

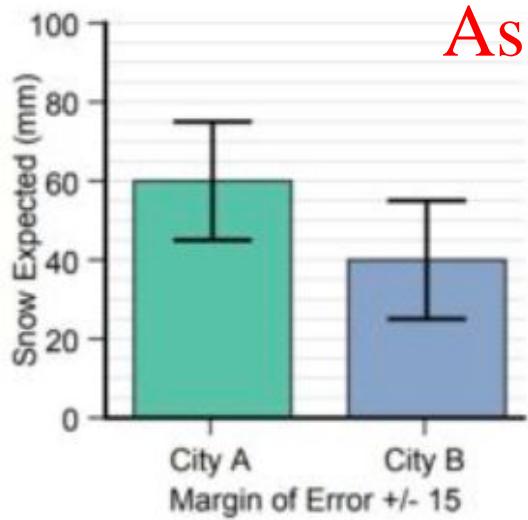
Assignment #2 (Nov-9)

- Work with challenge data
- Divide and conquer your data
- Submit individually (*one unique submission per student. No plagiarism!*)
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- Explore your data using <https://powcoder.com>
 - Simple statistics
 - Simple charts
- Report observations (*What do you see?*)
- Formulate hypotheses (*Why could that be?*)

Assignment #2 (Nov-9)

- Describe data
 - General type of data
 - How large and complex
 - Fields, links,
 - What's your challenge question
<https://powcoder.com>
- Explore
 - 4-5 exploratory graphs
 - Explanations
 - Simple stats
- Reflect and hypothesis
 - Reflect on data
 - 3-5 hypotheses

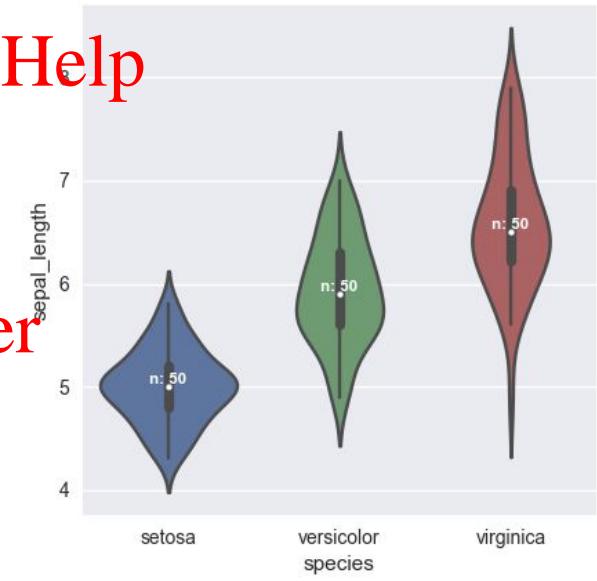
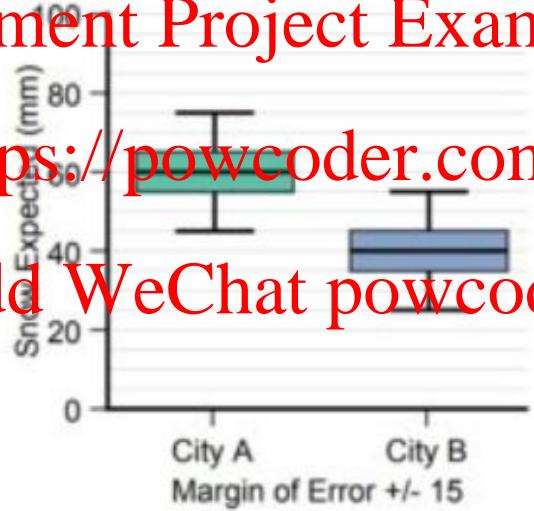
Python programming



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<https://powcoder.com>

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Outline for today

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What are visualizations and what do we need to learn about them?

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1. Visualization 101
2. Visualization Literacy <https://powcoder.com>
3. Basic Charts
4. Visualization design process

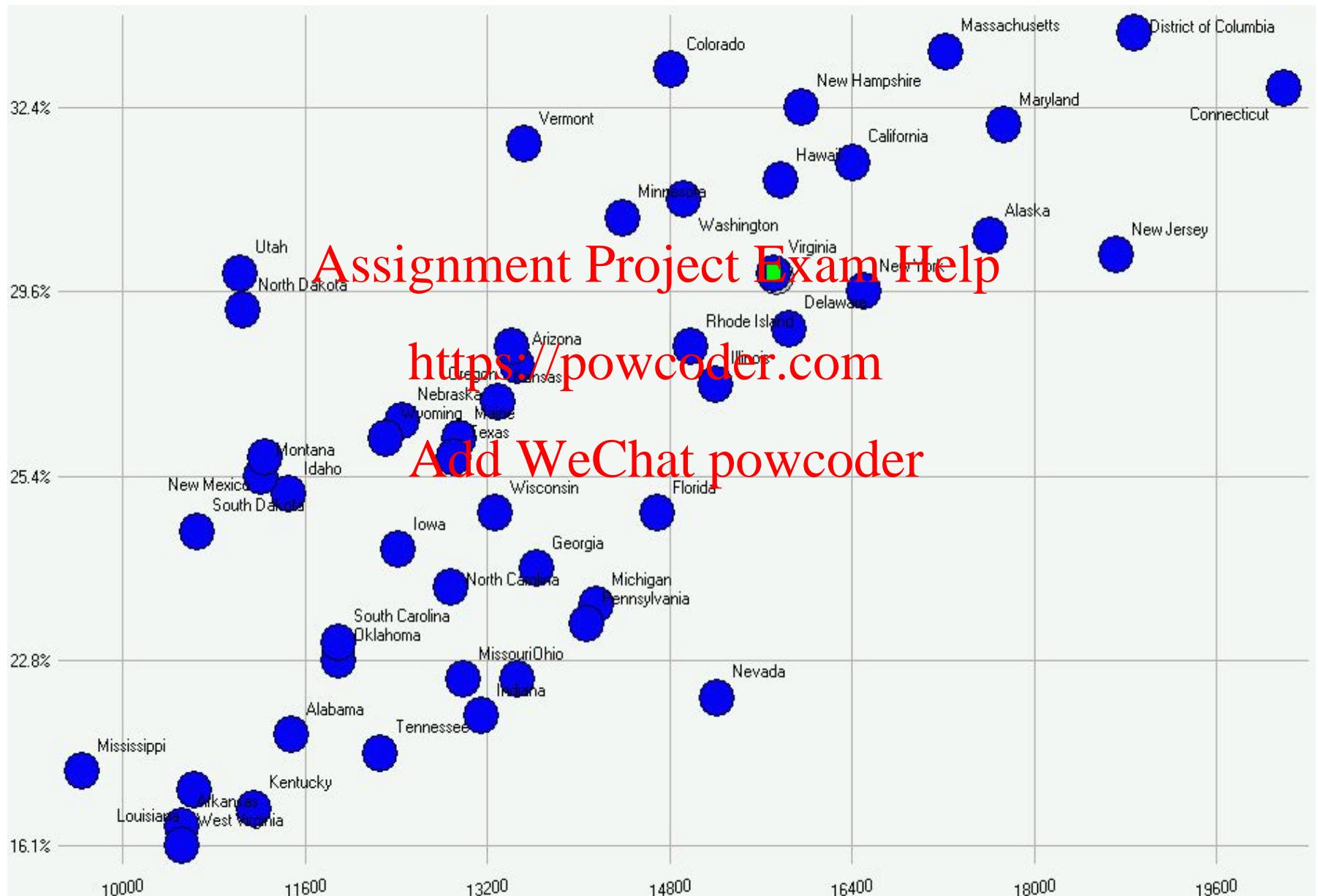
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Visual representation of data

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<https://powcoder.com>
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Table - StateData ()							
State	College Degree %	Per Capita Income	Load	Snap	Michigan	Lotto	Population
Alabama	20.6%	11486			Minnesota	30.4%	14389
Alaska	30.3%	17610			Mississippi	19.9%	9648
Arizona	27.1%	13461			Missouri	22.3%	12989
Arkansas	17.0%	10520			Montana	25.4%	11213
California	31.3%	16409			Nebraska	26.0%	12452
Colorado	33.9%	14021			Nevada	21.5%	15214
Connecticut	33.8%	20189			New Hampshire	32.4%	15959
Delaware	27.9%	15854			New Jersey	30.1%	18714
District of Columbia	36.4%	18820			New Mexico	26.5%	11246
Florida	24.9%	14698			New York	29.6%	16501
Georgia	24.3%	13631			North Carolina	24.2%	12885
Hawaii	31.2%	15770			North Dakota	28.1%	11051
Idaho	25.2%	11150			Ohio	22.3%	13461
Illinois	26.8%	15201			Oklahoma	22.8%	11893
Indiana	20.9%	13149			Oregon	27.5%	13418
Iowa	24.5%	12422			Pennsylvania	23.2%	14068
Kansas	26.5%	13300			Rhode Island	27.5%	14981
Kentucky	17.7%	11153			South Carolina	23.0%	11897
Louisiana	19.4%	10635			South Dakota	24.6%	10661
Maine	25.7%	12957			Tennessee	20.1%	12255
Maryland	31.7%	17730			Texas	25.5%	12904
Massachusetts	34.5%	17224			Utah	30.0%	11029
Michigan	24.1%	14154			Vermont	31.5%	13527
Minnesota	30.4%	14389			Virginia	30.0%	15713
			◀	▶	Washington	30.9%	14923
					West Virginia	16.1%	10520
					Wisconsin	24.9%	13276
					Wyoming	25.7%	42311

Visual representation of data



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Find every '5'

9176867991960386255930486551443

9353652502752141394912668766013

50954446634735459935043148078

6425620171155906710121069218701

0584448205561385902503573068845

1172102391879794238892669764599

6987227951015948926017759166604

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3280506428553158863136868380421

4055135906770329783671748392874

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Find every '5'

9176867991960386255930486551443
9353652502752141394912668766013
50954446634735459935043148078
6425620171155906710121069218701
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Pre-attentiveness:

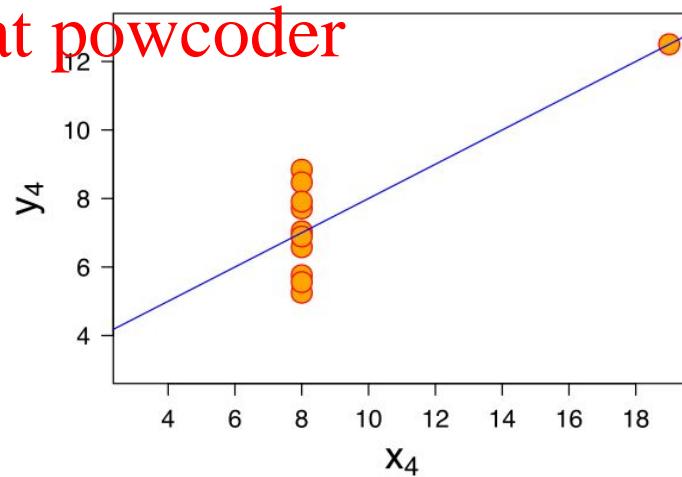
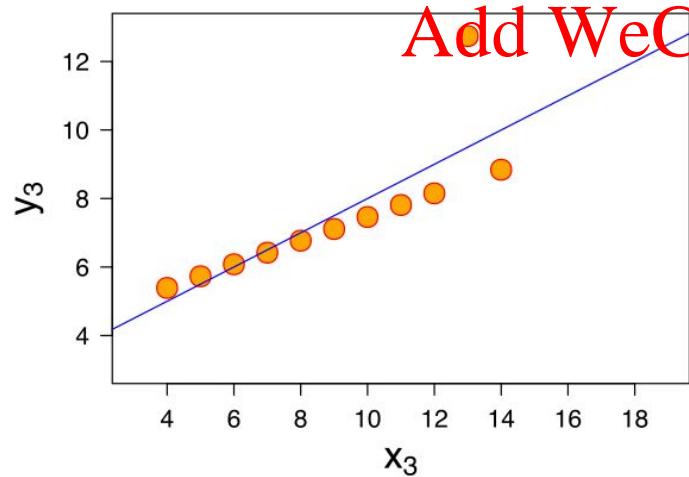
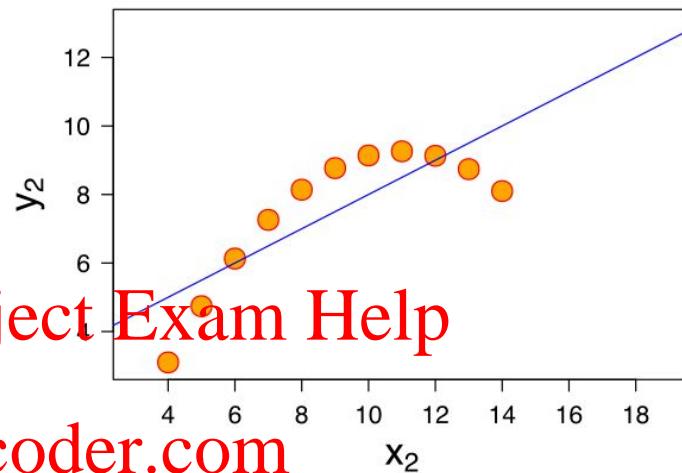
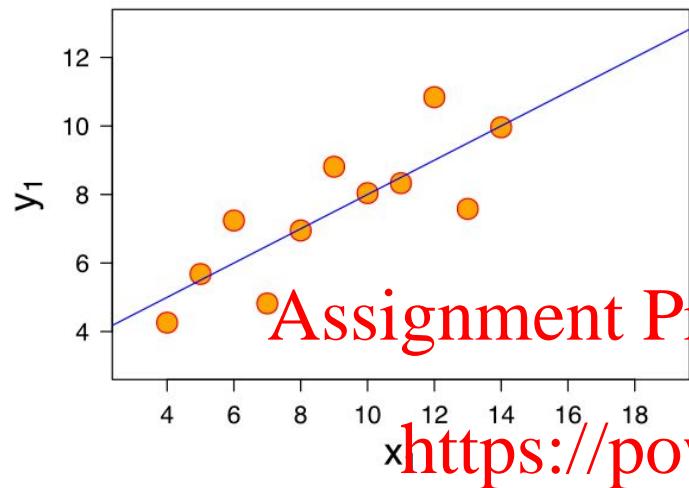
- is the subconscious accumulation of information from the environment
- realizing something before you think

Parallelity: Assignment Project Exam Help

- Perceiving stimuli in parallel

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Anscombe's Quartet

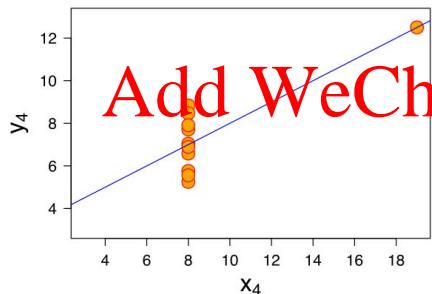
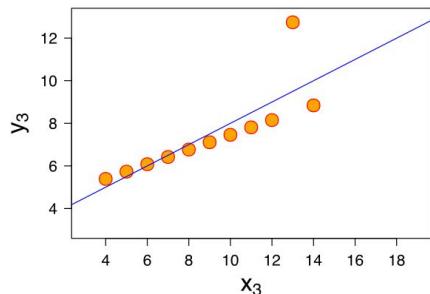
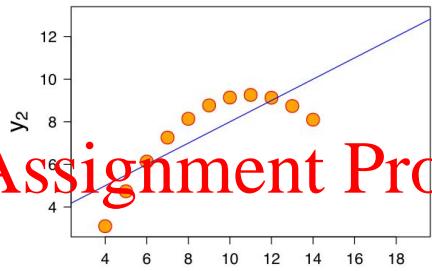
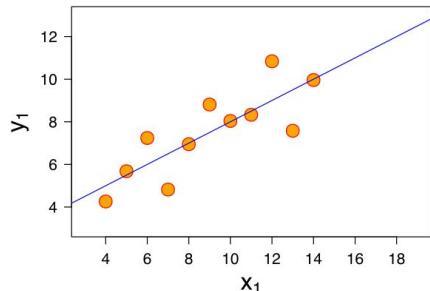


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Anscombe's Quartet



Property	Value
Mean of x	9
Sample variance of x	11
Mean of y	7.50
Sample variance of y	4.125
Correlation between x and y	0.816
Linear regression line	$y = 3.00 + 0.500x$
Coefficient of determination of the linear regression	0.67

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Statistics

- Numbers + math
- Comparison
- Small differences
- Answers questions
(hypothesis testing)
- Detail
- Single information
- ...

Visualization

- Overview
- Creates questions
(hypothesis generation)
- Serendipity
- Multiple information
- ...

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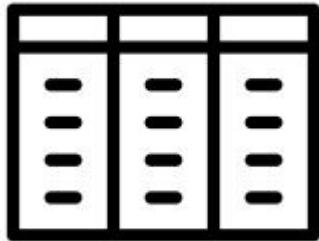
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Communication

- Interpretation
- Critiquing
- Contextualization
- Presentation
- ...

Sense making process

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Data

*Numbers,
relations,
records,
text,
analysis, ...*

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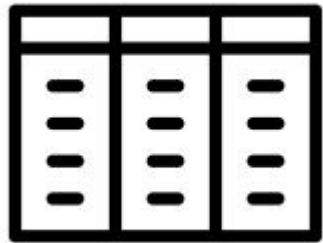
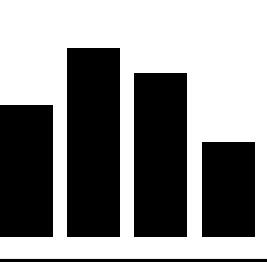
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Action

*Decisions
Emotions,
Knowledge
Insight*

Sense making process



Data
*Numbers,
relations,
records,
text,
analysis, ...*



Visualization
*visual
representation*
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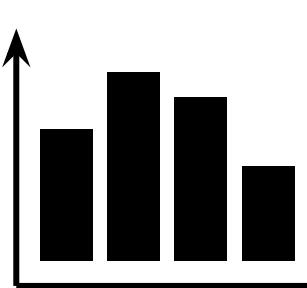
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Action
*Decisions
Emotions,
Knowledge
Insight*

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Sense making process



Assignment Project Exam Help

Data

*Numbers,
relations,
records,
text,
analysis, ...*

Visualization

*visual
representation*

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Information

*Insights,
Facts*

Action

*Decisions
Emotions,
Knowledge
Insight*

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Exploration

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<https://powcoder.com>

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Exploration *Insights*

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Exploration

Insights

Explanation

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Exploration

Insights

Explanation

Data centered

Domain experts

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Generating <https://powcoder.com>

Insight Add WeChat powcoder

Lab Setting

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Exploration

Insights

Explanation

Data centered

Human centered

Domain experts

Non-experts

Generating

Conveying

Insight

messages

Lab Setting

In-the-wild /
diverse

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Visualization Literacy

- the ability to **confidently use** a given data visualization,
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- to translate questions specified in the data domain into
visual queries in the visual domain,
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- **interpreting visual patterns** in the visual domain as
properties in the data domain

Visualization Literacy

Reading:

- Correctly decode (simple & complex) visual representations
- Know pitfalls and deceptions
- Think critically 'beyond' and see 'through' the visualization

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Design:

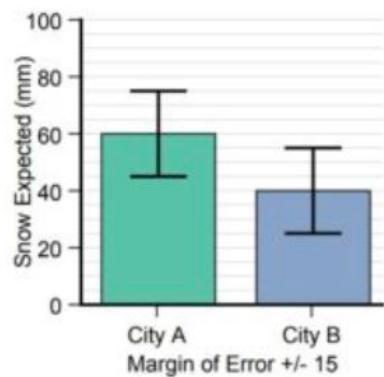
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- Create efficient and effective visualizations
- Design efficient and effective visualizations

Explore:

- perform tasks: ask and answer questions
- Interact with visualizations

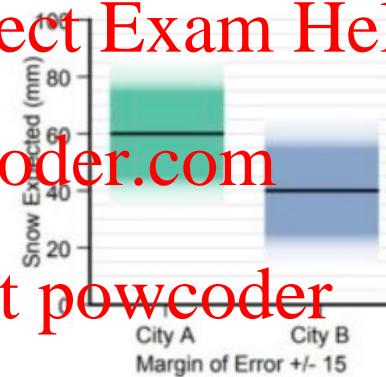
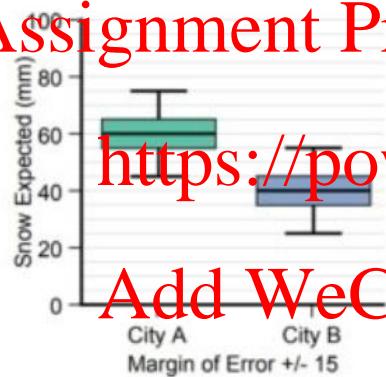
What are the differences?



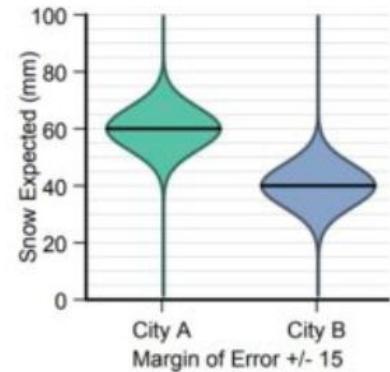
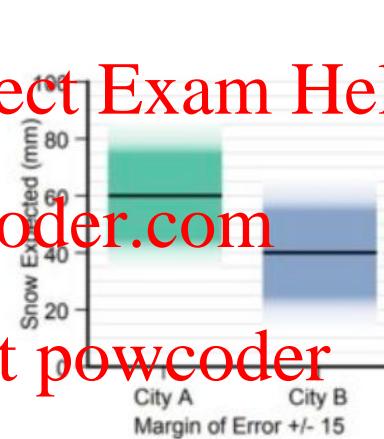
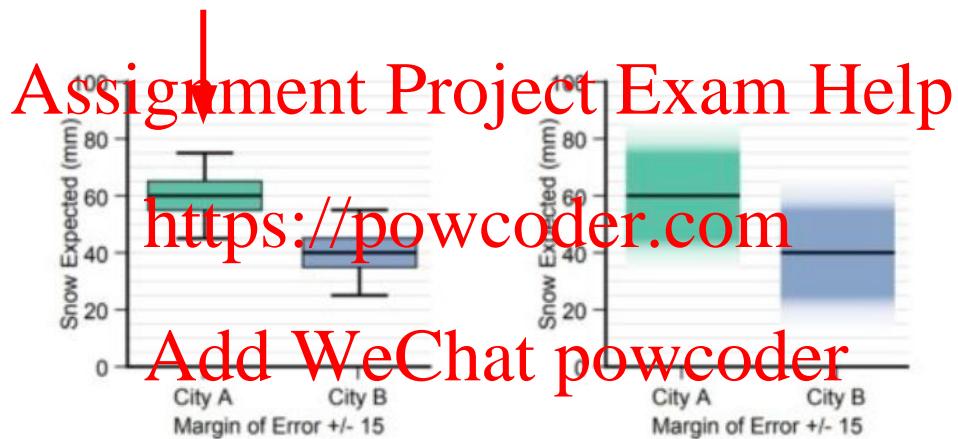
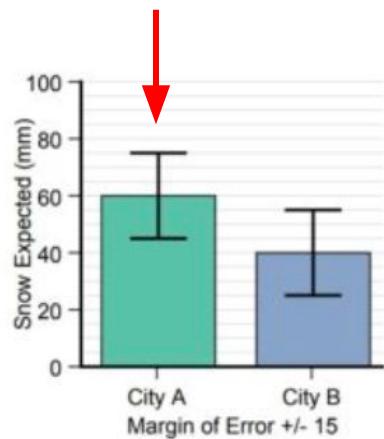
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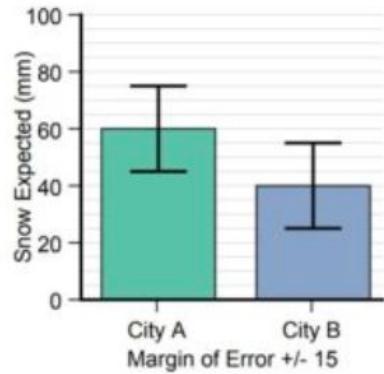
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What are the differences?



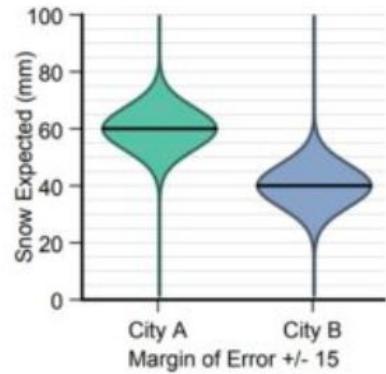
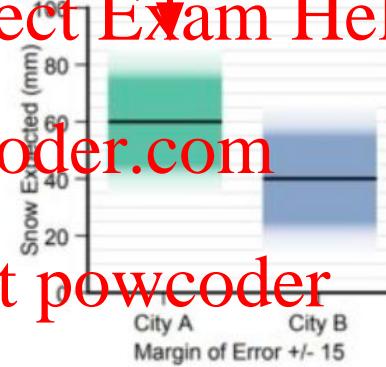
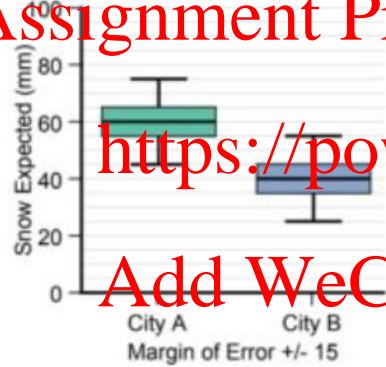
What are the differences?



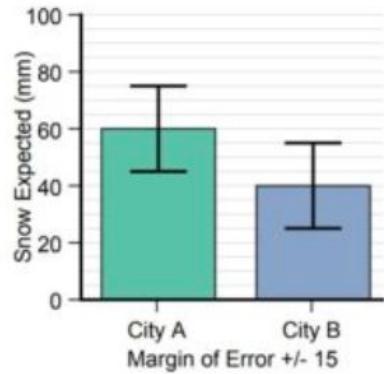
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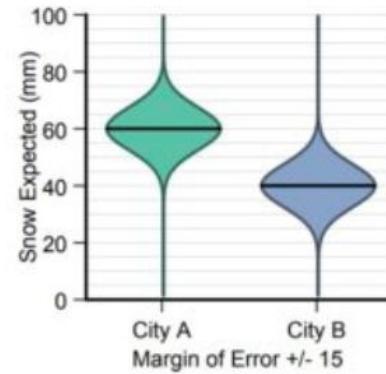
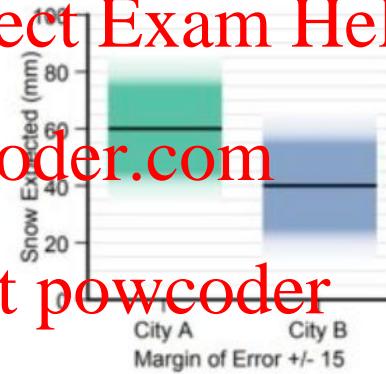
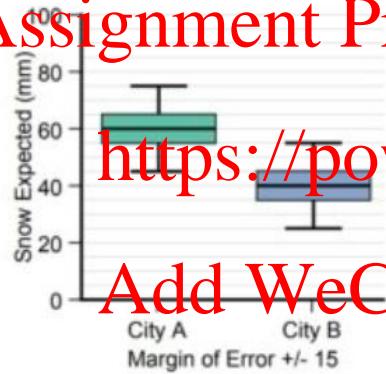
What are the differences? WeChat powcoder



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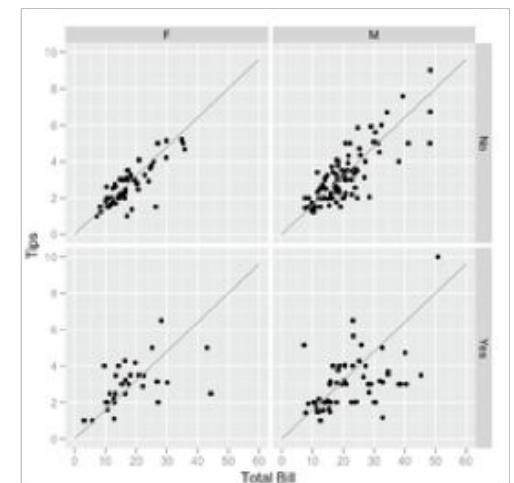
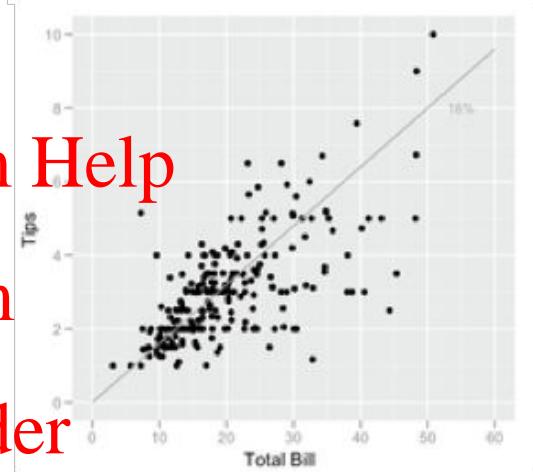
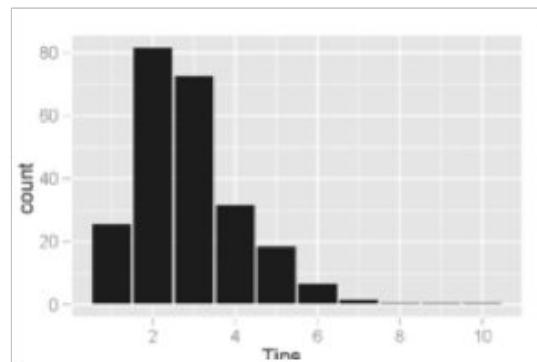
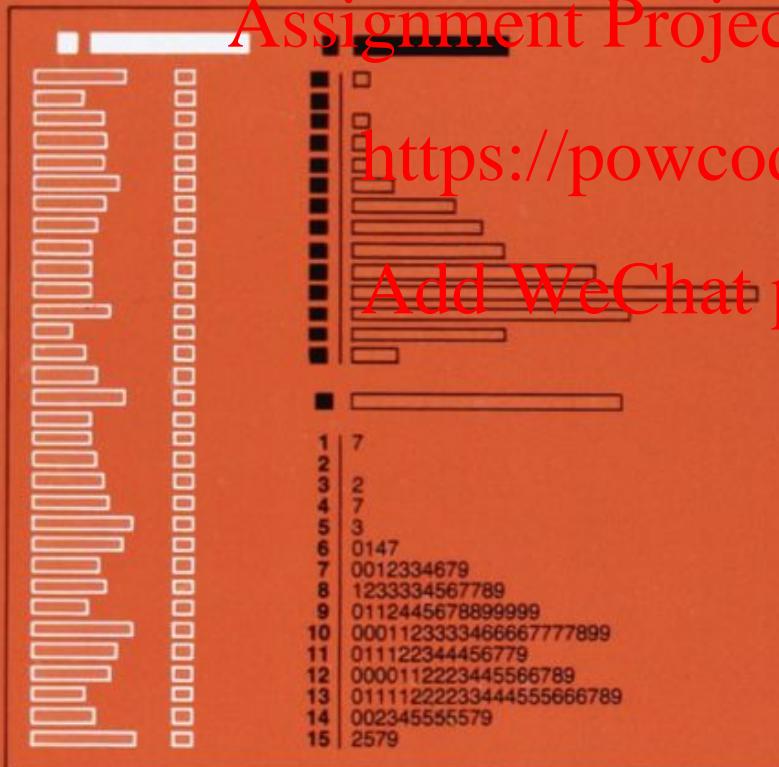
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John W. Tukey

EXPLORATORY DATA ANALYSIS



Exploratory Data Analysis

- Observe your data from many perspectives
- Observe as many facets as possible
- It's called the *Grand Tour*
- Obtain as much observations as possible
- Generate insight and information
- Take notes

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- Collaborate
- Communicate

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	Last Name	Sales
1	Smith	\$16,753.00
3	Johnson	\$14,808.00
4	Williams	\$10,644.00
5	Jones	\$1,390.00
6	Brown	\$4,867.00
7	Williams	\$12,438.00
8	Johnson	\$9,339.00
9	Smith	\$18,919.00
10	Jones	\$9,213.00
11	Jones	\$7,433.00
12	Brown	\$3,255.00
13	Williams	\$14,867.00
14	Williams	\$19,302.00
15	Smith	\$9,698.00
16		

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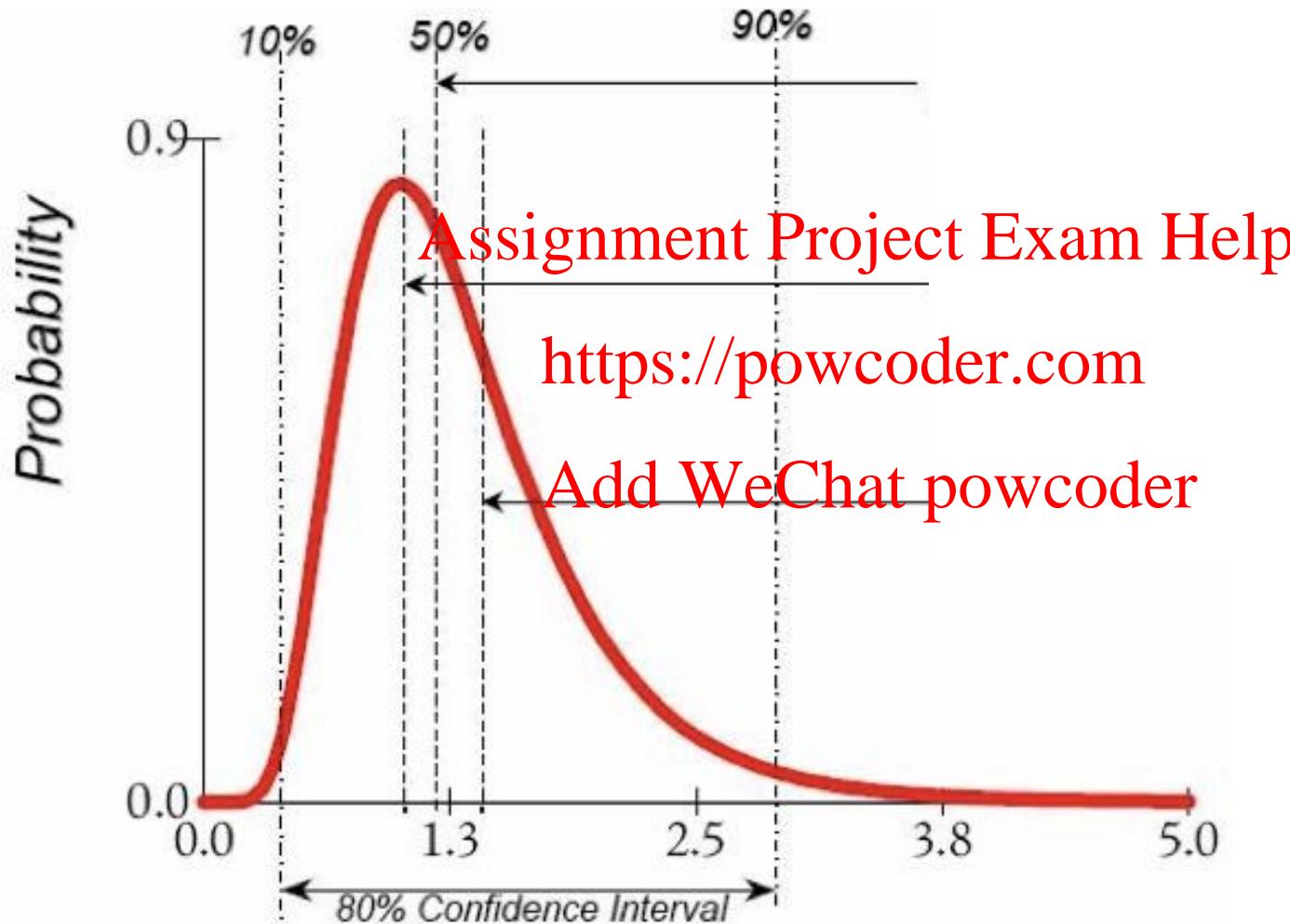
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Distributions

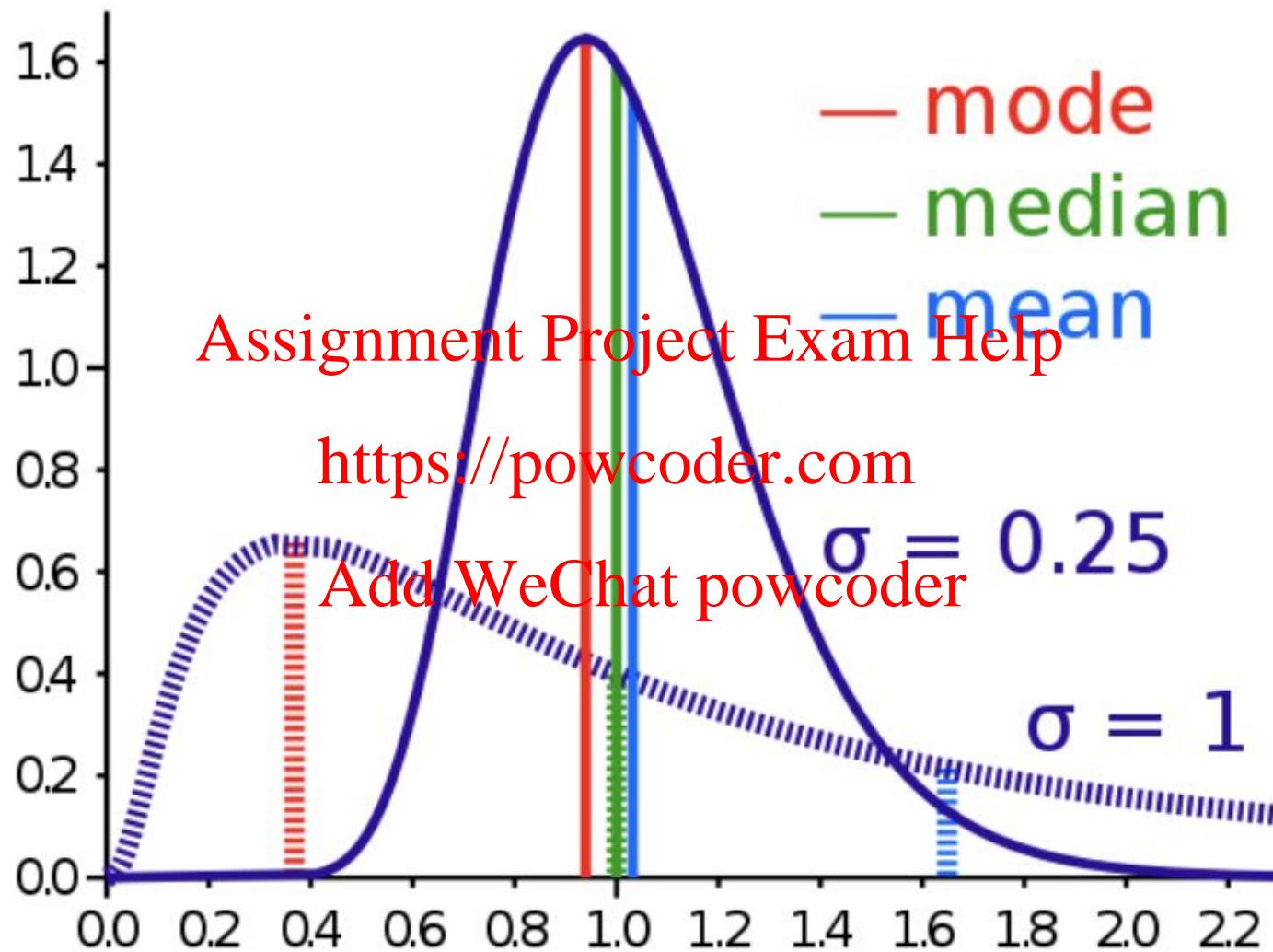
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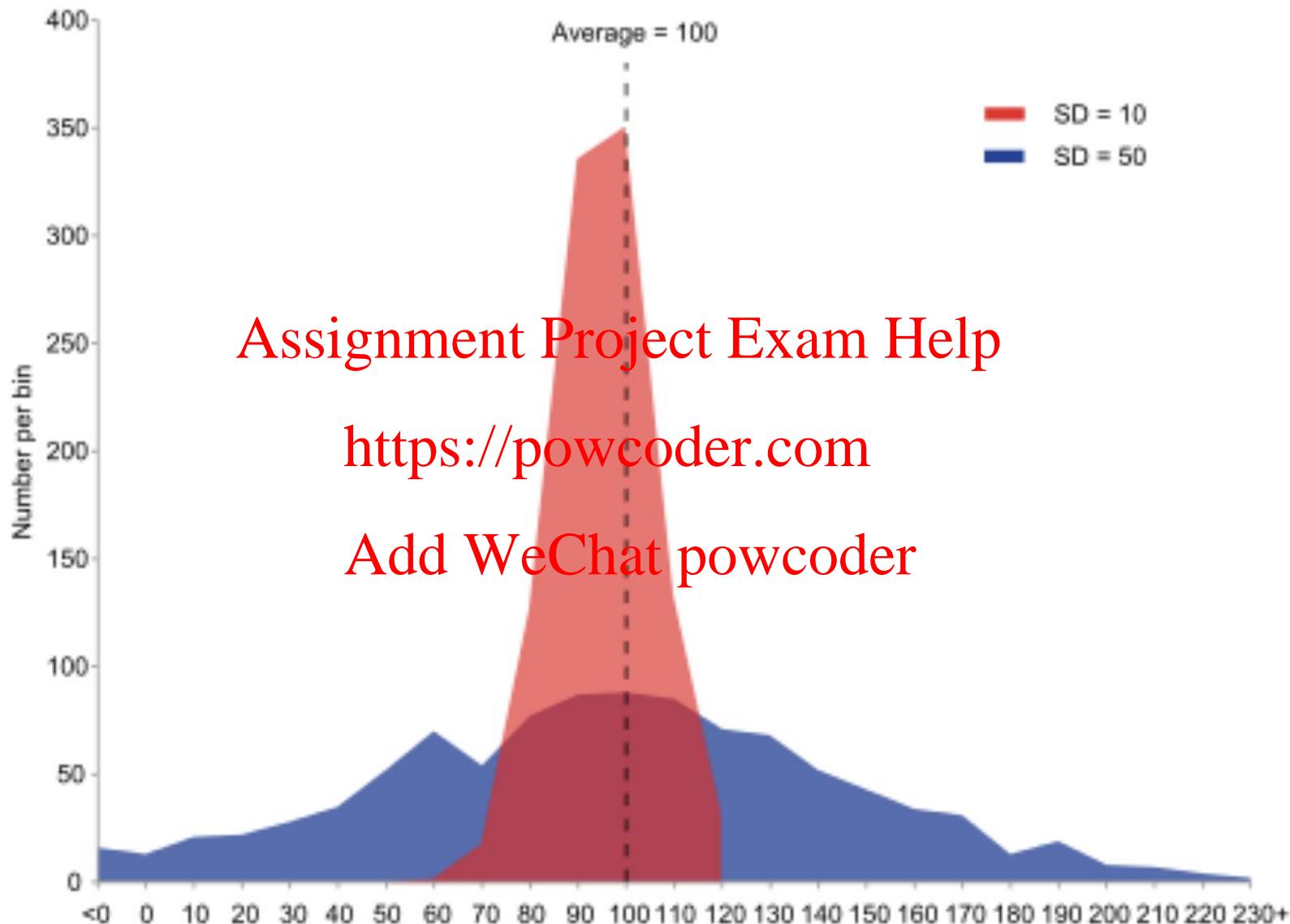
Descriptive Statistics with Numpy



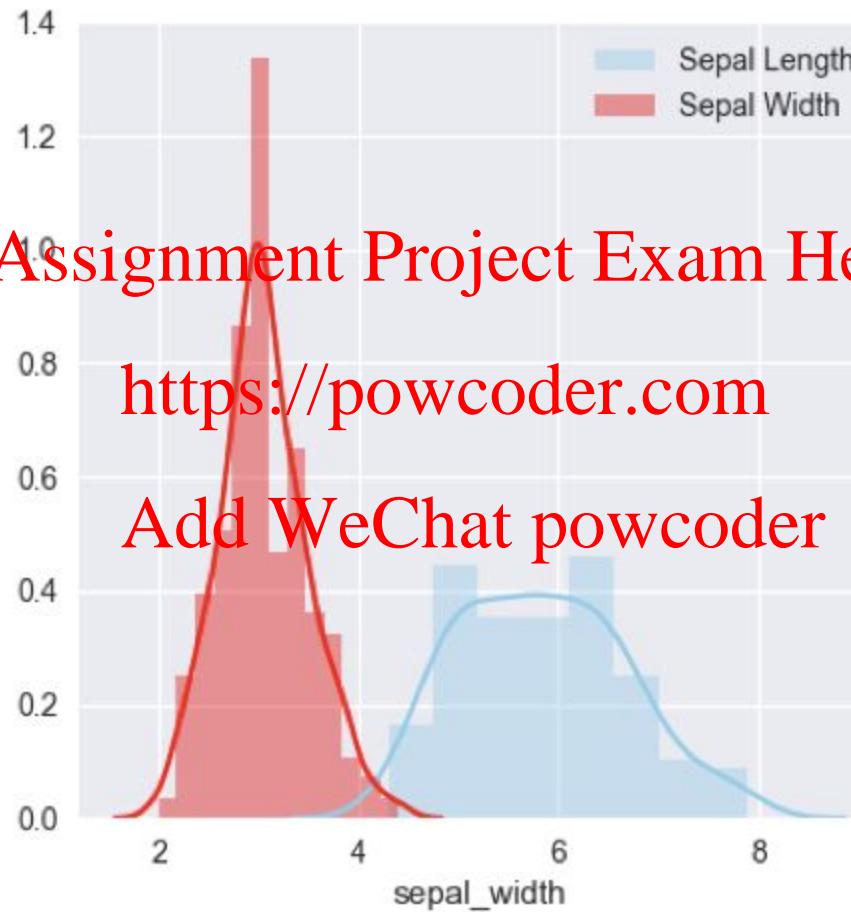
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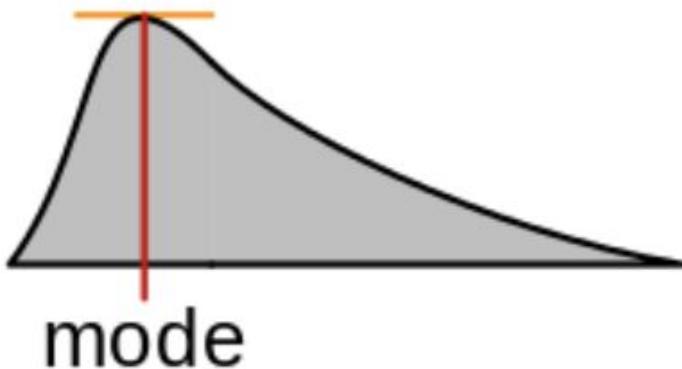
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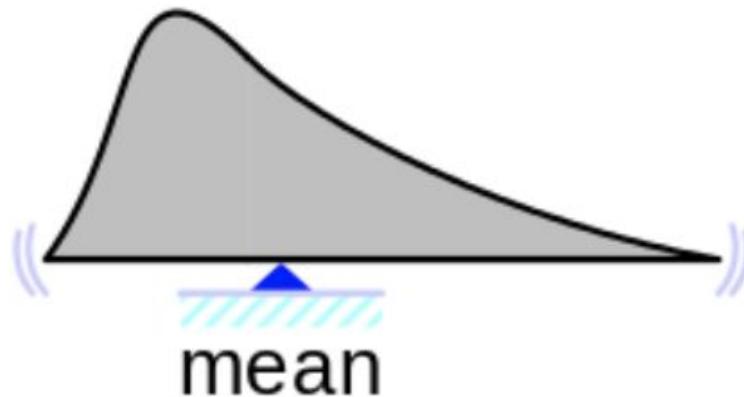
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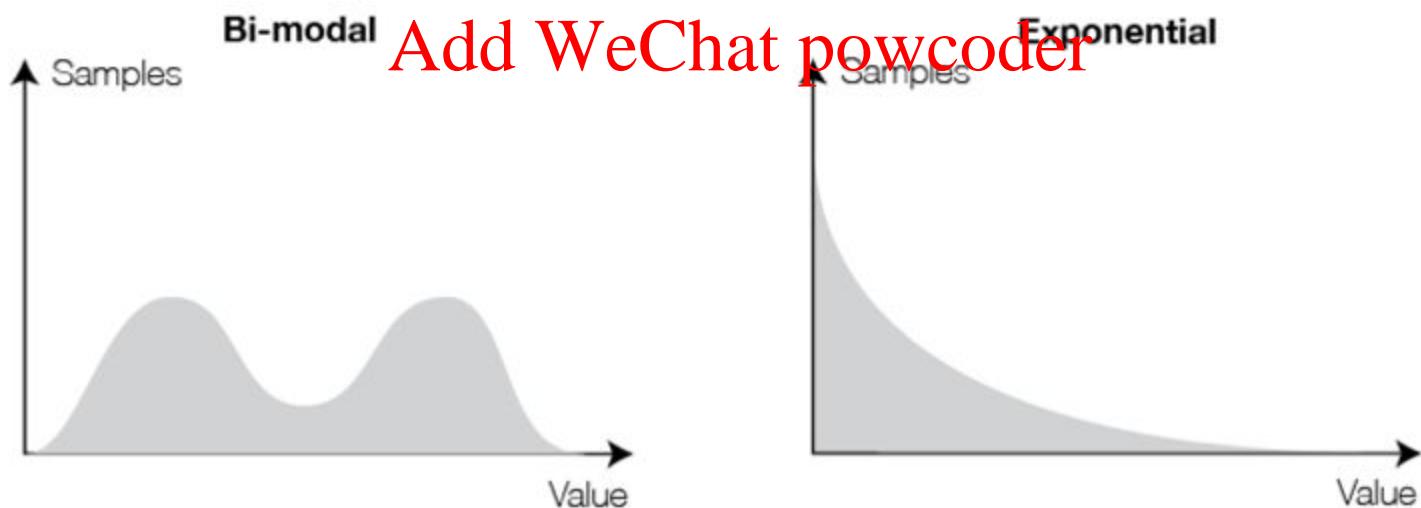
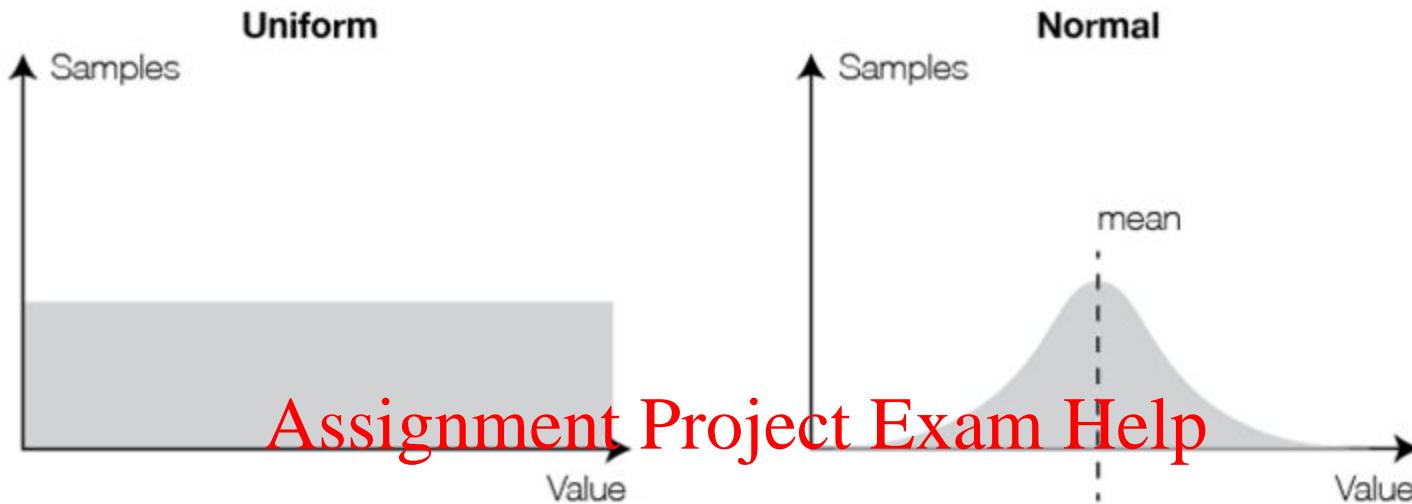
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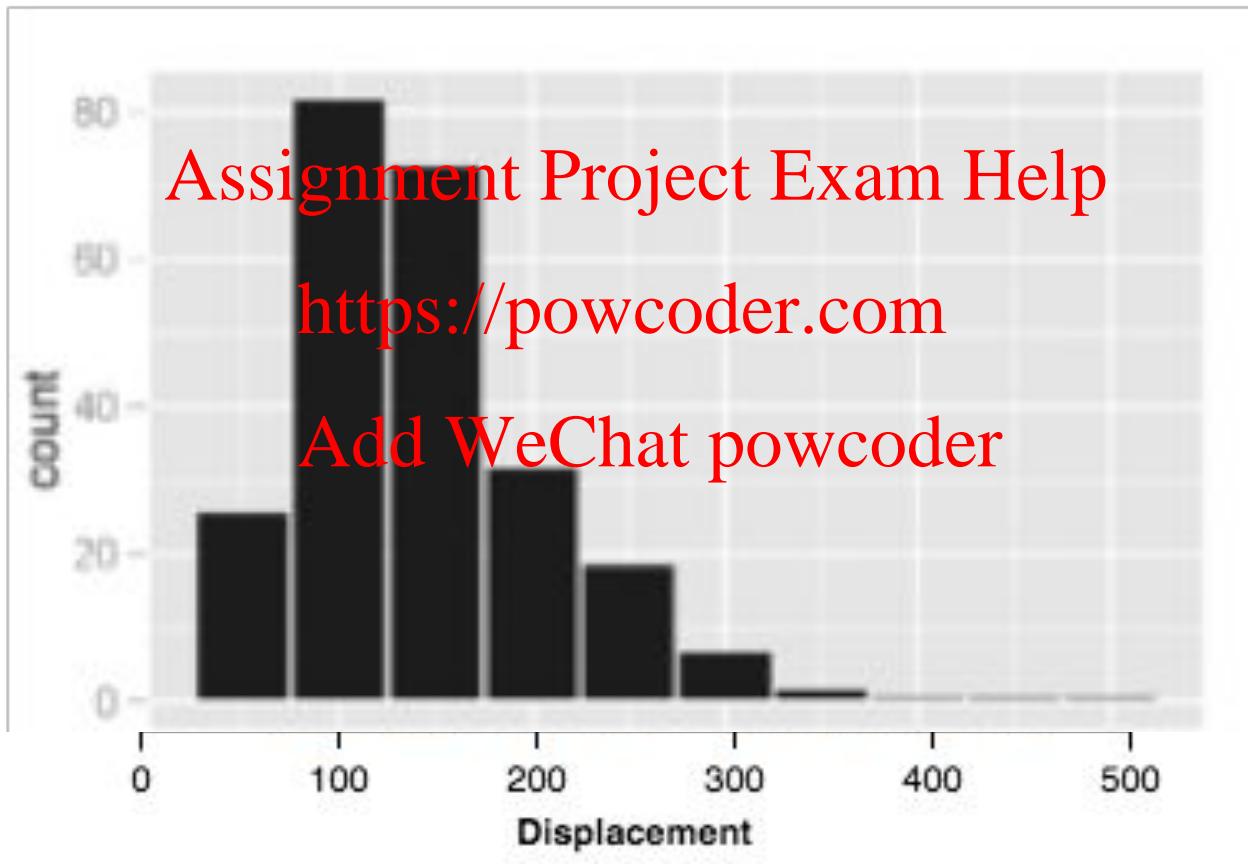
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median



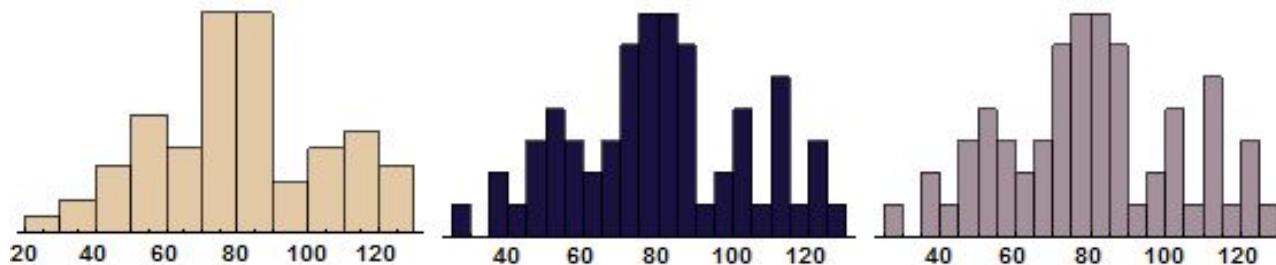
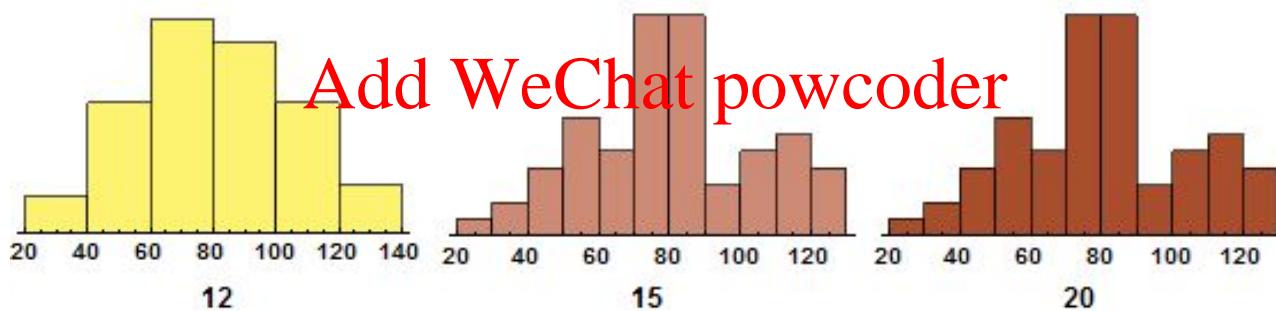
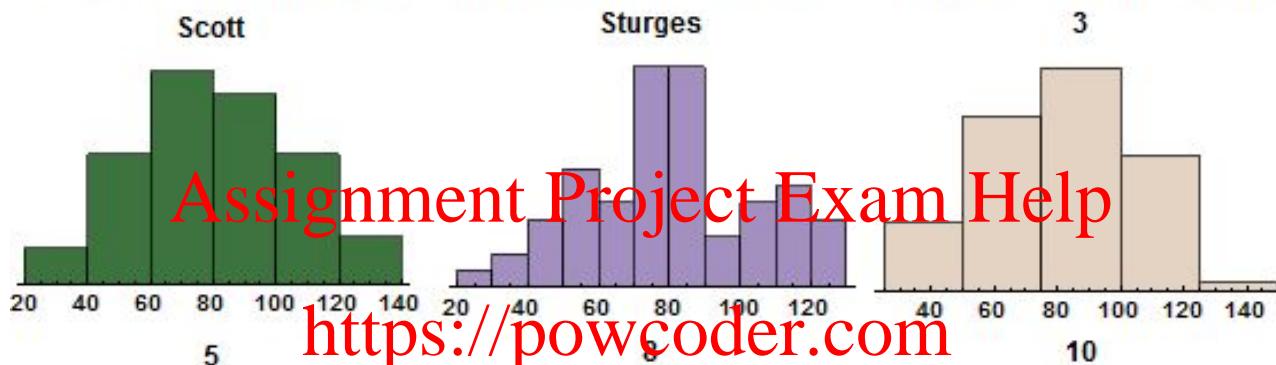
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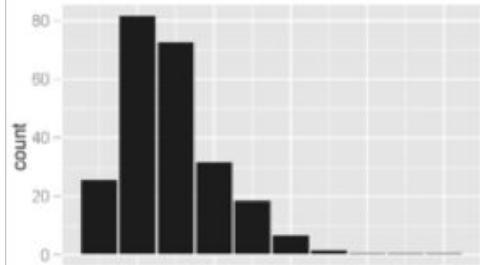


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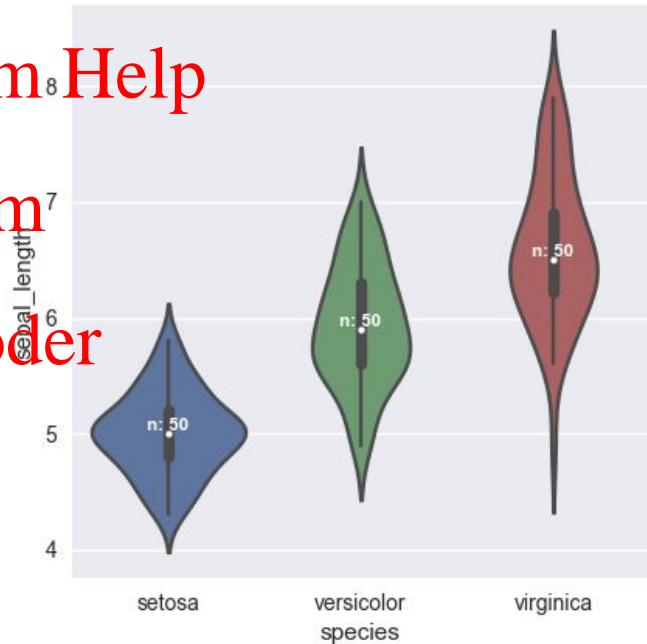
Violin plots

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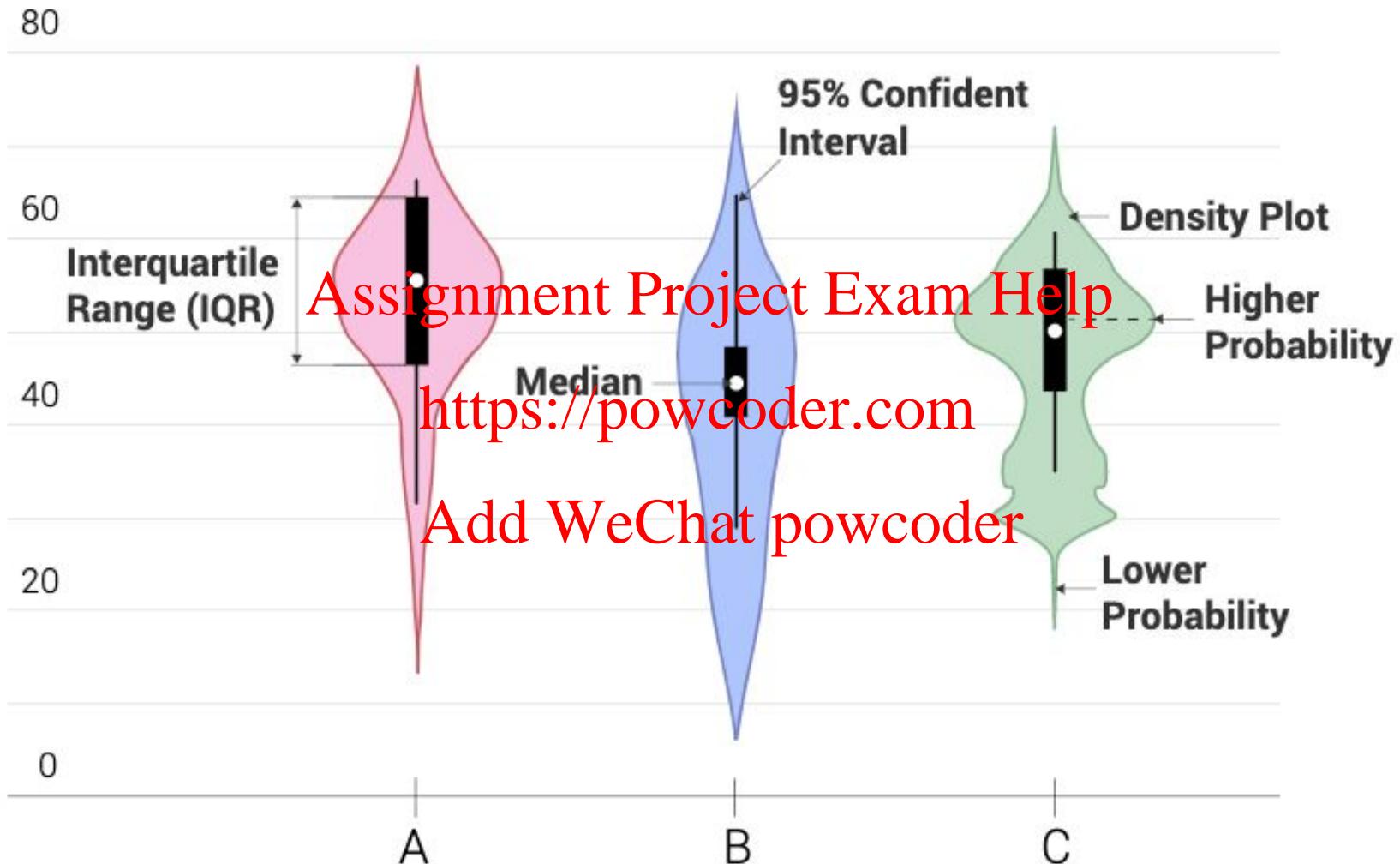
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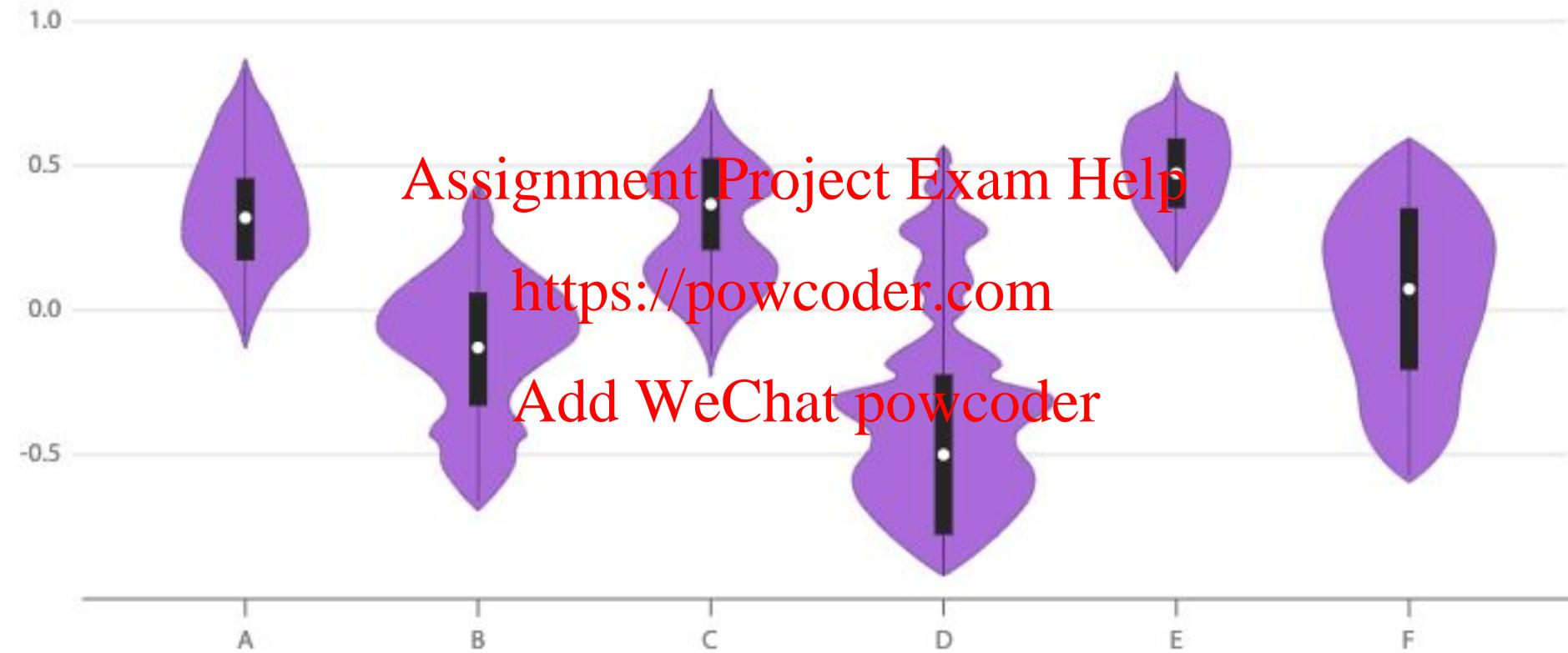
Violin plot

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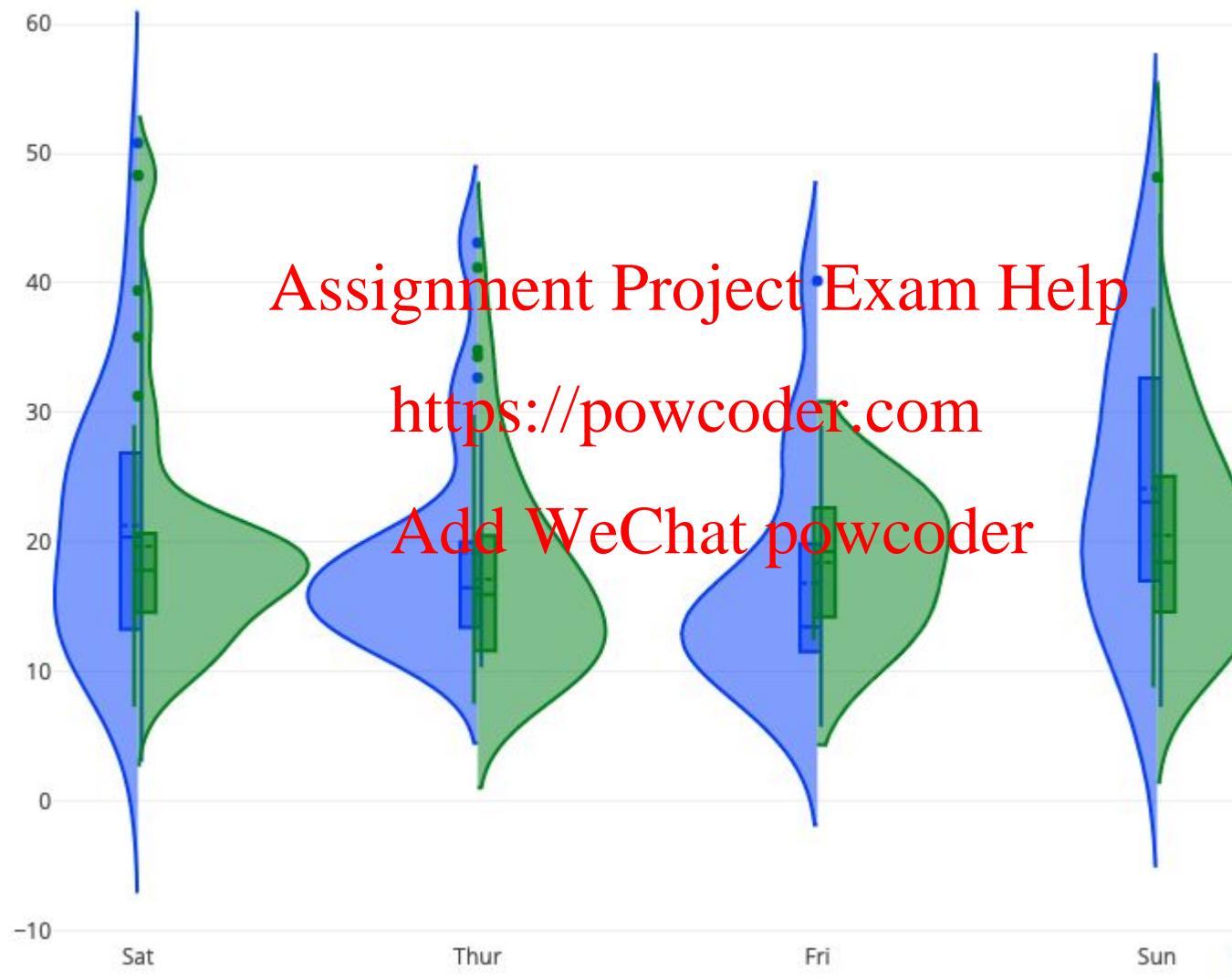


Violin plots

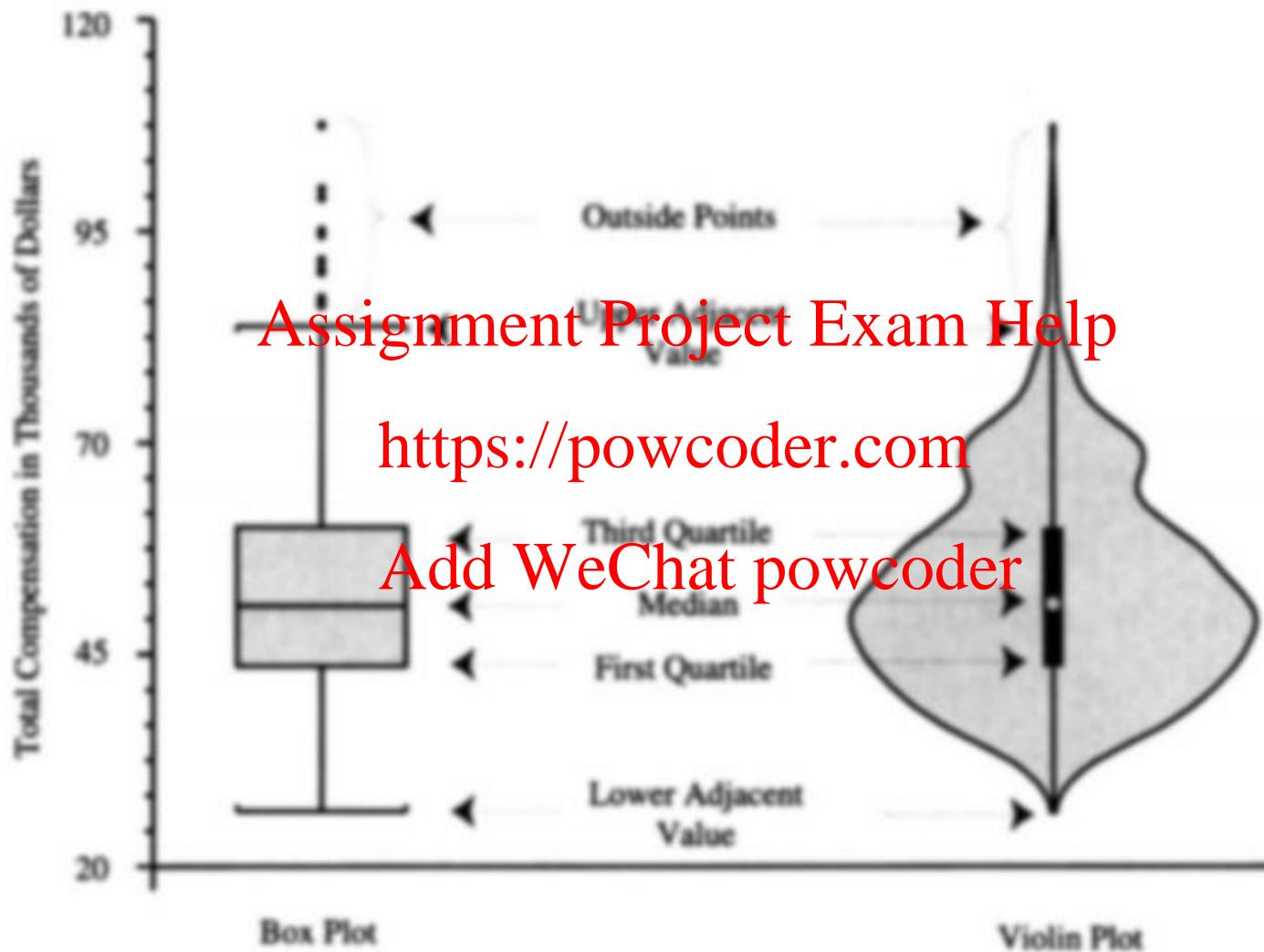
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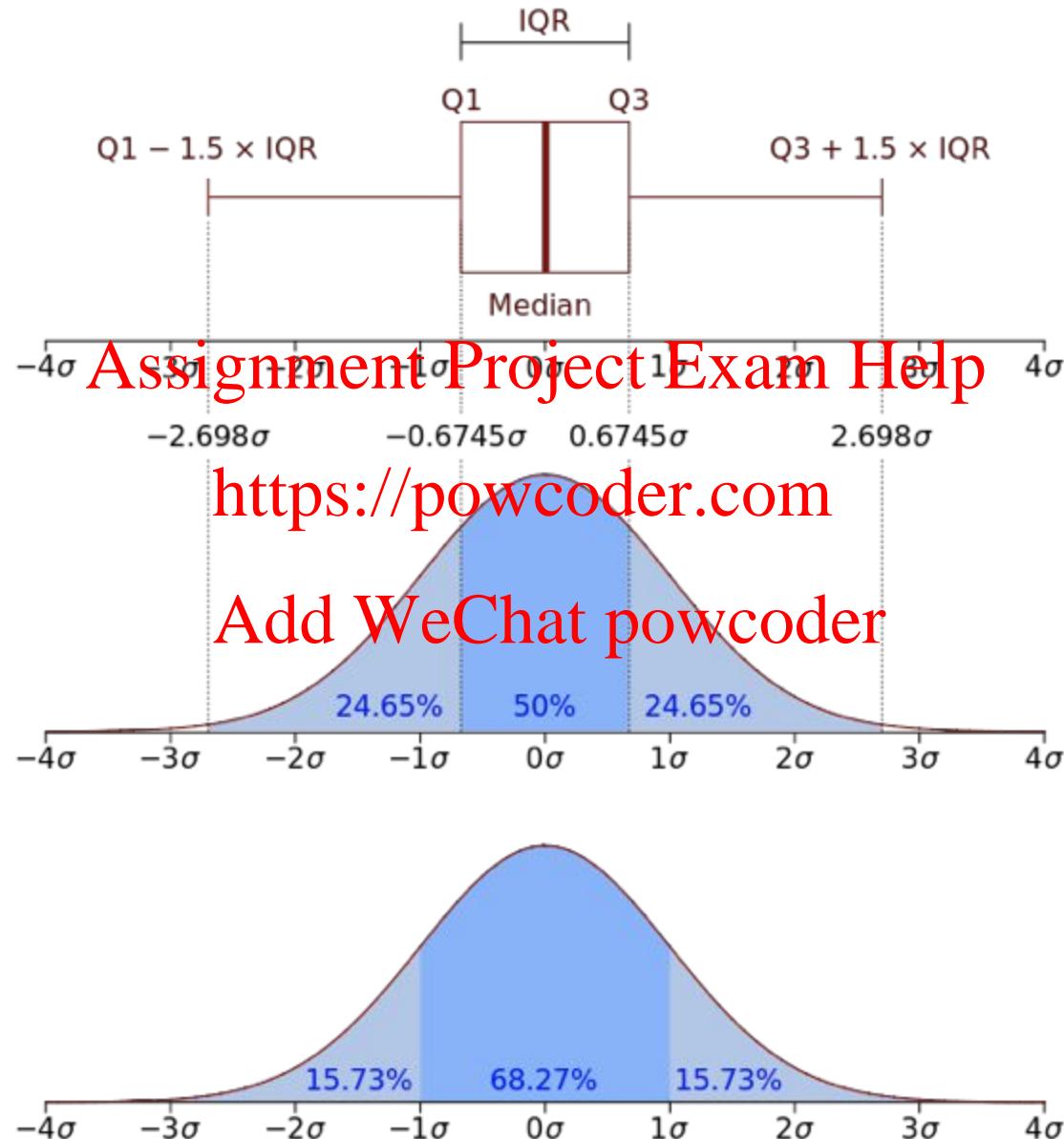
Violin plots for comparison



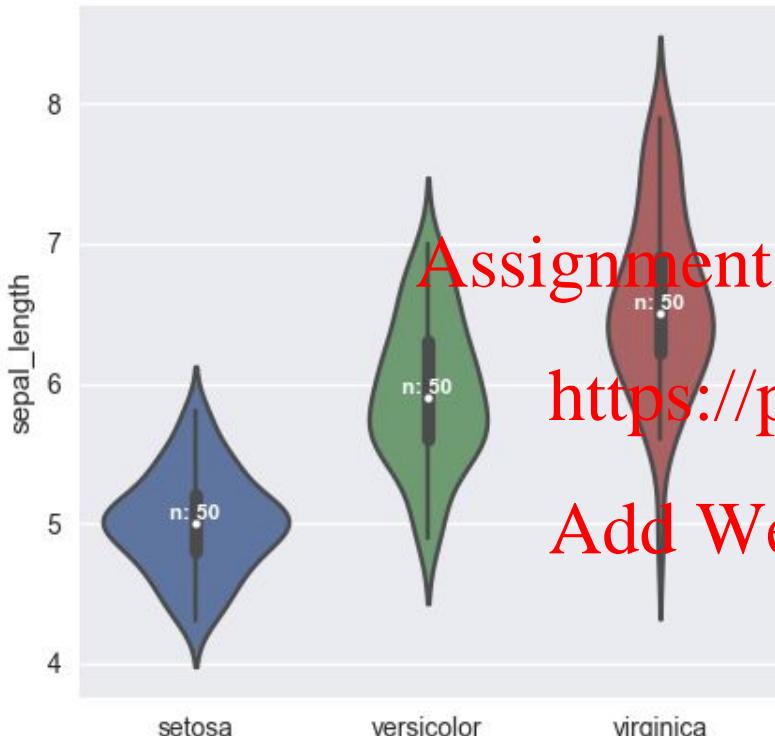
Violin plots vs. box plots



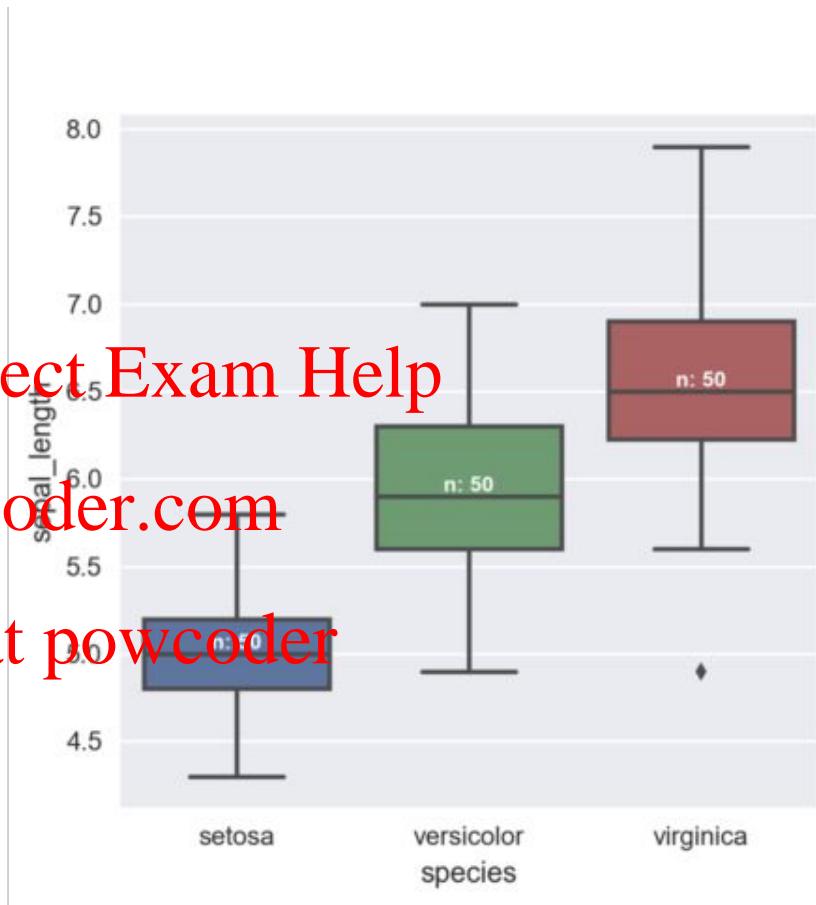
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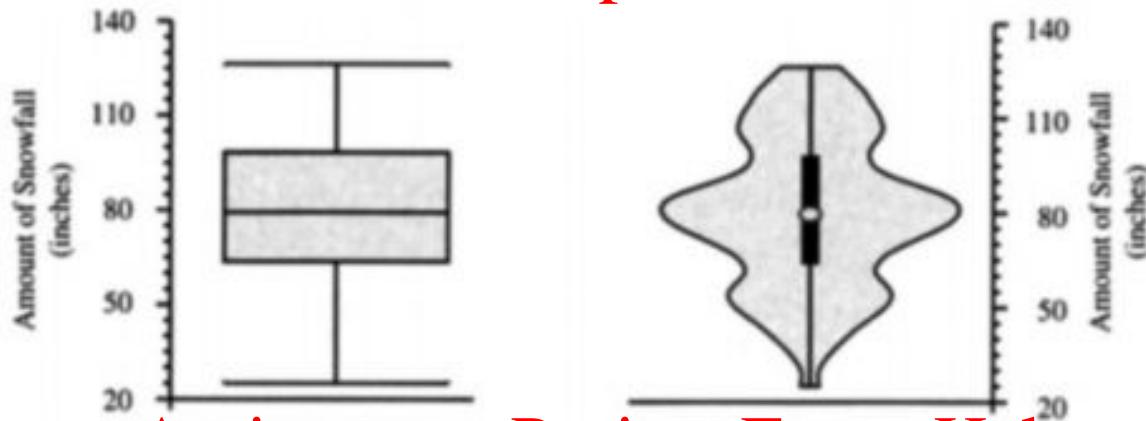
Violin plot



Box plot

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<https://powcoder.com>
Add WeChat powcoder

Add WeChat powcoder

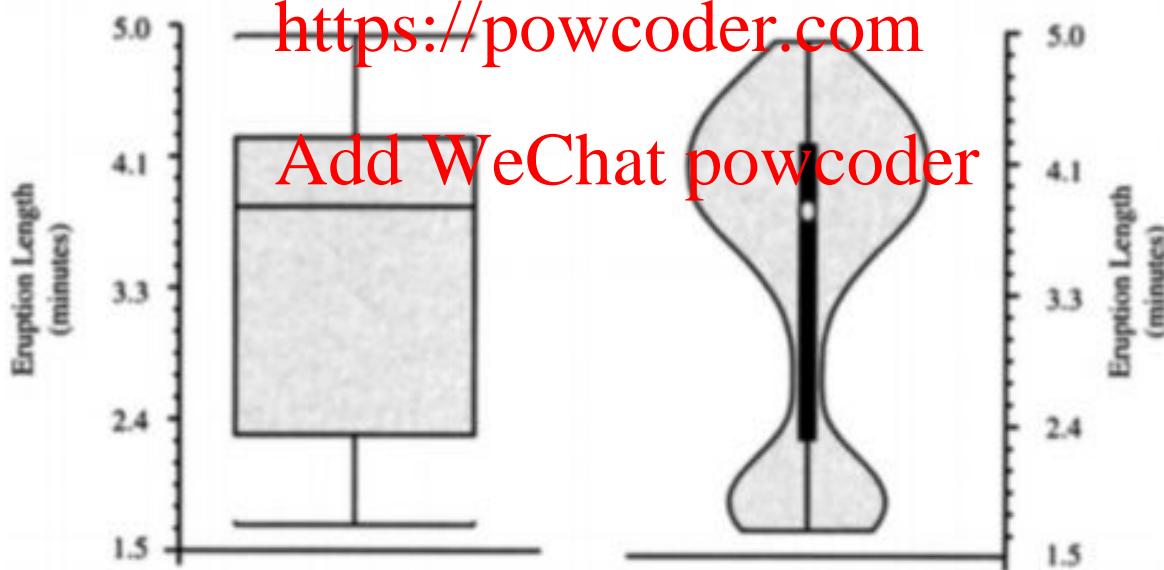


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(a)

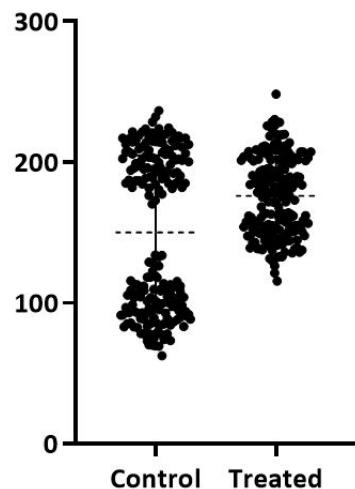
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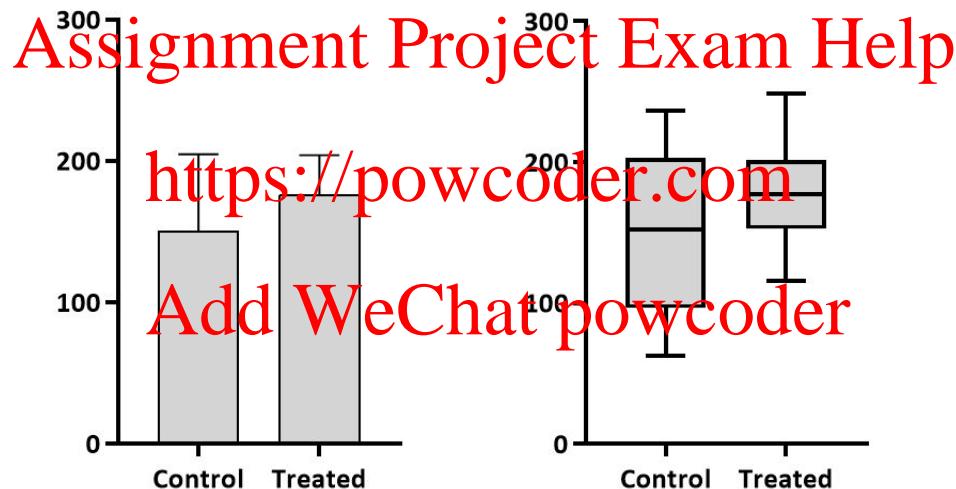


(b)

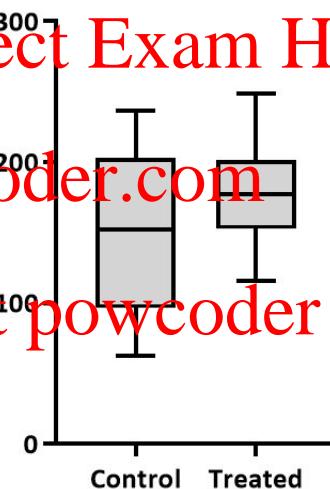
More plots! Add WeChat powcoder



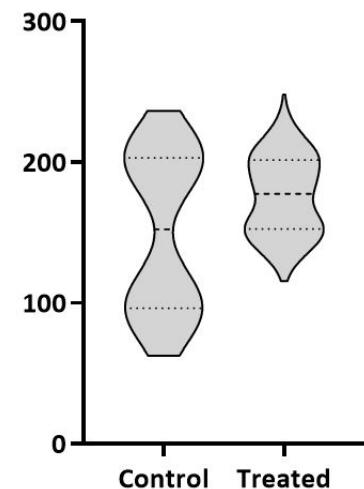
Dot plot



Error bars

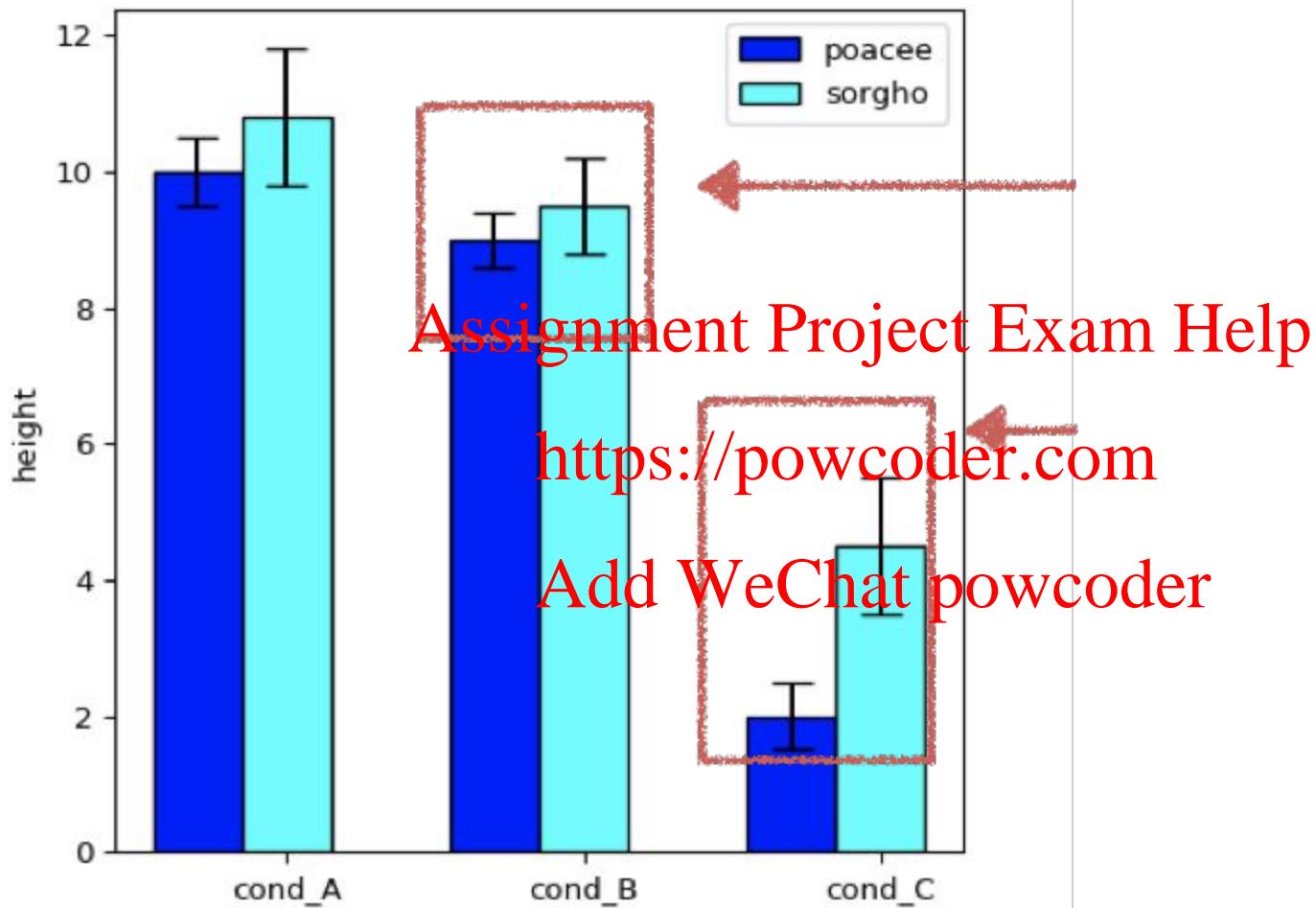


Box plots

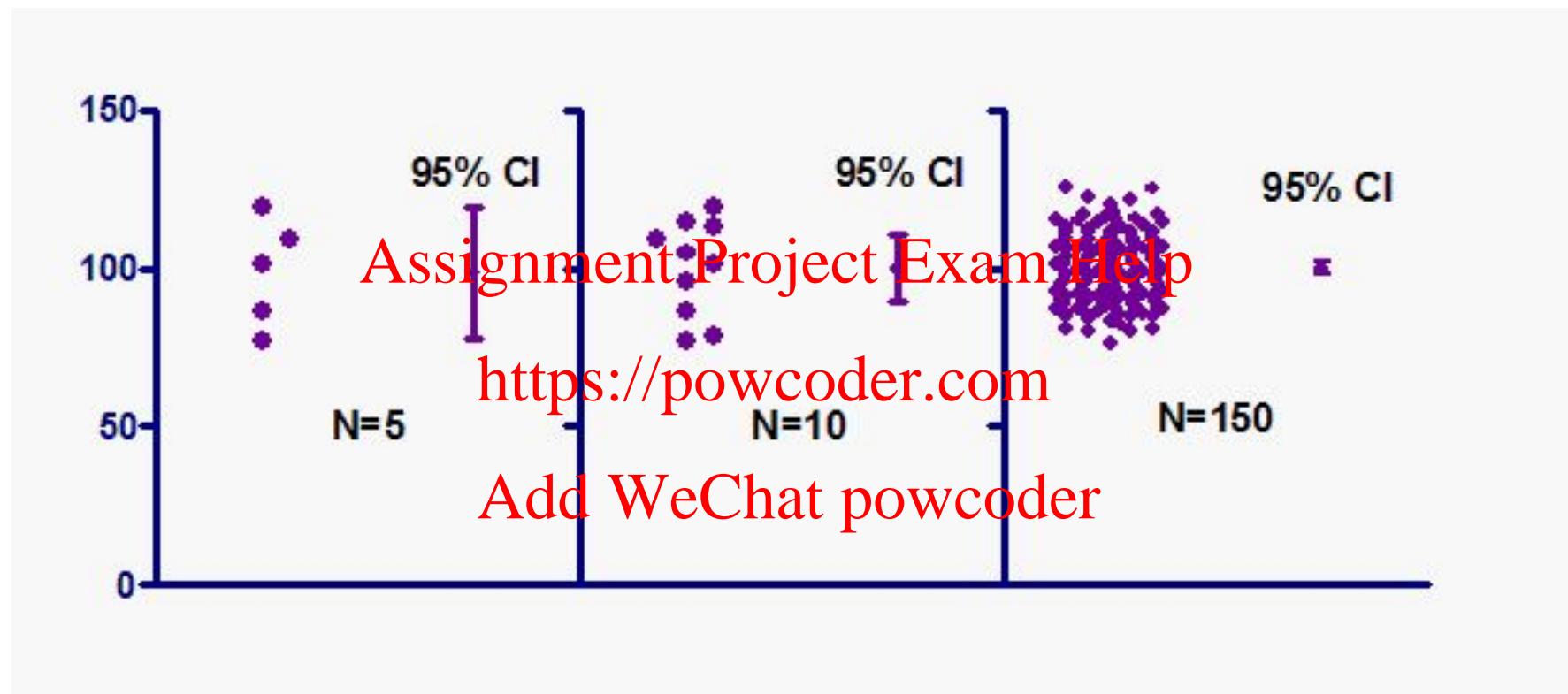


Violin plots

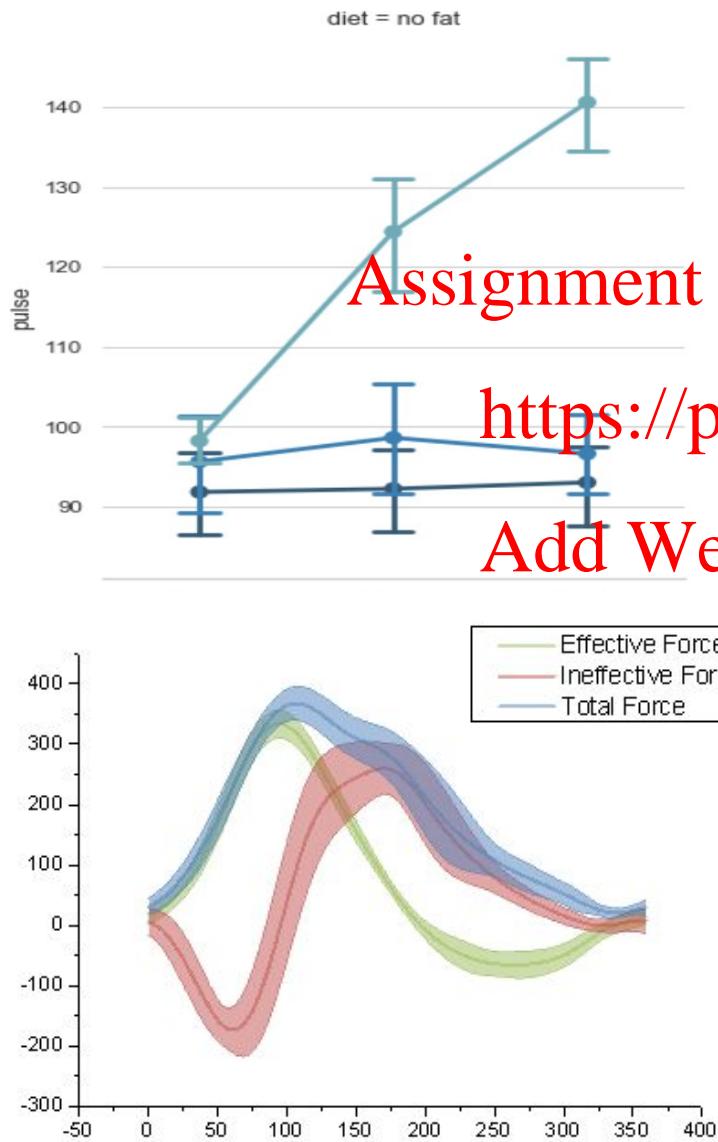
Add WeChat powcoder!!



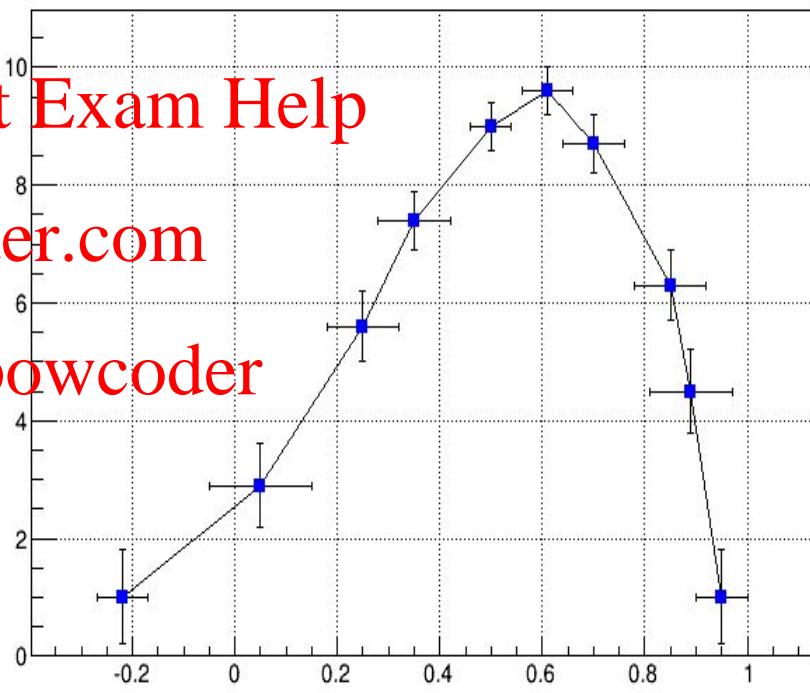
Confidence Intervals (error bars)



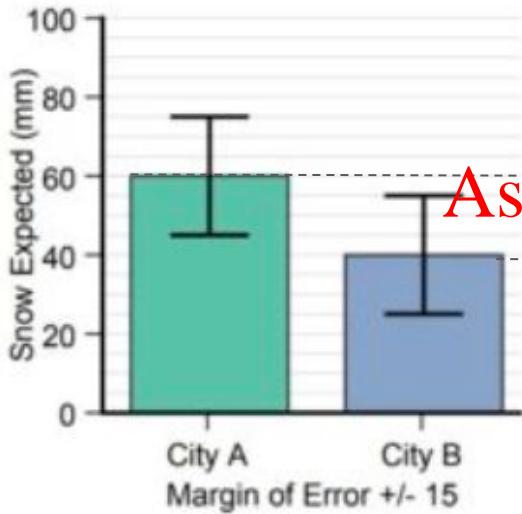
Error Bars in Line Charts



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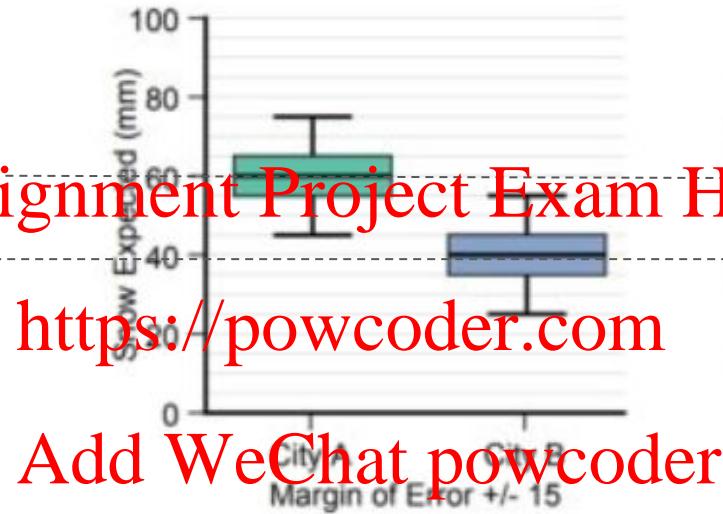


Alternatives



Bar plot

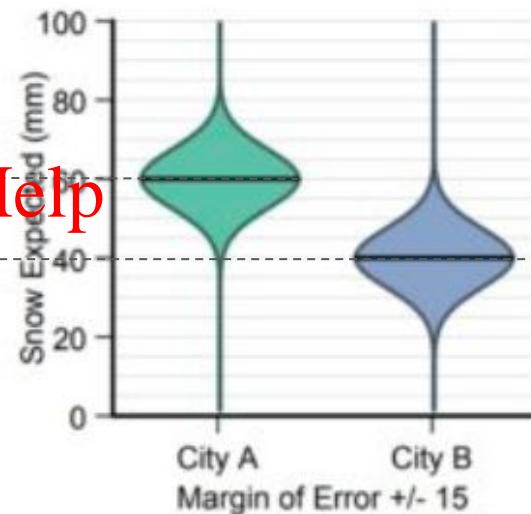
Mean +
CIs (Uncertainty)



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Box plot

Median +
IQR (spread)



Violin plot

Median +
Distribution

Add WeChat powcoder Cheat sheets

Adjacency Matrix

Anatomy

The same node A

Node Row Column Node

Node: Row: Column: Node

Filled Cell - Link

Empty Cell - No link

Diagonal - Self-links

Pitfalls

Follow a row

Be careful when following a row (or column), not to change into a neighboring cell.

Row and column order

The order of rows and columns can matter. Sometimes if you don't set any visual pattern, they may exist after reordering.

Matrices here look different, but present the same data set.

Matrices here look similar, but present different data sets.

Cliques and ordering

Cliques can appear smaller than they are sometimes. Empty cells within a cluster prevent us from seeing cliques.

Empty cells

Bordering can make a large clique appear.

Adjacency Matrix

Visual Patterns

Block

Node Clique

Set of nodes where every node is connected to every other node.

Clusters

Set of nodes where some nodes are connected to all links, would be present the cluster would be a clique.

Node Links

Indicates two connected nodes in the clusters.

Diagonals

Self Links

Self links are the links connecting the matrix diagonals.

Paths

Paths are the paths for single steps running down the matrix diagonals.

Off-diagonal cells

Connectors

Connectors indicate links between two cliques or clusters (A1 and B2).

Dense row / column

Hub nodes

Highly connected nodes are visible by row and columns with many cells. Cells do not need to be adjacent.

More links Less links

Same pattern but different row & column ordering

Parallel Coordinates

Parallel lines

Positive Correlation

Correlations indicate that high values in one data dimension co-occur with high values in another data dimension.

A correlation is visible through rather parallel polylines between two axes.

Negative Correlation

Inverse correlations indicate that high values in one data dimension co-occur with low values in another data dimension.

An inverse correlation is visible through lots of crossing polylines between two axes.

Converging lines

Groups

Groups indicate many elements with the same value or similar values.

Groups are visible by many lines intersecting an axis at the same position.

Grouped lines

Clusters

Clusters indicate data elements with similar values across several dimensions.

Clusters are visible as polylines following each other across several axes, resulting in bundles.

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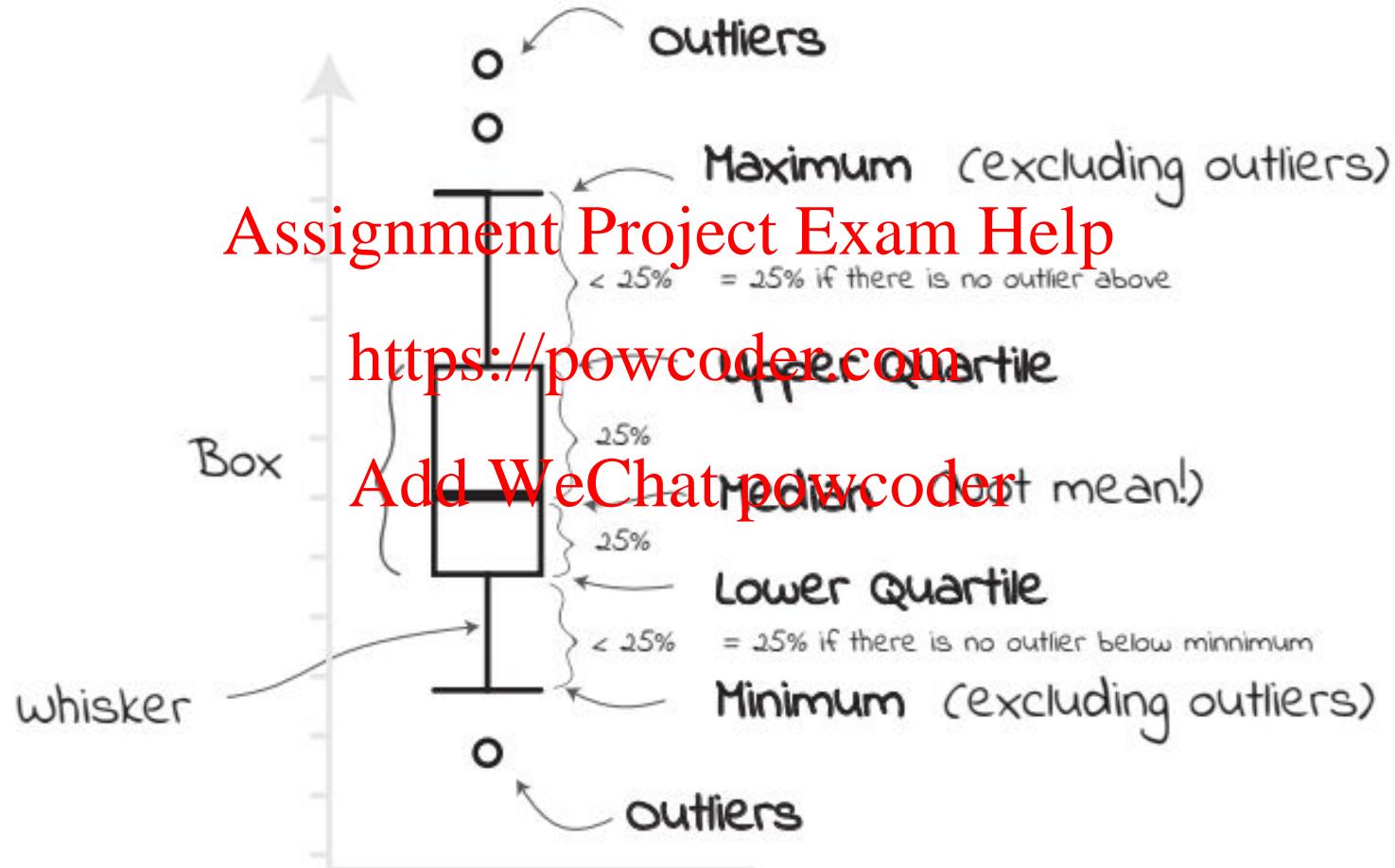
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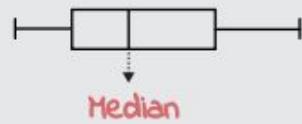


Boxplot

Add WeChat powcoder Anatomy



The 'median' splits the data set into **two equal groups**.



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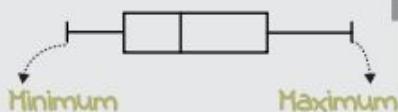
The 'lower quartile' and 'upper quartile' are the median values of lower half and higher half respectively.



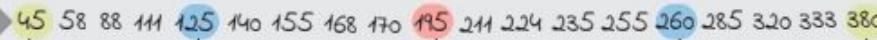
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<https://powcoder.com>

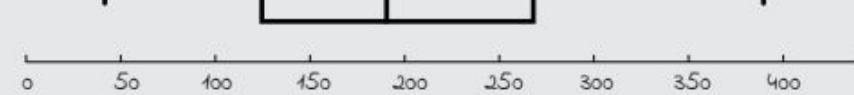
Find the 'minimum' and 'maximum'.



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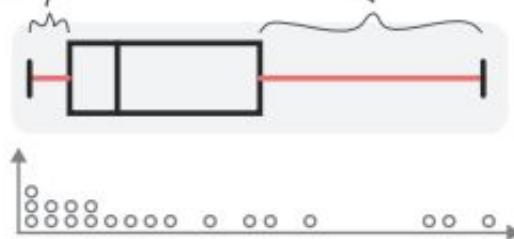


The last step, put these 5 values on the axis, draw a 'box' between 'lower quartile' and 'upper quartile' and link two 'whiskers' to 'minimum' and 'maximum'.



Possitive Skewness

A distribution with a **positive skew** would have a **longer whisker in the positive direction** than in the negative direction.

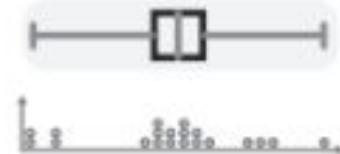


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Fat box

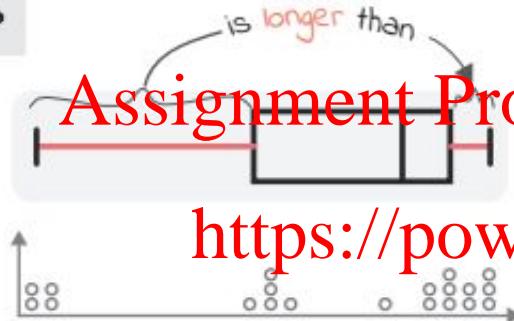


Thin box



Negative Skewness

A distribution with a **negative skew** would have a **longer whisker in the negative direction** than in the positive direction.

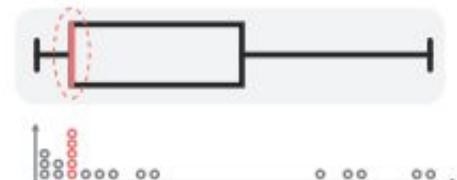


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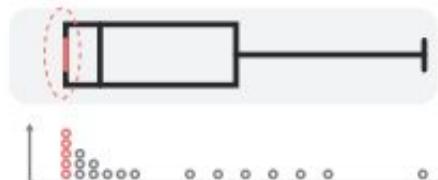
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overlapping



The lower quartile and the median are **overlapped**, this occurs when the **25%** of values are **same** between the lower quartile and the median.



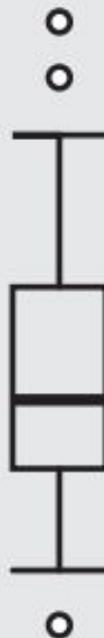
The minimum and the lower quartile are **overlapped**, this occurs when the **25%** of values are **same** between the minimum and the lower quartile.



Boxplot

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Boxplots



Candlesticks

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No horizontal stroke

No horizontal stroke
edge the box

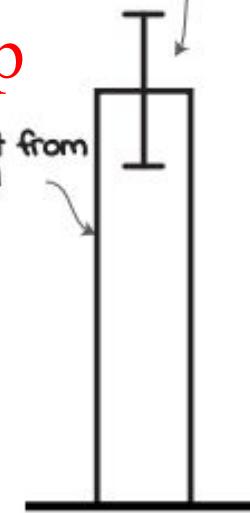
A candlestick represents the price activity of an asset during a specified timeframe through the use of four main components: the open, close, high and low.

Error bars

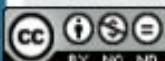
No outliers

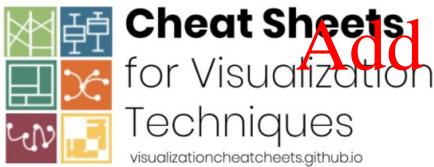
Error bars only on the top of the bar

Bar start from the ground



Error bars are graphical representations of the variability of data and used on graphs to indicate the error or uncertainty in a reported measurement.





Cheat Sheets
for Visualization
Techniques
visualizationcheatsheets.github.io

Home

Download all (PDF+PNG), 76MB

Download guidelines (PDF), 8MB

Paper

Cheat Sheets for Data Visualization

Techniques: Zezhong Wang, Lovisa Sundin, Dave Murray-Rust, Benjamin Bach, ACM Conference on Human Factors in Computing Systems (CHI), 2020

By Type

Anatomy | Introduction | Construction

Visual Pattern | Pitfalls

Well-known Relative | False Friends

By Visualization

-  Boxplots
-  Confluence Graphs
-  Adjacency Matrix
-  Parallel Coordinates
-  Time Curve
-  Treemap



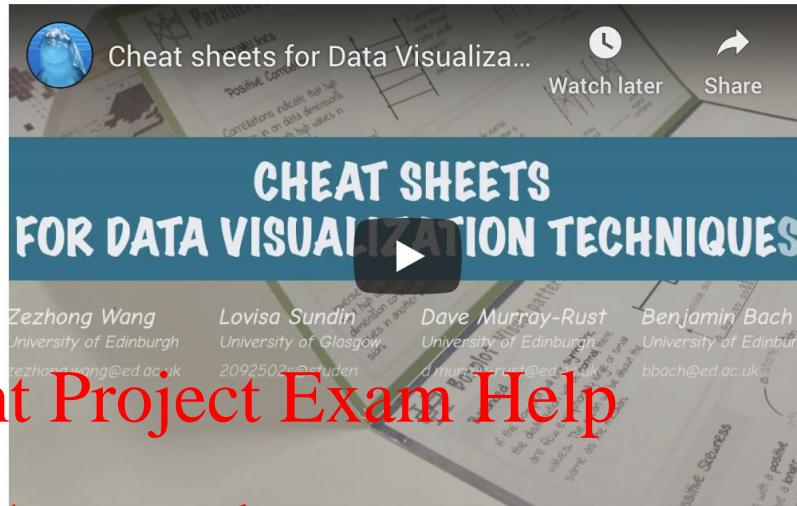
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of EDINBURGH



University
of Glasgow

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Cheat Sheets for Visualization Techniques



<https://powcoder.com>

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By Type

Anatomy

Cheat sheets are sets of concise graphical and textual explanations, inspired by infographics, data comics, and cheat sheets in other domains. Cheat sheets aim to support learning, teaching, and the regular use of both common and novel visualization techniques in a variety of contexts. To design cheat sheets on visualization techniques, we describe six components of a cheat sheet: anatomy, build-up, visual patterns, pitfalls, false-friends, variations. We present examples for several visualization techniques, created through an iterative design process which involved data science and visualization teachers, visual designers and students. In a qualitative and iterative user study, we gather subjective feedback from participants, show readability and usefulness of our cheat sheets, and iterated on their design. We bring this together as a design methodology, with a comprehensive design framework to easily create cheat sheets for additional visualizations.

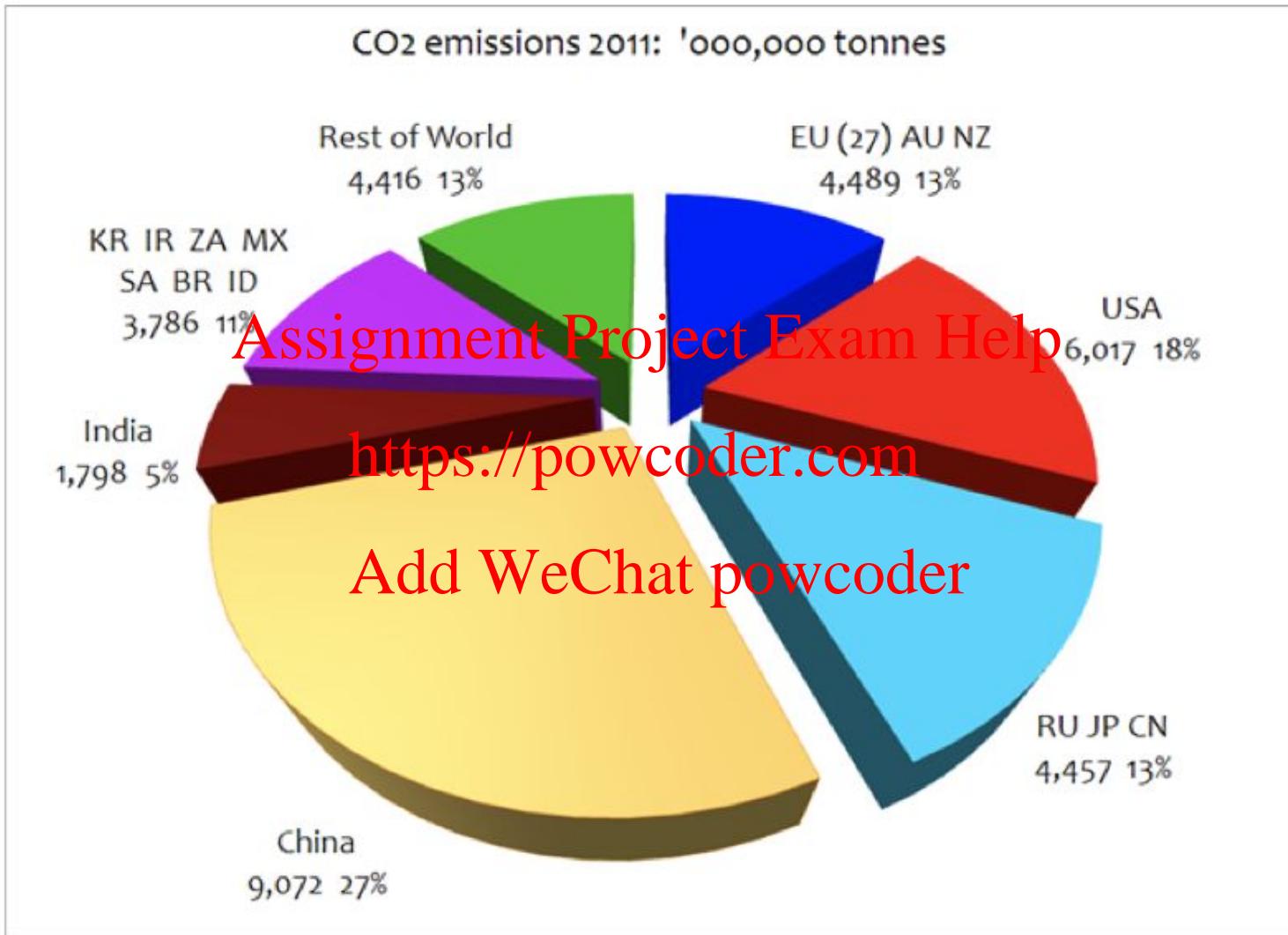
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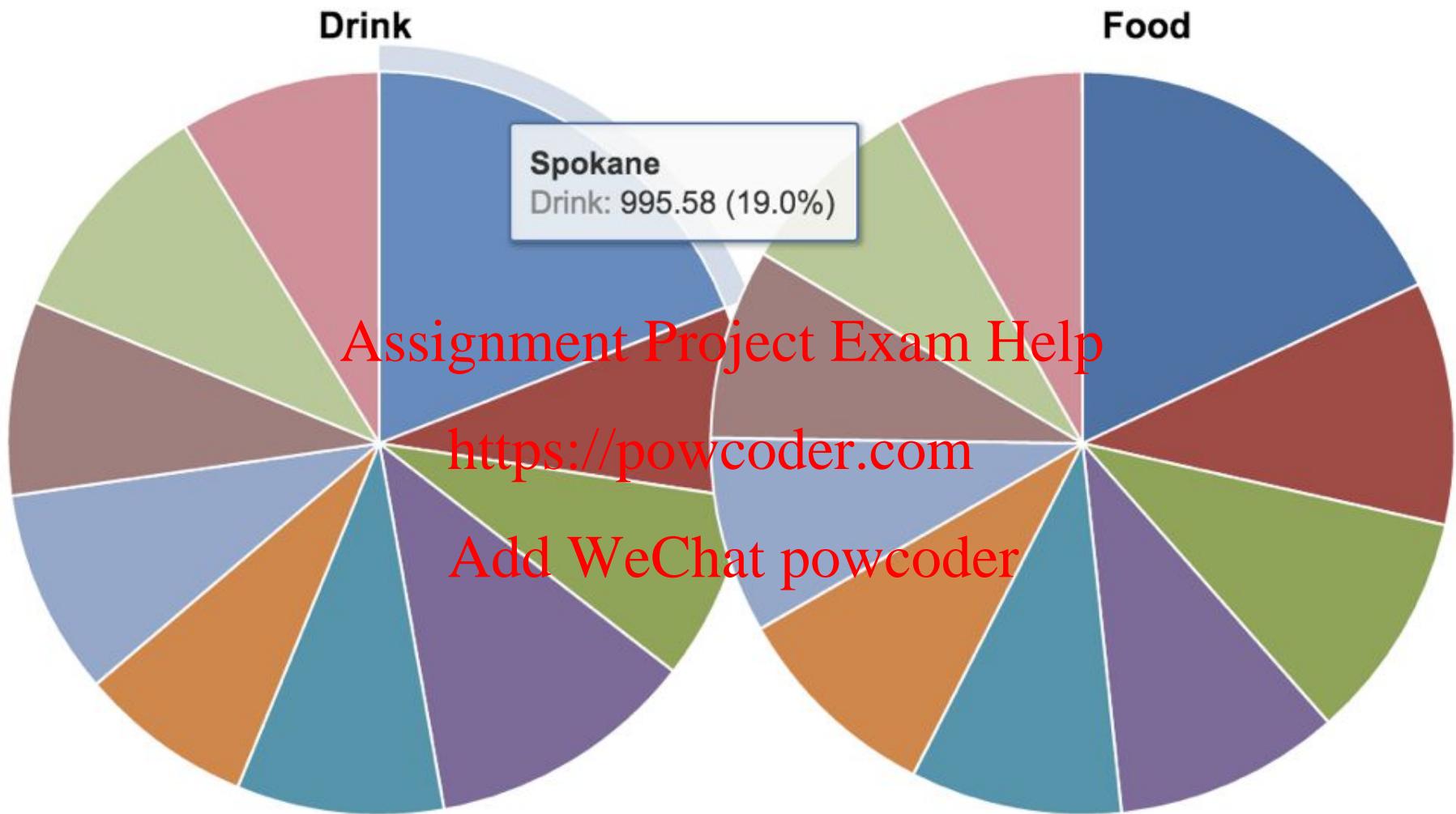
<https://powcoder.com>
Pie charts

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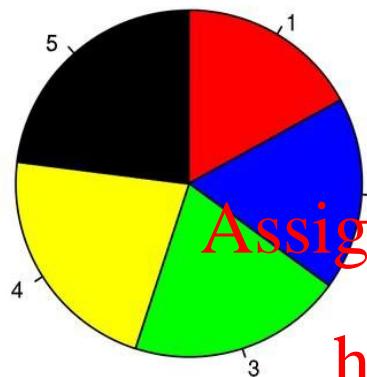


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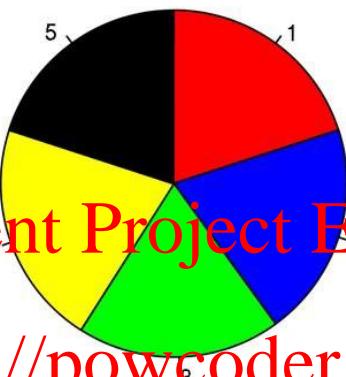


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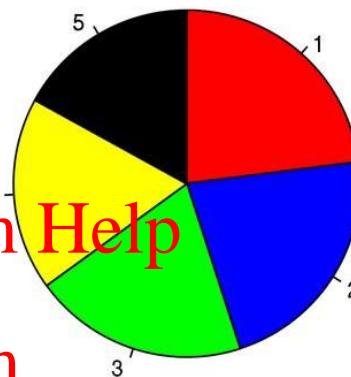
A



B



C



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Pie Charts

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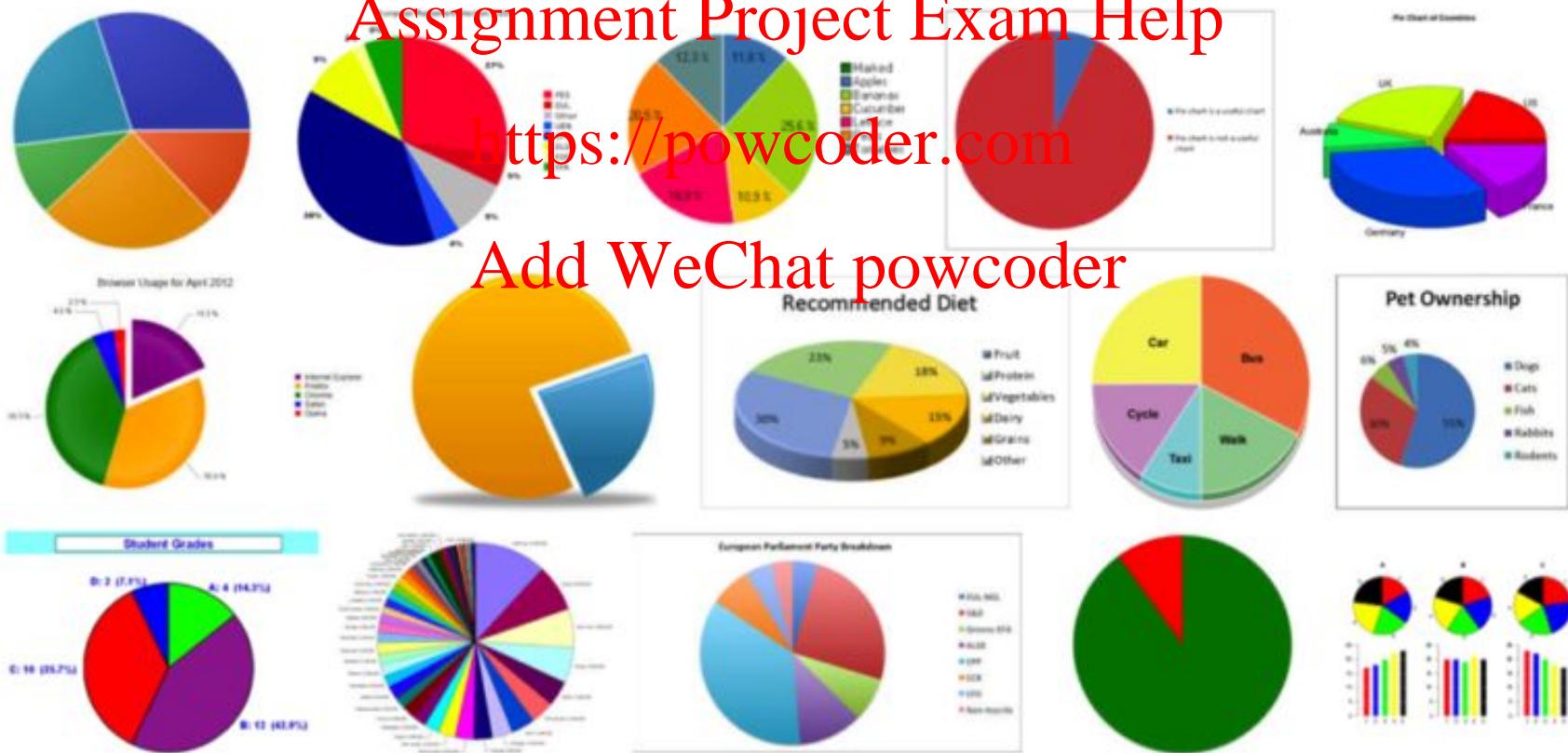
- + Few values
- + Huge differences

- + Easy communication
- + Order by size!

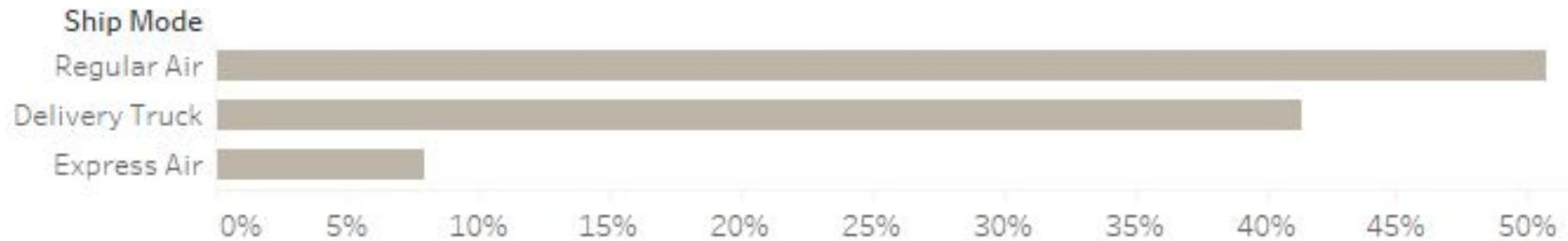
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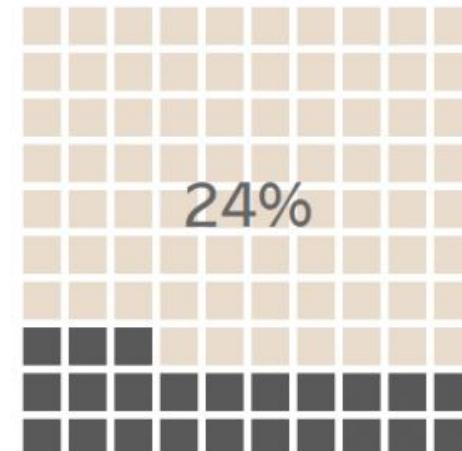
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Alternatives to pie charts



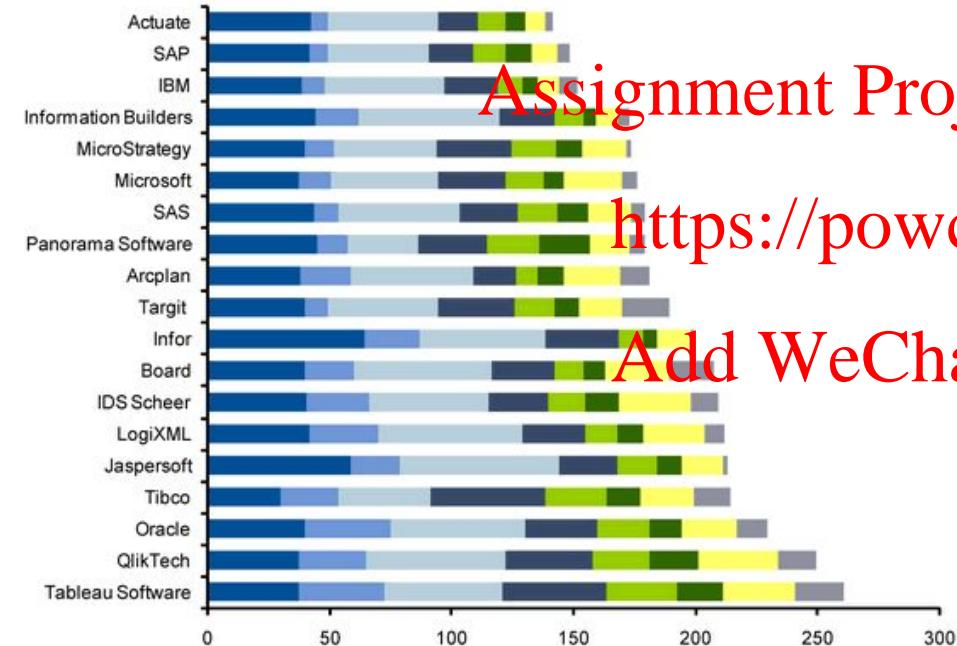
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Alternatives to pie charts

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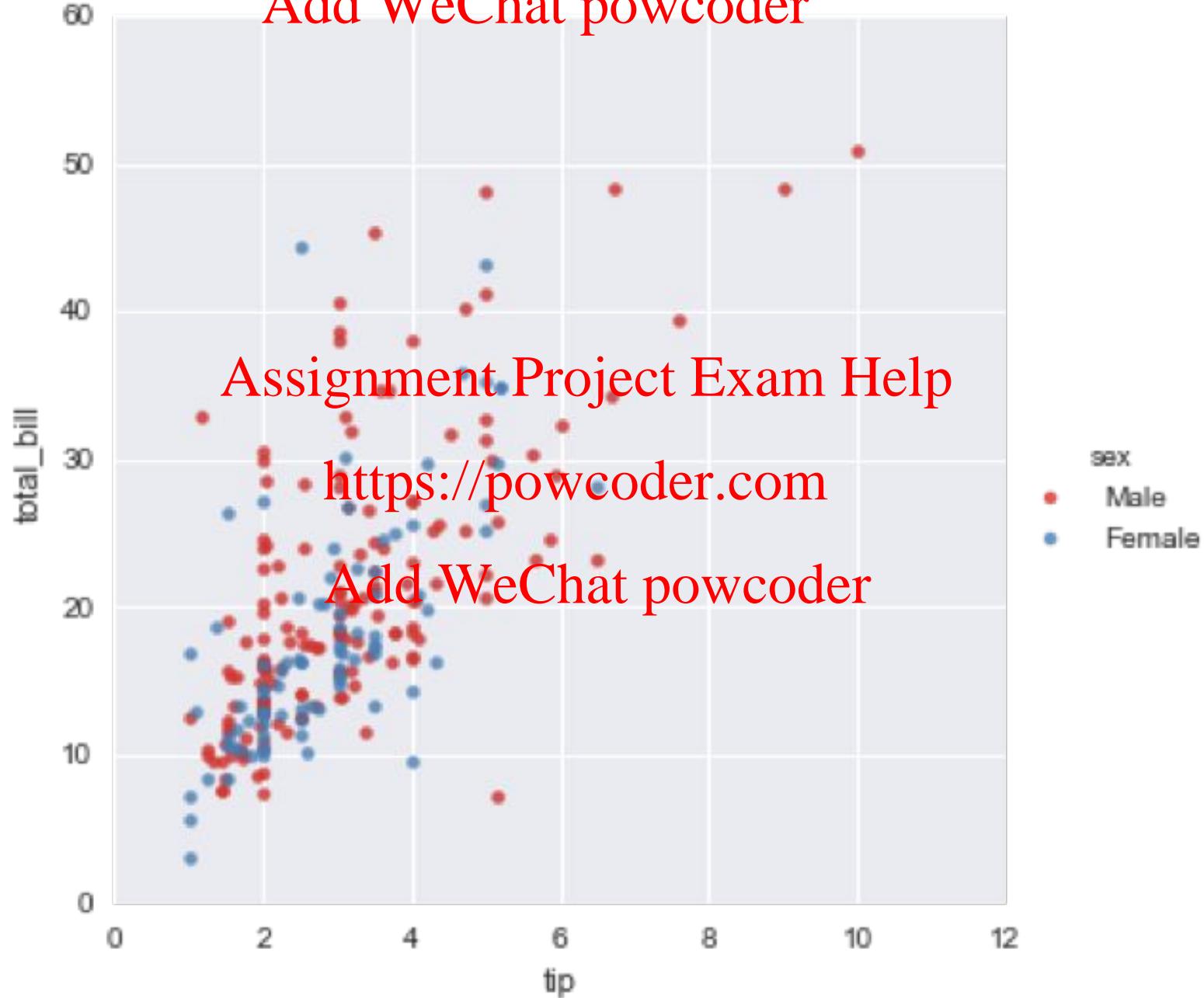
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Multi-dimensional data

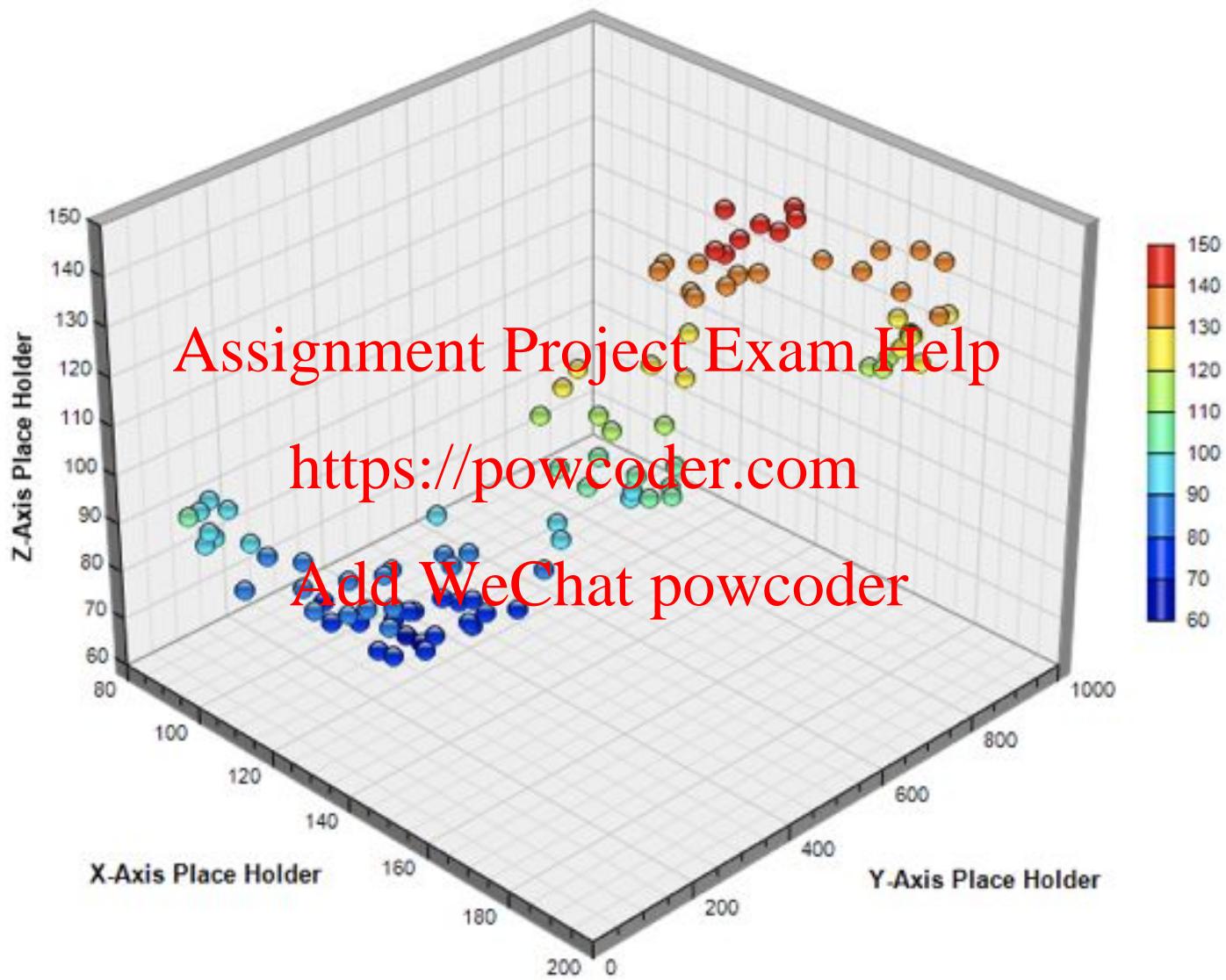
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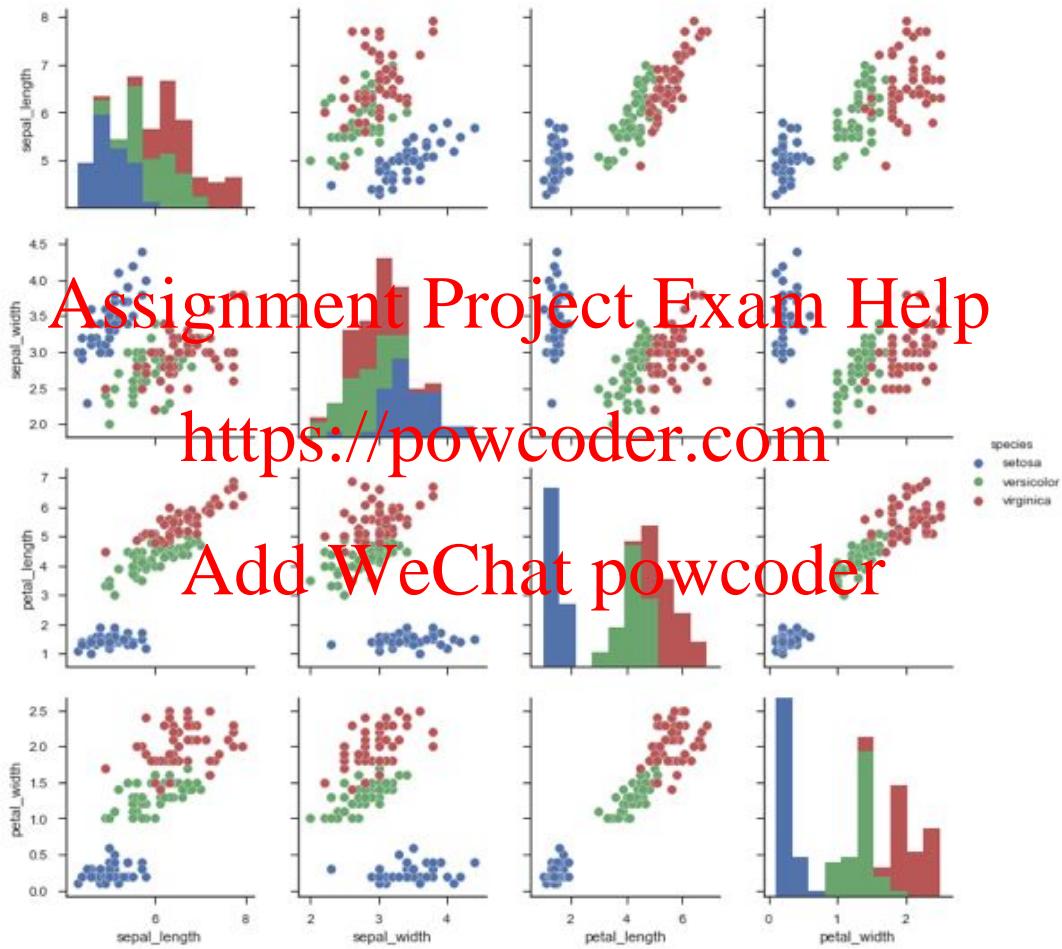


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3D Scatter Chart (1)

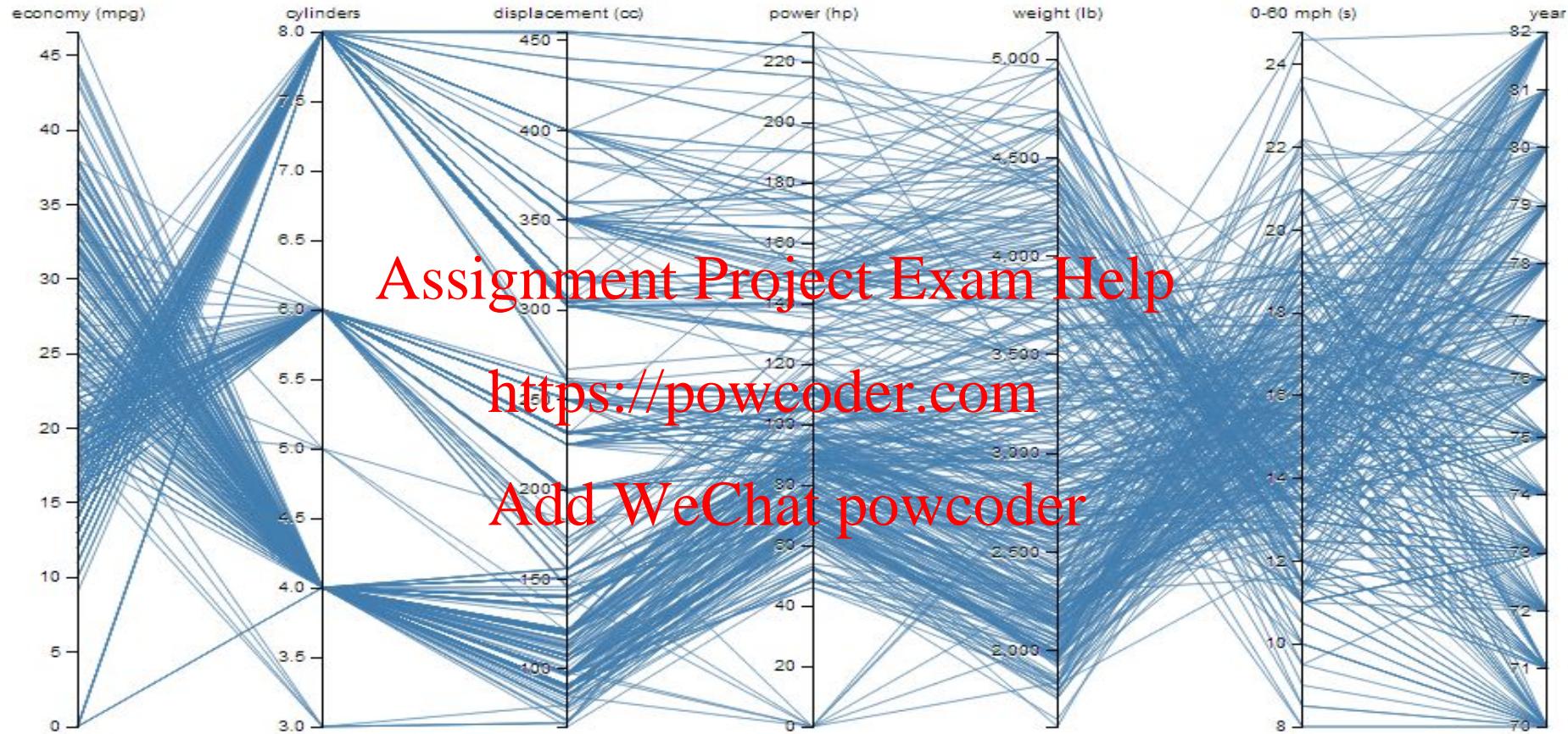


Add WeChat powcoder Multivariate data



Scatterplot matrix

Parallel Coordinates Plot



- + Scalable
- + Concise
- + Good overview

- Depending on ordering
- Can suffer from clutter
- Visual path following can be hard

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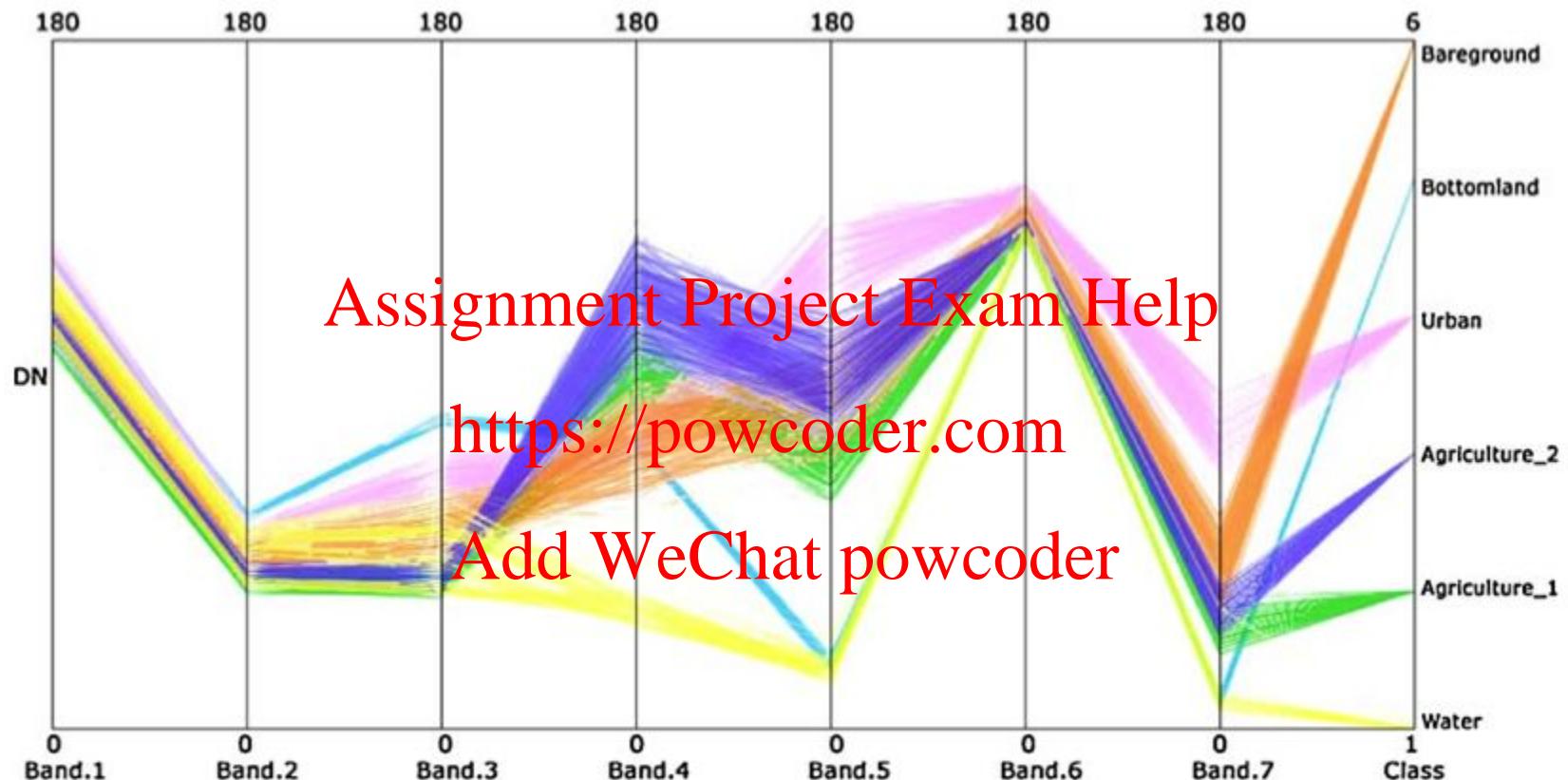
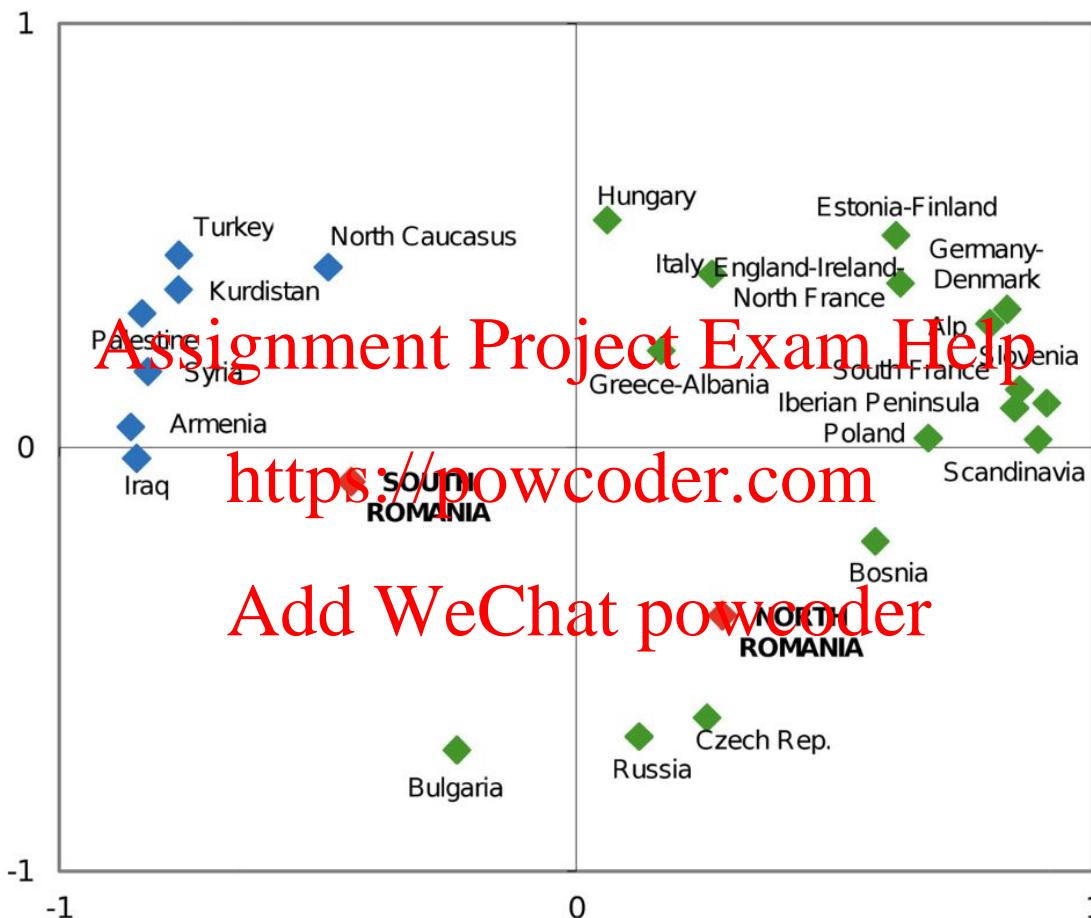


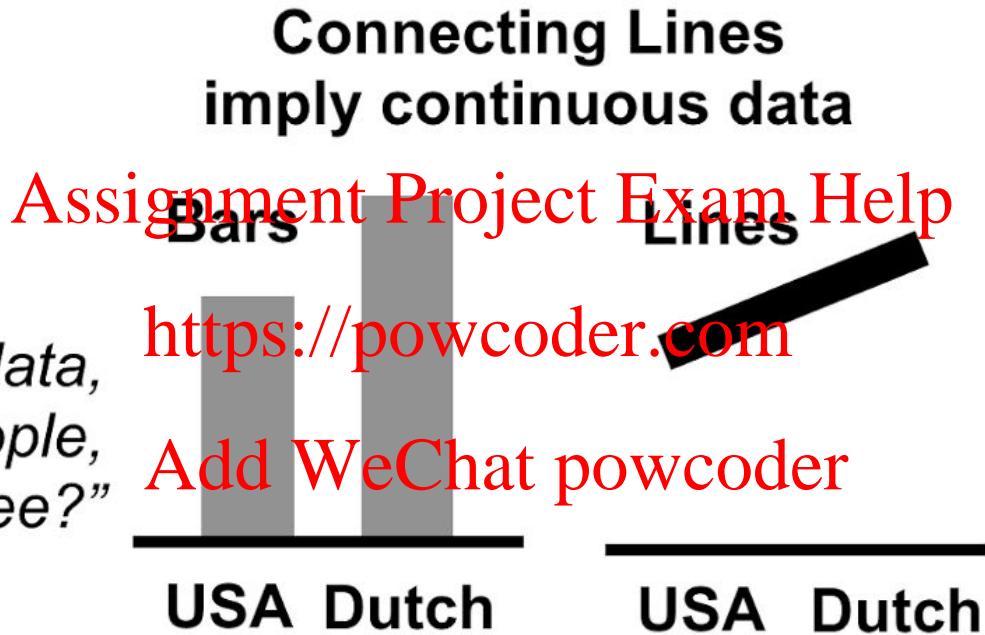
Fig. 3. PCP of sample data.

Multidimensional Scaling (MDS)



- + Dimension reduction
- + Visualization in 2D or 3D
- + Visual clustering
- Information lost
- Creates artifacts:
 - false neighbors and
 - Tears

Which visualization?



1. Data

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		mpg	cyl	disp	hp	drat	wt	qsec
1								
2	Mazda RX4	21	6	160	110	3.9	2.62	16.46
3	Mazda RX4 Wag	21	6	160	110	3.9	2.875	17.02
4	Datsun 710	22.8	4	108	93	3.85	2.32	18.61
5	Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44
6	Hornet Sportabout	18.7	8	360	175	3.15	3.44	17.02
7	Valiant	18.1	6	225	105	2.76	3.46	20.22
8	Duster 360	14.3	8	360	125	3.21	3.57	15.84
9	Merc 240D	24.4	4	146.7	62	3.69	3.19	20
10	Merc 230	22.8	4	140.8	95	3.92	3.15	22.9
11	Merc 280	19.2	6	167.6	123	3.92	3.44	18.3
12	Merc 280C	17.8	6	167.6	123	3.92	3.44	18.9
13	Merc 450SE	16.4	8	275.8	180	3.07	4.07	17.4
14	Merc 450SL	17.3	8	275.8	180	3.07	3.73	17.6
15	Merc 450SLC	15.2	8	275.8	180	3.07	3.78	18
16	Cadillac Fleetwood	10.4	8	472	205	2.93	5.25	17.98

1. Data

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		mpg	cyl	disp	hp	drat	wt	qsec
1								
2	Mazda RX4	21	6	160	110	3.9	2.62	16.46
3	Mazda RX4 Wag	21	6	160	110	3.9	2.875	17.02
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6	Hornet Sportabout	18.7	8	360	175	3.15	3.44	17.02
7	Valiant	18.1	6	225	105	2.76	3.46	20.22
8	Duster 360	14.3	8	360	145	3.21	3.57	15.84
9	Merc 240D	24.4	4	146.7	62	3.69	3.19	20
10	Merc 230	22.8	4	140.8	95	3.92	3.15	22.9
11	Merc 280	19.2	6	167.6	123	3.92	3.44	18.3
12	Merc 280C	17.8	6	167.6	123	3.92	3.44	18.9
13	Merc 450SE	16.4	8	275.8	180	3.07	4.07	17.4
14	Merc 450SL	17.3	8	275.8	180	3.07	3.73	17.6
15	Merc 450SLC	15.2	8	275.8	180	3.07	3.78	18
16	Cadillac Fleetwood	10.4	8	472	205	2.93	5.25	17.98

Item

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1. Data

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Attribute

		mpg	cyl	disp	hp	drat	wt	qsec
1								
2	Mazda RX4	21	6	160	110	3.9	2.62	16.46
3	Mazda RX4 Wag	21	6	160	110	3.9	2.875	17.02
4	Datsun 710	22.8	4	108	93	3.85	2.32	18.61
5	Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44
6	Hornet Sportabout	18.7	8	360	175	3.15	3.44	17.02
7	Valiant	18.1	6	225	105	2.76	3.46	20.22
8	Duster 360	14.3	8	360	105	3.21	3.57	15.84
9	Merc 240D	24.4	4	146.7	62	3.69	3.19	20
10	Merc 230	22.8	4	140.8	95	3.92	3.15	22.9
11	Merc 280	19.2	6	167.6	123	3.92	3.44	18.3
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13	Merc 450SE	16.4	8	275.8	180	3.07	4.07	17.4
14	Merc 450SL	17.3	8	275.8	180	3.07	3.73	17.6
15	Merc 450SLC	15.2	8	275.8	180	3.07	3.78	18
16	Cadillac Fleetwood	10.4	8	472	205	2.93	5.25	17.98

Item

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1. Data

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Item

		Value	Attribute					
1								
2	Mazda RX4	21	cyl	disp	hp	drat	wt	qsec
3	Mazda RX4 Wag	21	6	160	110	3.9	2.62	16.46
4	Datsun 710	22.8	4	108	93	3.85	2.32	18.61
5	Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44
6	Hornet Sportabout	18.7	8	360	175	3.15	3.44	17.02
7	Valiant	18.1	6	225	105	2.76	3.46	20.22
8	Duster 360	14.3	8	360	95	3.21	3.57	15.84
9	Merc 240D	24.4	4	146.7	62	3.69	3.19	20
10	Merc 230	22.8	4	140.8	95	3.92	3.15	22.9
11	Merc 280	19.2	6	167.6	123	3.92	3.44	18.3
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14	Merc 450SL	17.3	8	275.8	180	3.07	3.73	17.6
15	Merc 450SLC	15.2	8	275.8	180	3.07	3.78	18
16	Cadillac Fleetwood	10.4	8	472	205	2.93	5.25	17.98

Visual Marks

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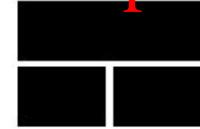
Points



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Lines



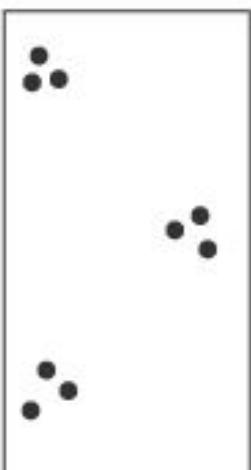
Areas

Visual Variables

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Bertin's Visual Variables

POSITION



Selective
Associative
Ordered
Quantitative

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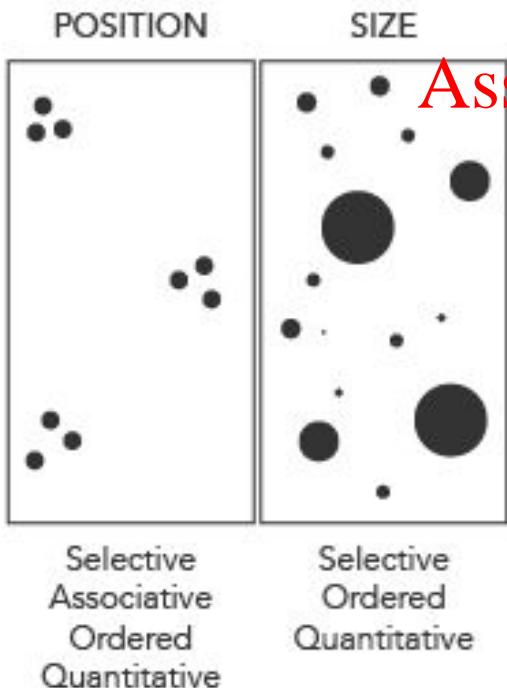
<https://powcoder.com>

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Visual Variables

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Bertin's Visual Variables



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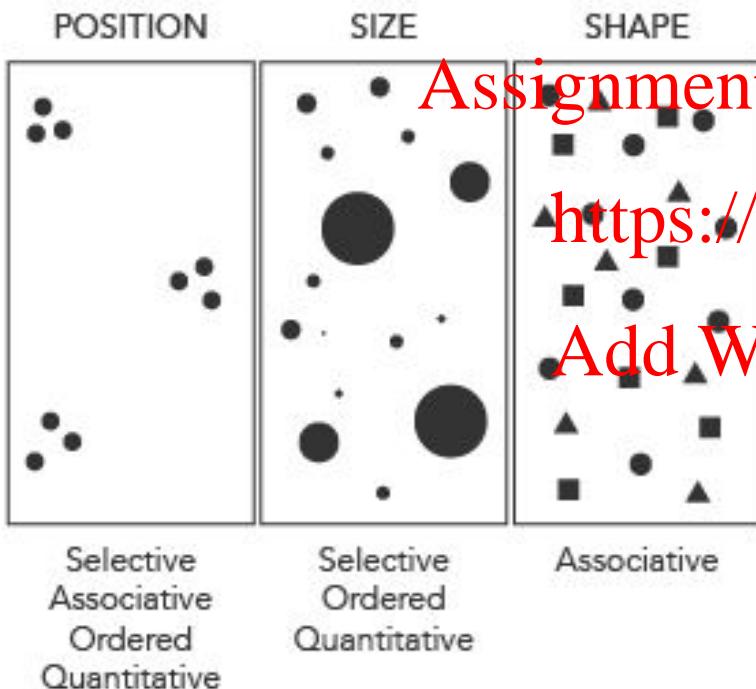
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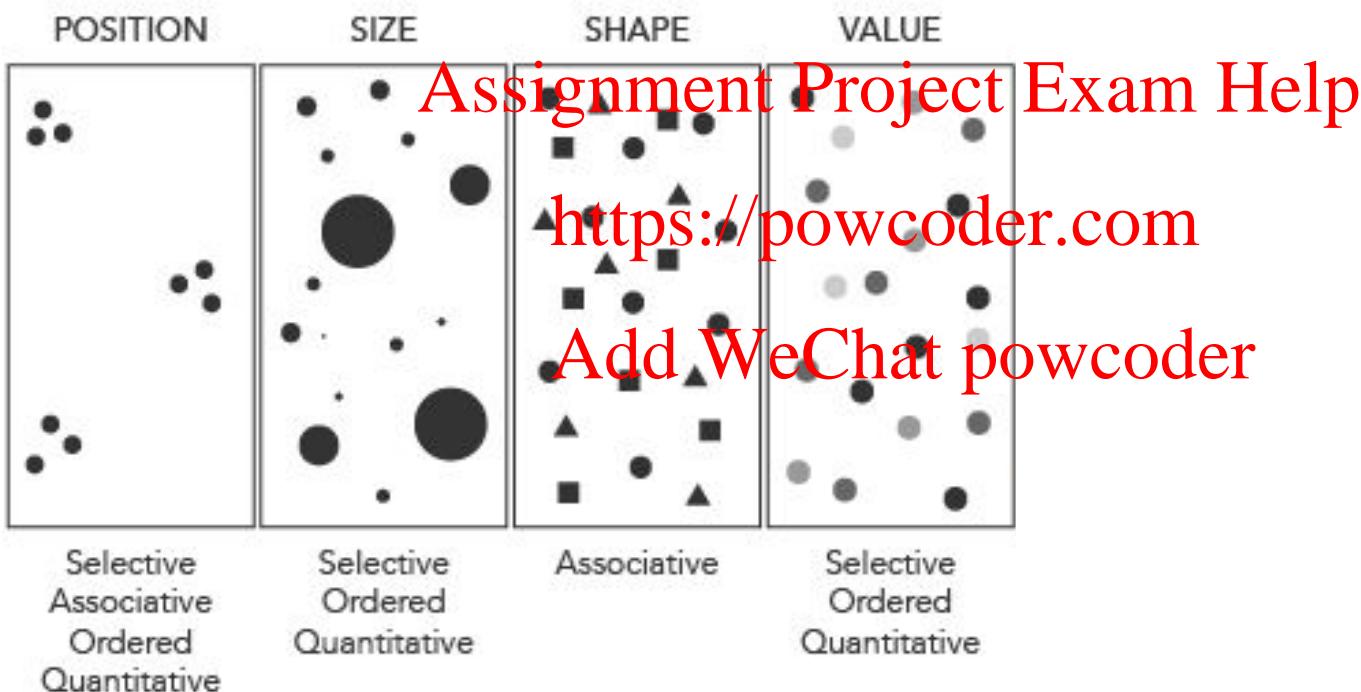
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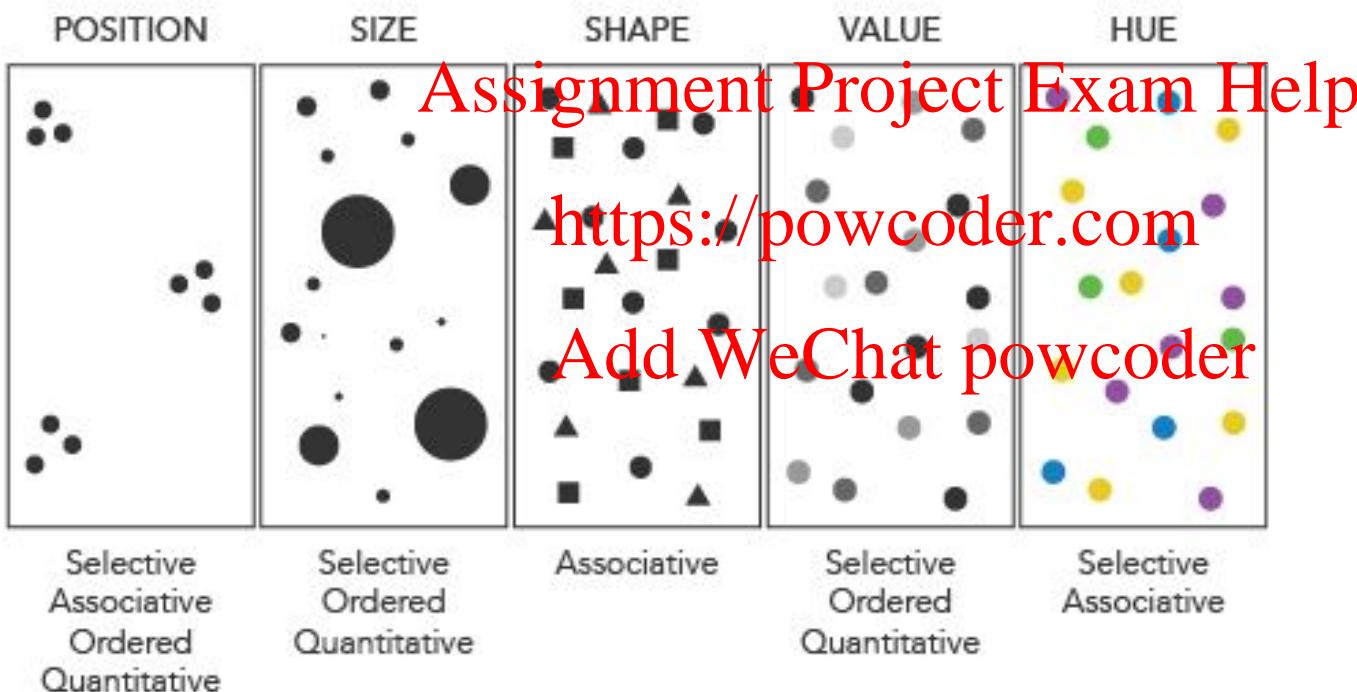
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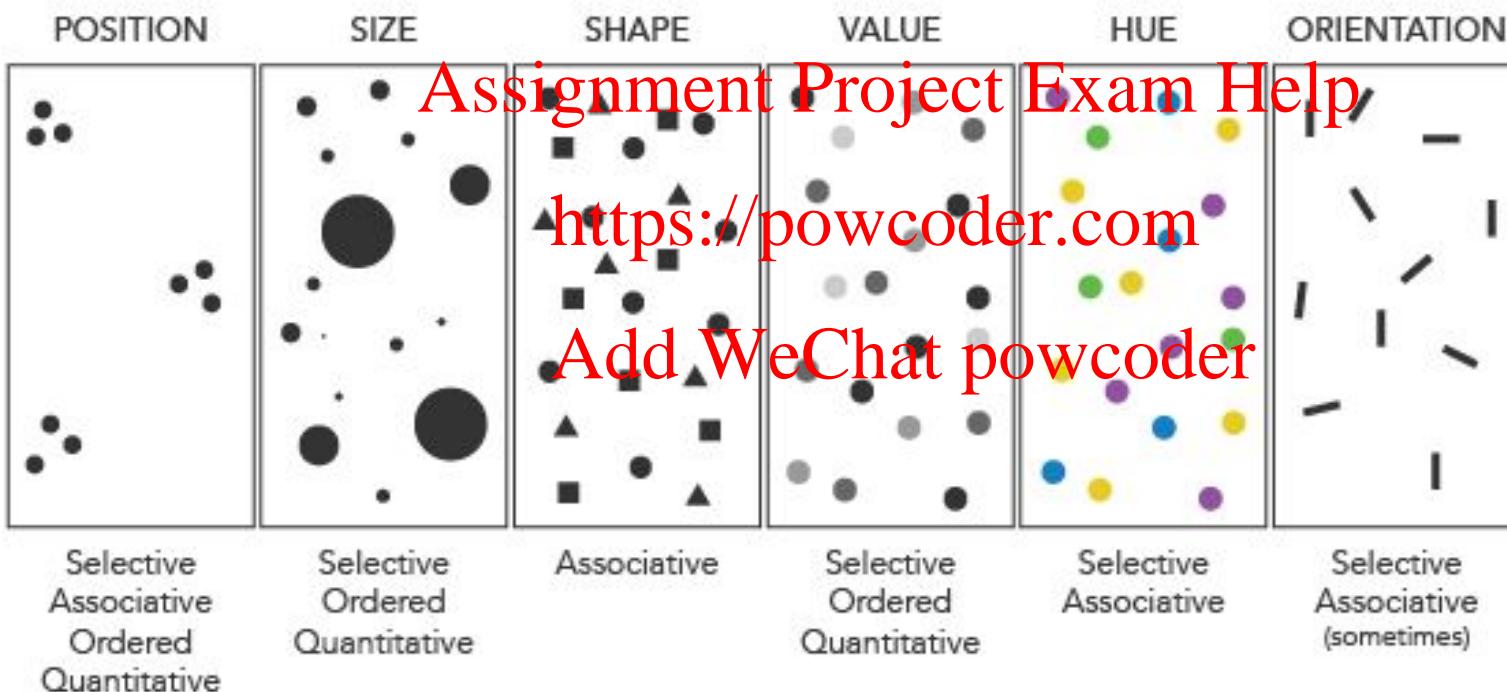
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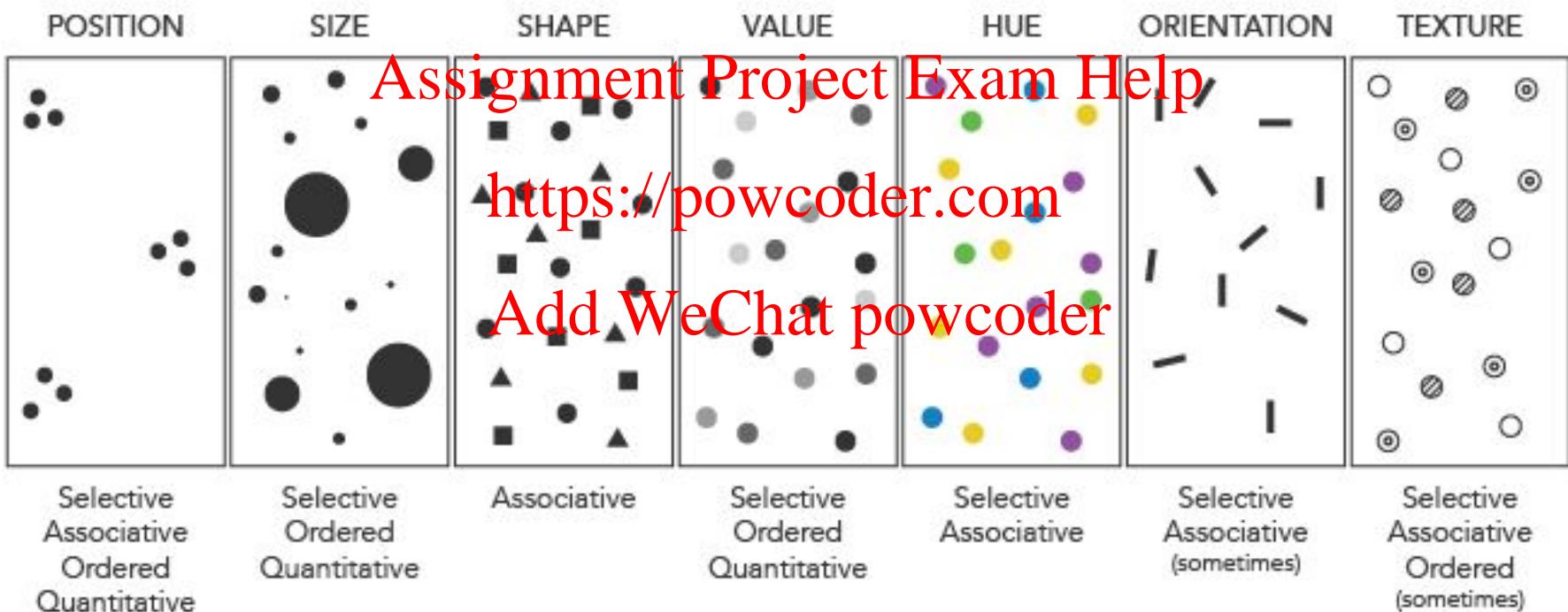
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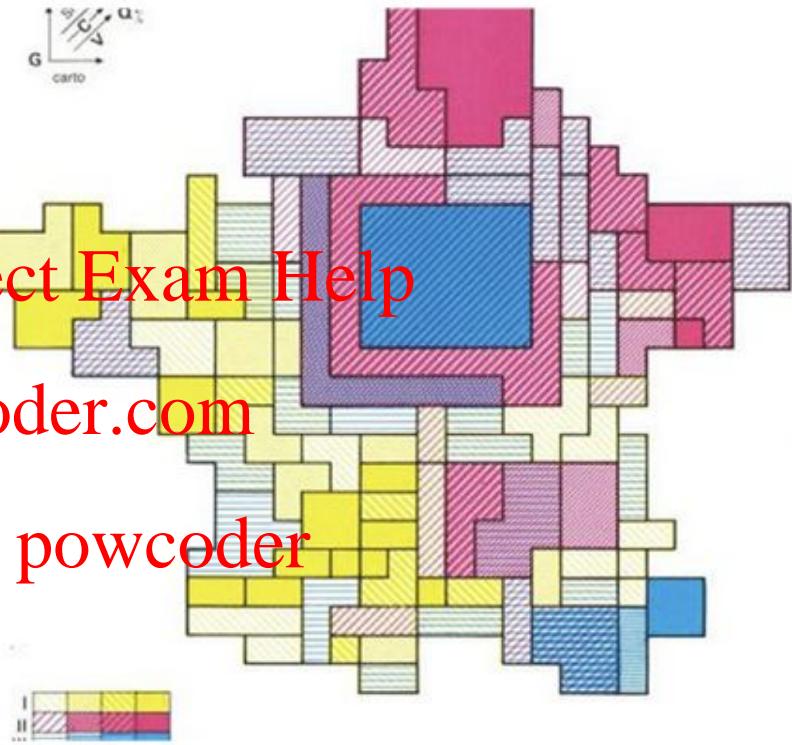
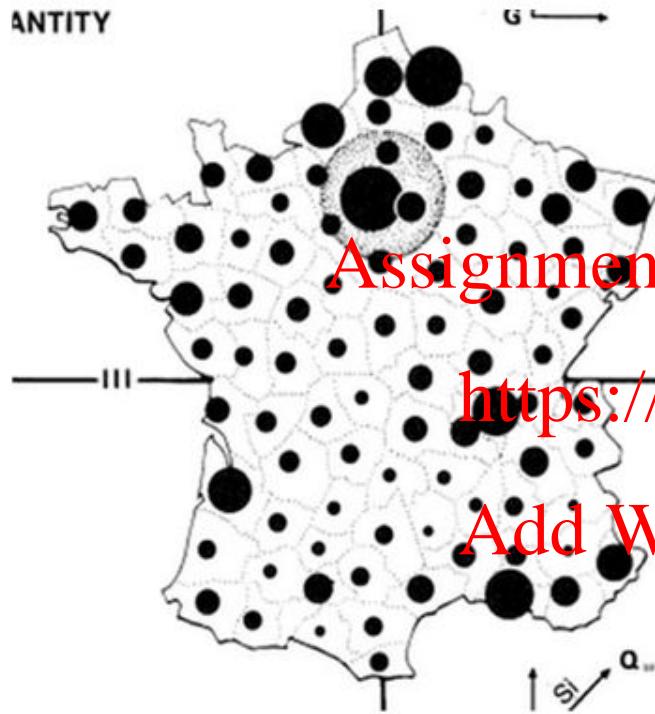
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- Points
- Size

Visual Variables

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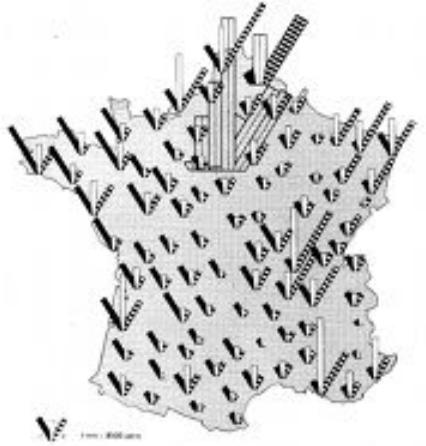
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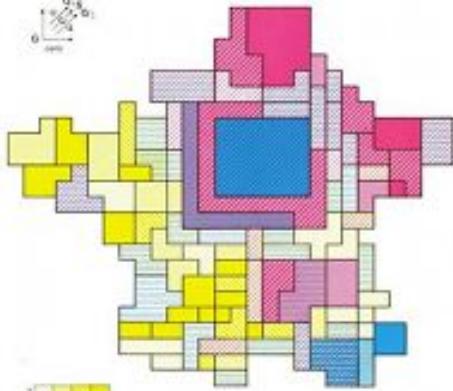
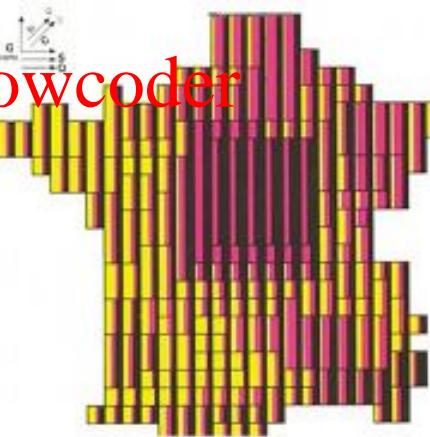
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- Points
- Size

- Areas
- Size
- Hue
- Texture

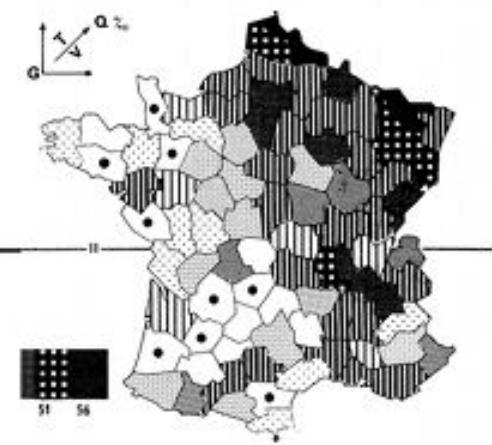
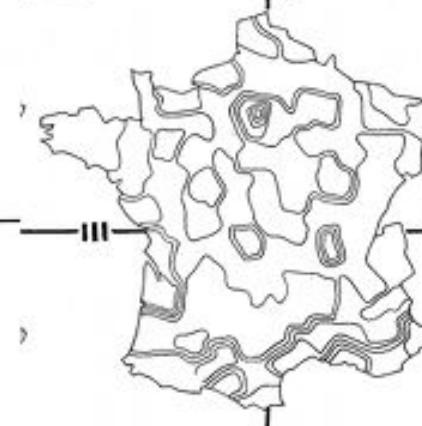
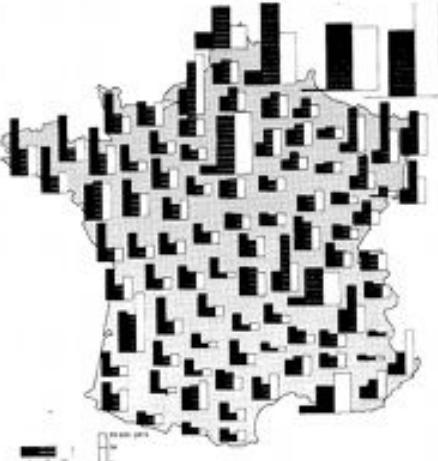


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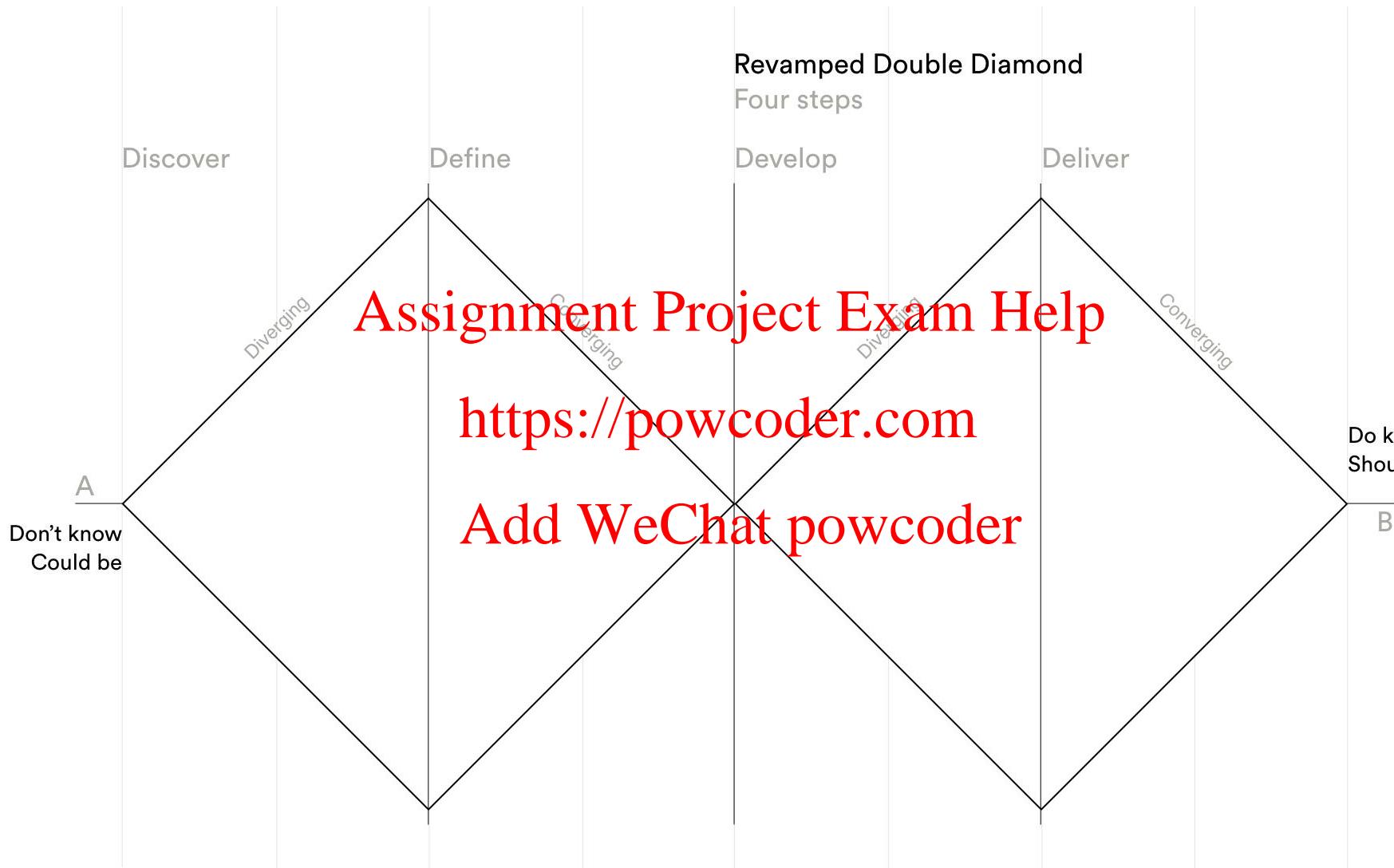
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Double Diamond

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Design Thinking

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Design thinking is a human-centered approach to creative problem solving.

- is about **people**
○ empathy, problems, context, problem

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<http://www.theagileelephant.com/what-is-design-thinking/>

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-

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- **hands-on**
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- **Show, don't tell**
- **iterative**
○ failure, progress, iterate, feedback,...

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Wrap-up

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1. Many forms of visualization
2. Visualization works through pre-attentiveness and parallel processing
3. Visualization is a process
4. Visualization literacy is the ability to correctly understand and use visual representations of data
5. Many basic chart types
6. Visual variables for design
7. Design thinking process