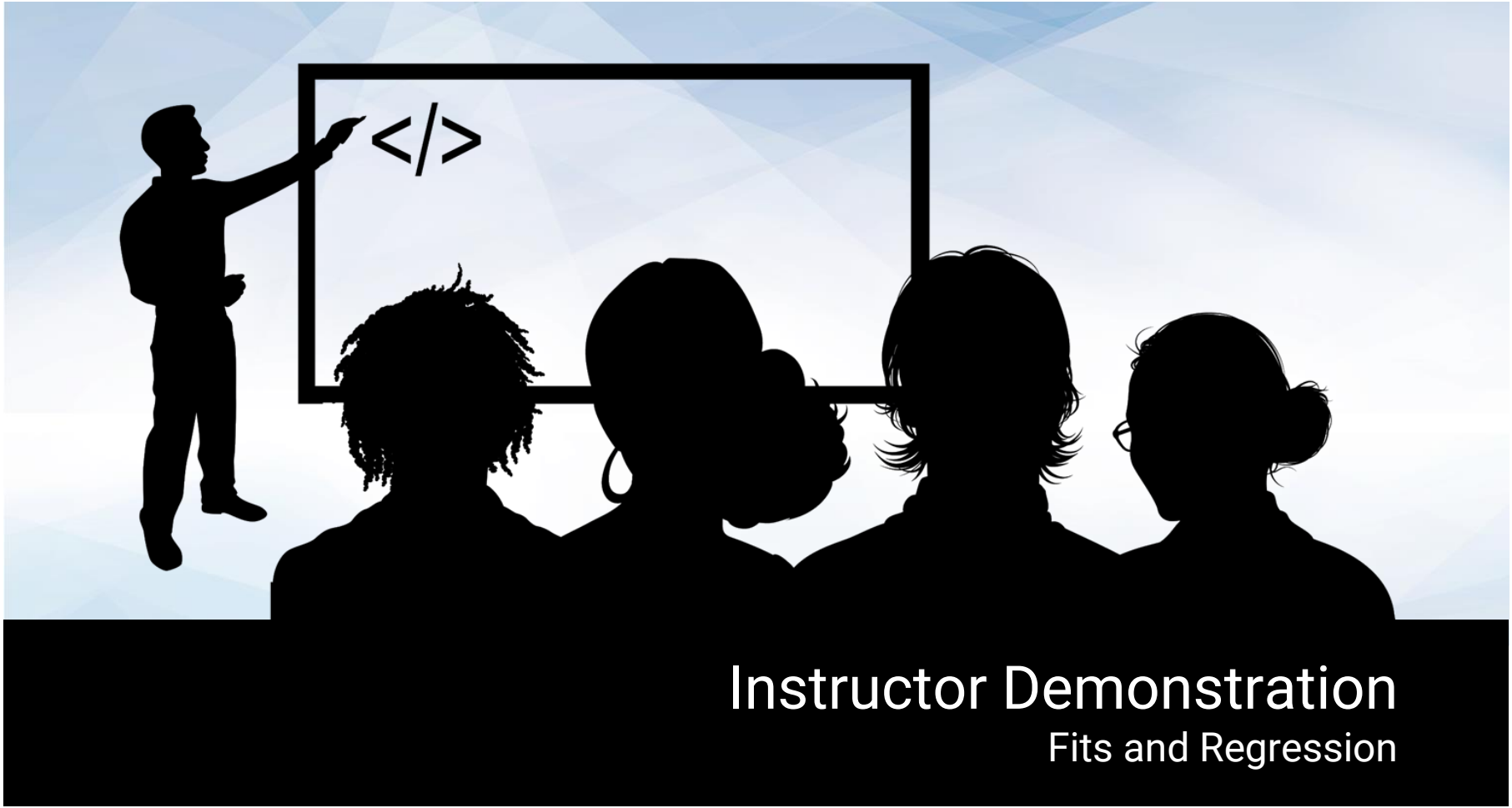
Suggested Time:
A Few Minutes

Instructions: Correlation Conquerors

- Open `correlations.ipynb` in the activity folder and execute the starter code.
- Using the dataset, plot the factors malic acid versus flavanoids on a scatter plot.
    - Is this relationship positively correlated, negatively correlated, or not correlated?
    - How strong is the correlation?
- Calculate the Pearson's correlation coefficient for malic acid versus flavanoids.
    - Compare the correlation coefficient to the "Strength of Correlation" table.
    - Was your prediction correct?

Absolute Value of r	Strength of Correlation
$r < 0.3$	None or very weak
$0.3 \leq r < 0.5$	Weak
$0.5 \leq r < 0.7$	Moderate
$r \geq 0.7$	Strong

Time’s Up! Let’s Review.



Instructor Demonstration

Fits and Regression

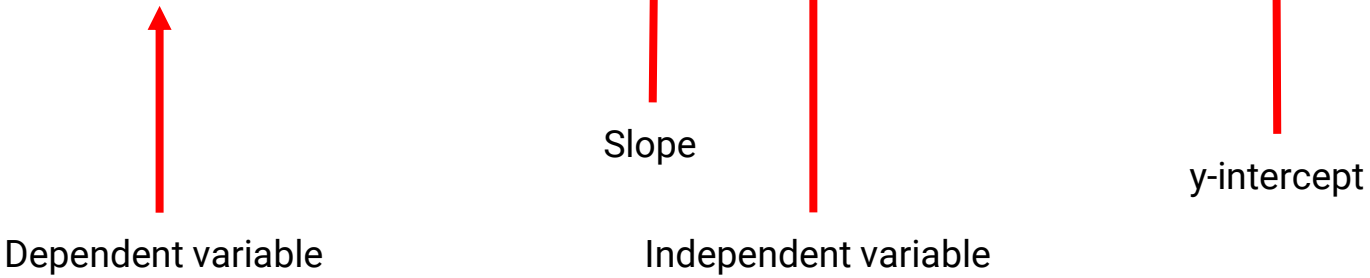
What is the equation of a line?

The equation of a line is:

$$y = mx + b$$

The Equation of a Line

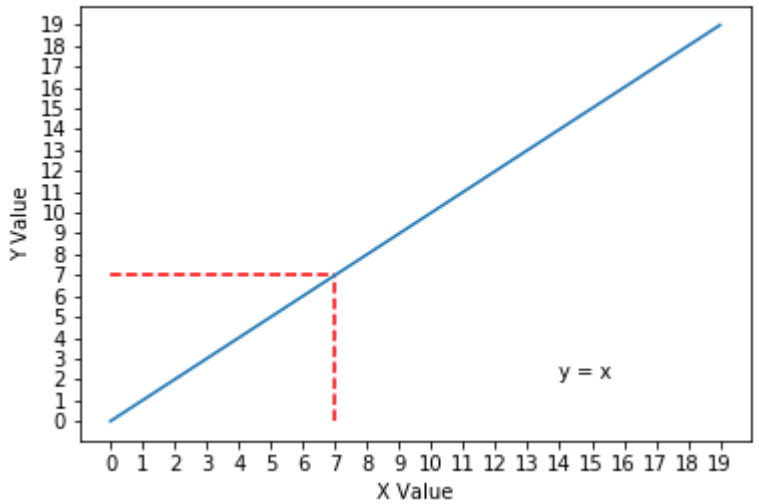
$$y = mx + b$$



The equation of a line determines y values given x

In this example:

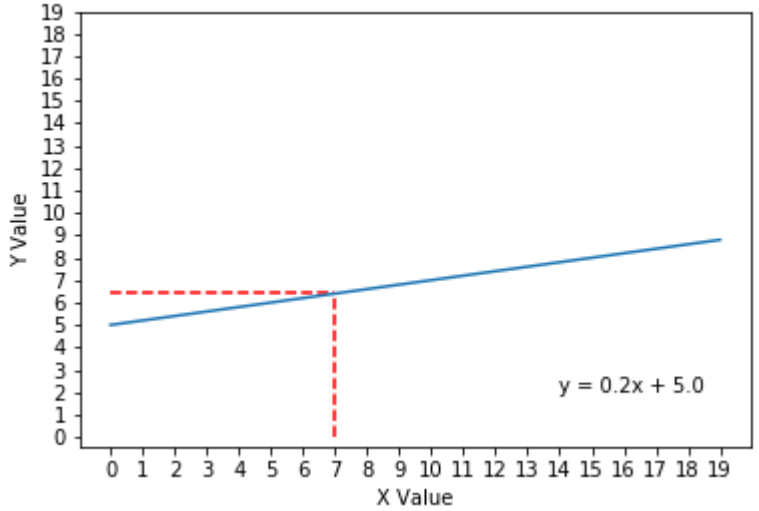
- Slope = 1
- *y*-intercept = 0
- Whatever *x* is, the value of *y* is the same.



The Equation of a Line Determines *y* Values, Given *x*

In this example:

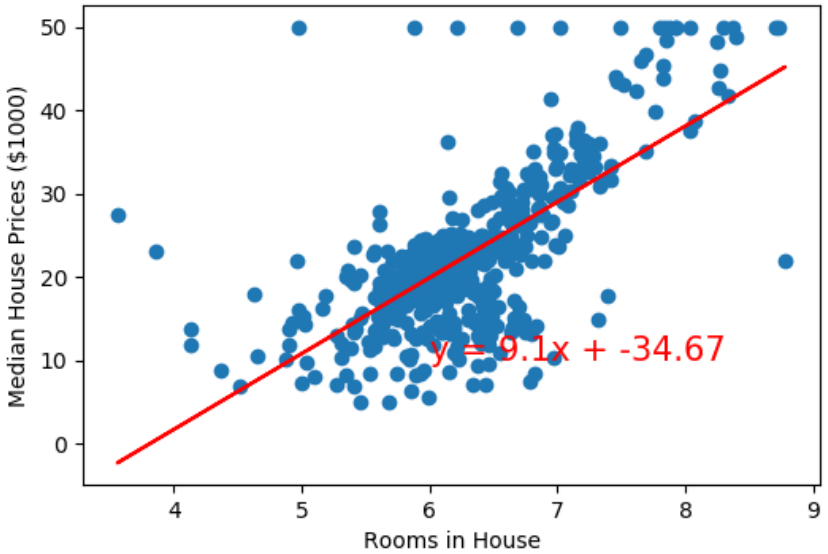
- Slope = 0.2
- *y*-intercept = +5
- If *x* = 7, then *y* = 6.4



Linear Regression Fits the Equation of a Line to Real-World Data

Linear regression…

- Predicts the values of factor B, given values from factor A.
- Estimates where data points that were not measured might end up if more data was collected.
- Is used to predict housing prices, stock market, weather, etc.



<Time to Code>

Activity: Fits and Regressions

In this activity you will be predicting the crime rates in 2019, using linear regression models.

(Instructions sent via Slack.)

Suggested Time:
MMMinutes

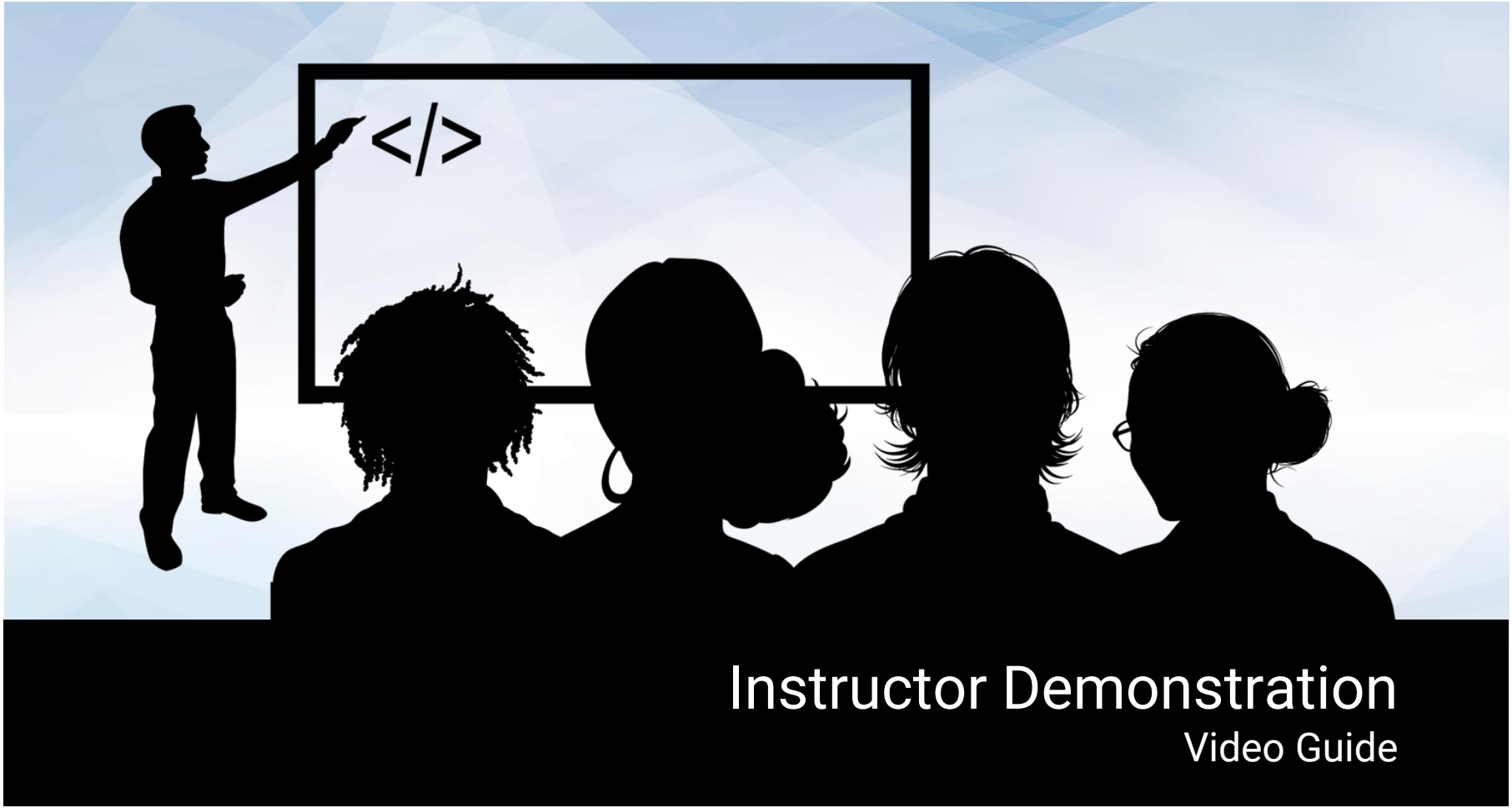
Instructions: Correlation Conquerors

- Open `crime.ipynb` and execute the starter code.
- Generate a scatter plot with Matplotlib using the year as the independent (*x*) variable and violent crime rate as the dependent (*y*) variable.
- Use `stats.linregress` to perform a linear regression with the year as the independent variable (*x*) and violent crime rate as the dependent variable (*y*).
- Use the information returned by `stats.linregress` to create the equation of a line from the model.
- Calculate the predicted violent crime rate of the linear model using the year as the *x*-value.
- Plot the linear model of year versus violent crime rate on top of your scatter plot.
- Repeat the process of generating a scatter plot, calculating the linear regression model, and plotting the regression line over the scatter plot for year versus murder rate, and year versus aggravated assault.

Bonus

Use `pyplot.subplots` from Matplotlib to create a new figure that displays all three pairs of variables on the same plot.

Time’s Up! Let’s Review.



Instructor Demonstration

Video Guide