

+ Toy Cars and
Box-and-
Whiskers Plots:
Statistics and
Science
Students Love

NCTM

Philadelphia

2012

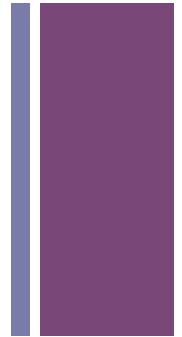
Kim Hartweg
LaVerne Logan
Western Illinois University

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The speakers will use science concepts related to force and motion to design and build a jet toy car that either (1) travels the farthest or (2) travels the fastest. They will gather and analyze data to create box-and-whisker plots to help determine the “best” toy car.



STEM Process: Start with a Question



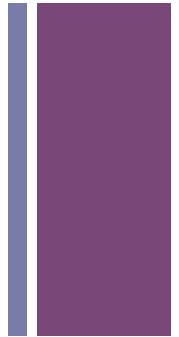
Which group can design “the best”
toy car?

What are the design features of the
fastest toy cars?

What are the design features of the
toy cars that travel the farthest?



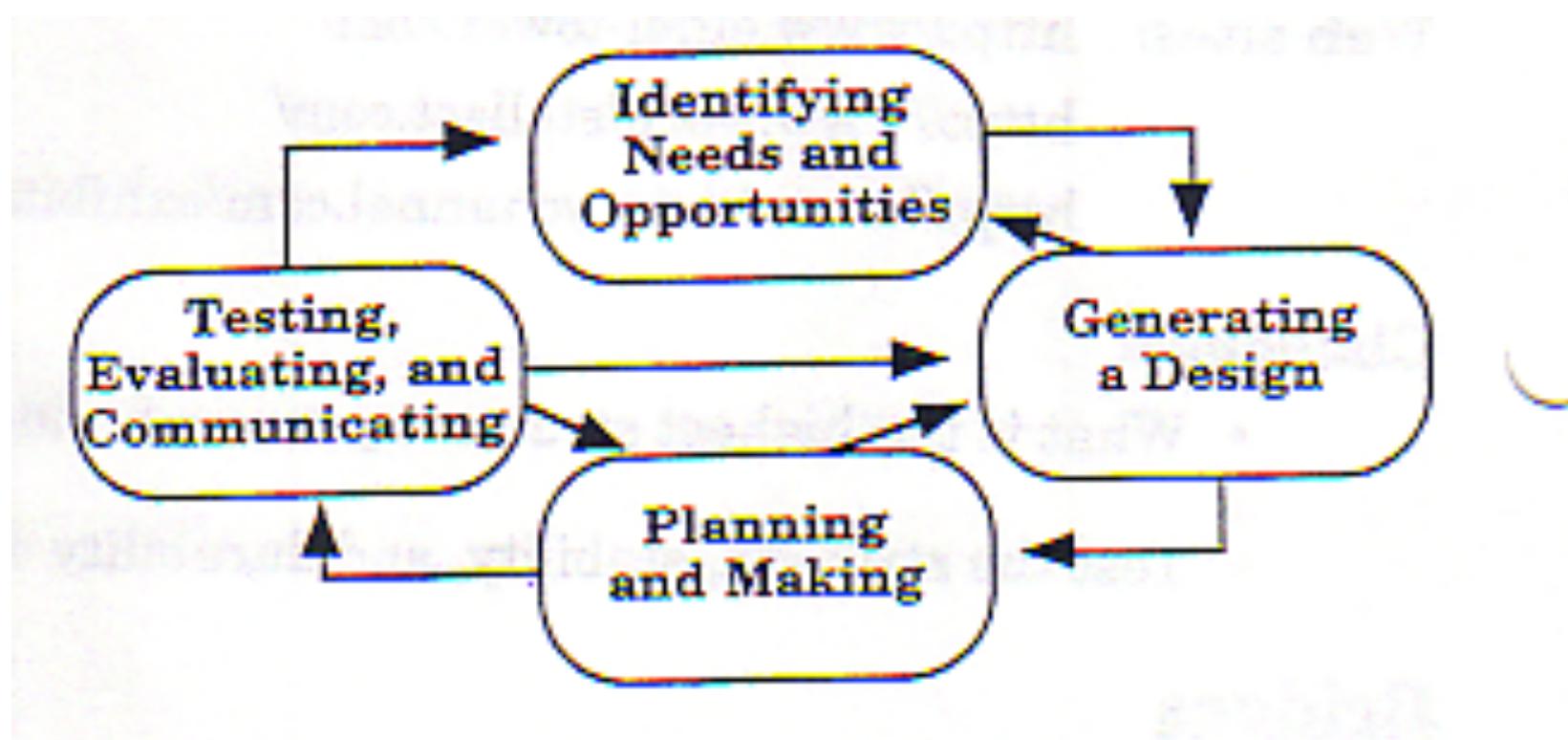
Scientific Process



- Observation
 - Qualitative
 - Quantitative (measurement)
- Predict/Infer/Test (PIT)
- Record
- Communicate/Experiment

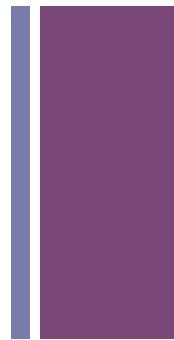


Technology Design - Recursive Process



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Design Process



■ Assemble Car

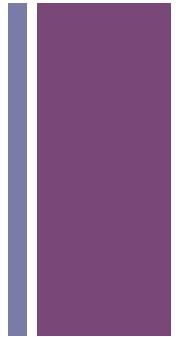
- Test drive with Chassis only!!
- No balloon test drives!!

■ Decide How/What to Measure

- Gather Data on 10 Trials (with balloon)
- Evaluate and Redesign
- Record TI-73 (List) or Paper/Pencil

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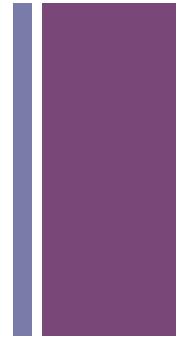
Links to Assembly Directions



- [Step 1 Chassis Assembly](#)
- [Step 2 Wheel Assembly](#)
- [Step 3a Balloon Mount Option](#)
- [Step 3b Balloon Mount Option](#)



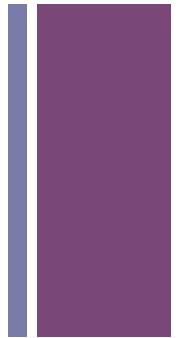
Data Analysis



How can we represent our data
to help answer our question(s)?



Data Analysis



How can we represent our data
to help answer our question(s)?

- Box and Whiskers - Distance
- Scatter Plot - Speed

■ Why Use a Box and Whisker Plot?

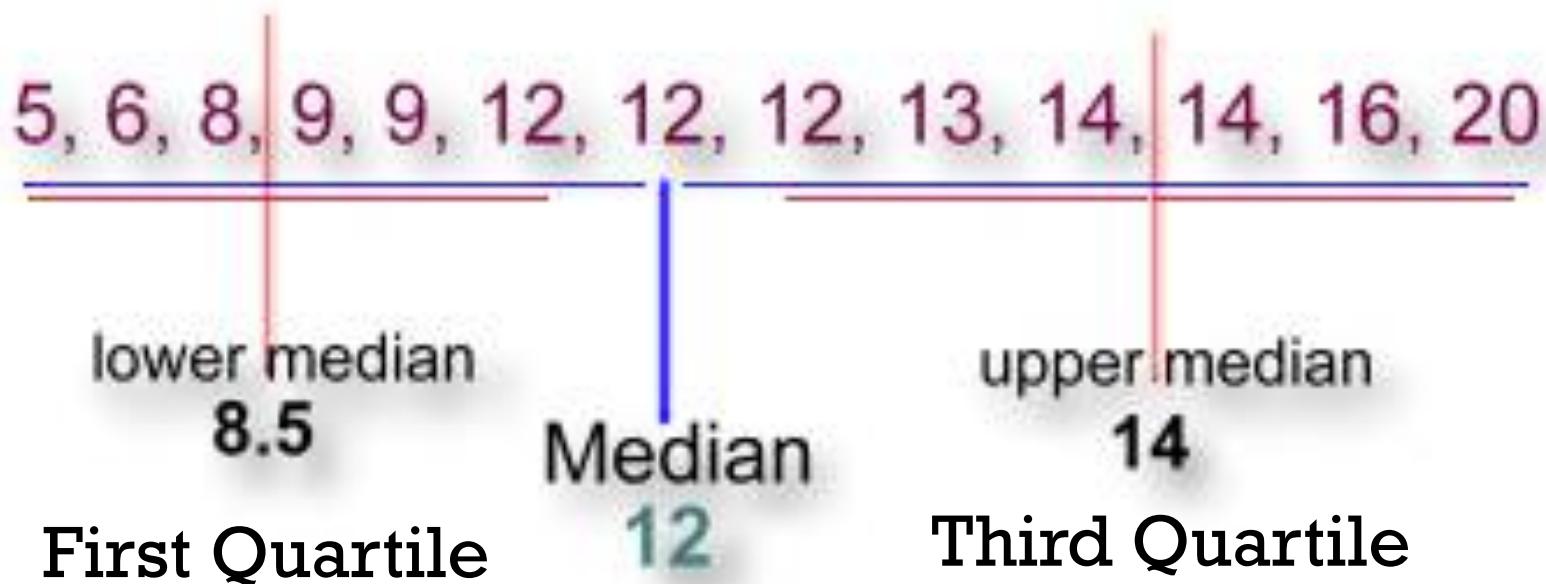
Box and whisker plots are very effective and easy to read. They summarize data from multiple sources and display the results in a single graph. Box and whisker plots allow for comparison of data from different categories for easier, more effective decision-making.

■ When to Use a Box and Whisker Plot

Use box and whisker plots when you have multiple data sets from independent sources that are related to each other in some way. Examples include test scores between schools or classrooms, data from before and after a process change, or data from duplicate machines manufacturing the same products.

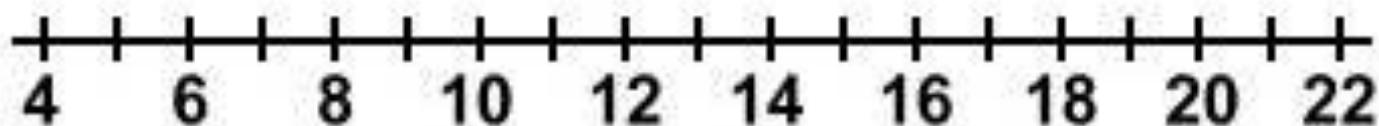
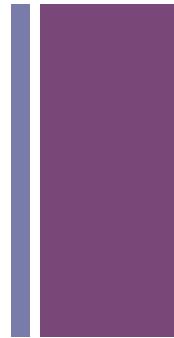
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Find the 5 Number Summary: Median, First Quartile, Third Quartile, Minimum, Maximum

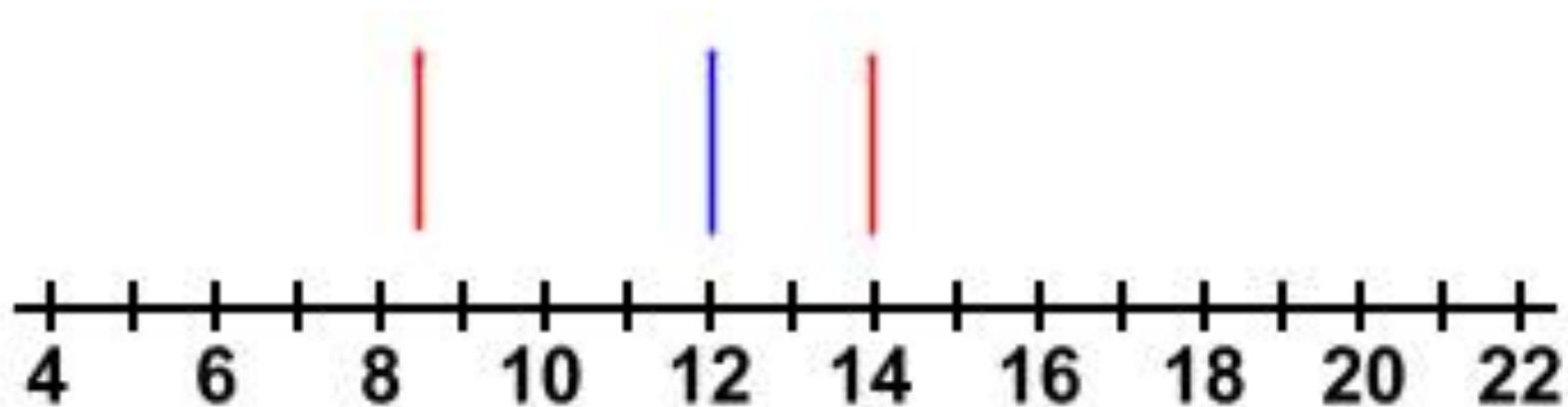


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Draw a number line that extends far enough in both directions to include all the numbers in your data.

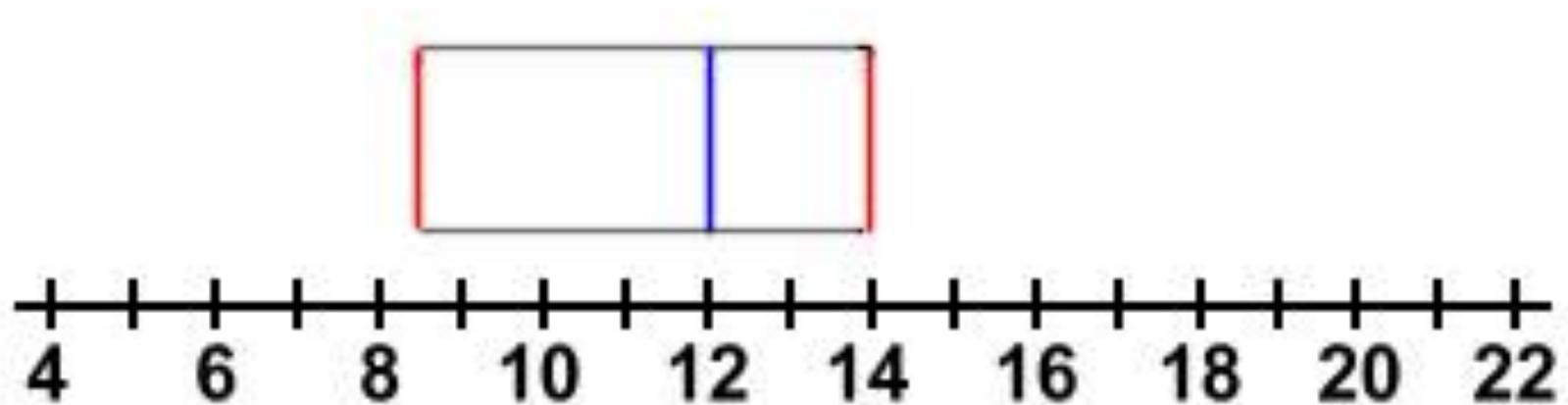


+ Draw lines to represent the first quartile, the median, and the third quartile.

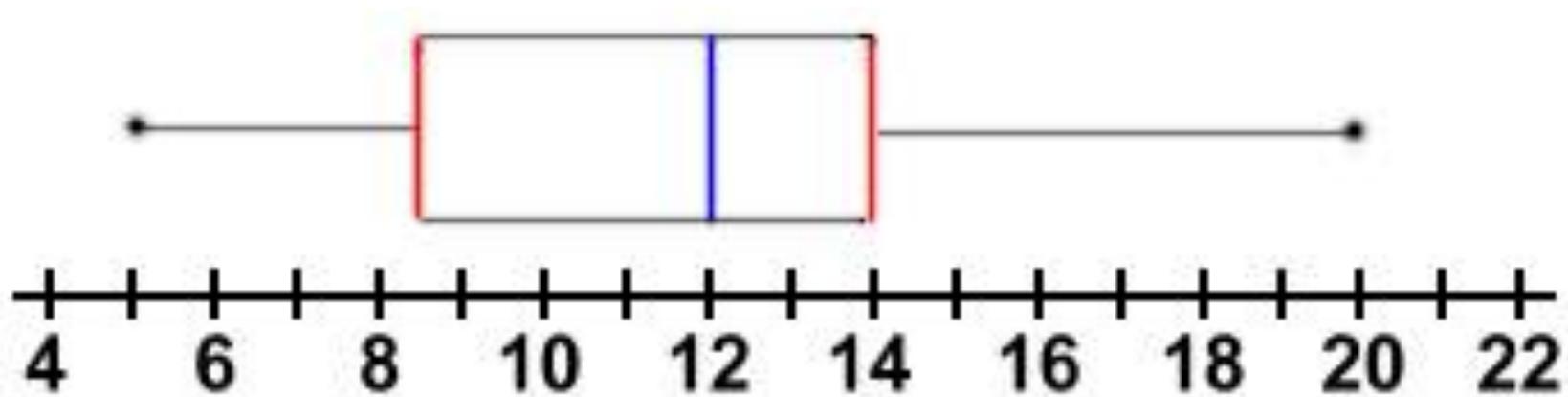


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Draw a box using the first and third quartiles as the side lengths.

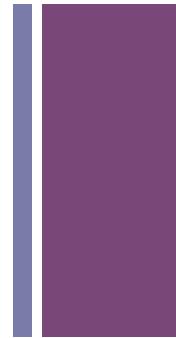


- + Plot the minimum and maximum value points and draw lines (whiskers) to the box.



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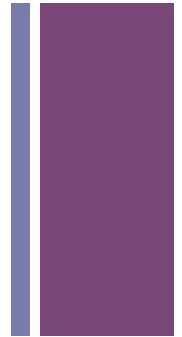
Write 3 statements that describe your box and whisker plot



Send someone up to enter
your car's data in the
[Excel Spreadsheet](#)



STEM Process: Start with a Question



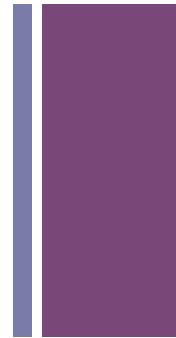
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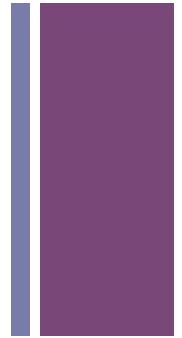
Force and Motion



- Newton's Laws
- Friction and Inertia
- Acceleration
- Speed (derived measures)
- Balanced/Unbalanced Forces

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Creativity!!!

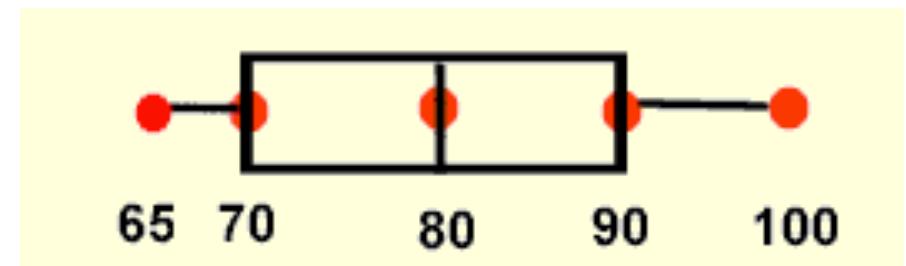


■ Toy Cars and Box-and-Whiskers Plots: Statistics and Science Students Love



TI-73

- Enter data for all 10 trials in the L1 list on your TI-73 (Press the LIST button)
- Create a box and whisker plot (a.k.a. box plot) to represent the 10 trials (steps will follow)



+ TI-73

- To Sort: [2nd quit for home screen]
 - 2nd Stat
 - Right Arrow to OPS
 - Enter for 1:SortA(
 - 2nd Stat
 - Enter for 1:L1
 - Close parenthesis
 - Enter [message will say DONE]
- Press LIST to see sorted L1 column!

+ TI-73

No need to sort column first!

■ To Find 5-number summary: [2nd quit for home screen]

- 2nd Stat
- Right Arrow to CALC
- Enter for 1: -Var Stats
- 2nd Stat
- Enter for 1:L1

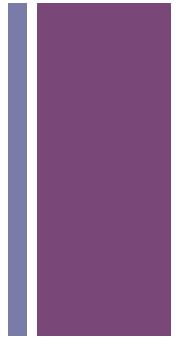
[Screen will show “1-Var Stats L1”]

■ Enter [Lots of data will show up on the screen]

■ Look for 5 number summary information:

- minX, Q1, Med, Q3, maxX

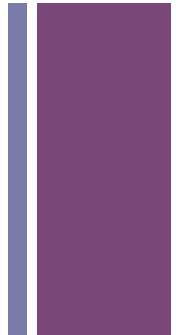
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■ [Click Here For Directions to
Graph Box and Whisker Plots
on a TI-73](#)



Common Core Connections and
Other Resources...



+ STANDARDS of Mathematical Practices

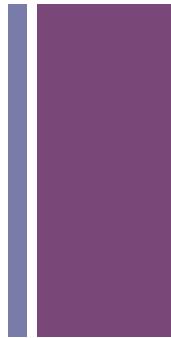
- **Make sense of problems and persevere in solving them.**
- **Reason abstractly and quantitatively.**
- **Construct viable arguments and critique the reasoning of others.**
- **Model with mathematics.**
- **Use appropriate tools strategically.**
- **Attend to precision.**
- **Look for and make use of structure.**
- **Look for and express regularity in repeated reasoning.**

+ Data Analysis Concepts

- Data collection and measurement
- Data Distributions/Variance
- Box and Whiskers Plots
- Measures of central tendency
(Mean, Median, Mode)
- 5-point Summary (Minimum,
Quartile 1, Median, Quartile 3,
Maximum)



Common Core Data Analysis and Probability



K-12 Domains	K	1	2	3	4	5	6	7	8	M 1	M 2	M 3	M 4
Measurement and Data	X	X	X	X	X	X							
Statistics and Probability							X	X	X				
<i>Interpreting Categorical and Quantitative Data (S-ID)</i>										X		X	
<i>Making and Inferences and Justifying Conclusions (S-IC)</i>												X	
<i>Conditional Probability & the Rules of Probability (S-CP)</i>											X		
<i>Using Probability to Make Decisions (S-MD)</i>											X	X	X



Common Core Measurement and Data

- 3.MD.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.
- 4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit.
- 5.MD.1 Convert like measurement units within a given measurement system. 1. Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.



Common Core 6th Grade Statistics and Probability

- Develop understanding of statistical variability.
 - 1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.
 - 2. Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.



Common Core 6th Grade Statistics and Probability

- 3. Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.
- 4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots

- 5. Summarize numerical data sets in relation to their context, such as by:

- Reporting the number of observations.
- Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
- Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
- Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.



Common Core 7th Grade Statistics and Probability

- Use random sampling to draw inferences about a population.
- Draw informal comparative inferences about two populations.
- Investigate chance processes and develop, use, and evaluate probability models.



Common Core 8th Grade Statistics and Probability

- Investigate patterns of association in bivariate data.
 - 1. Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association
 - 2. Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.



Common Core 8th Grade Statistics and Probability

- 3. Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept. For example, in a linear model for a biology experiment, interpret a slope of 1.5 cm/hr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.
- 4. Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?



Box Plot Illuminations

<http://illuminations.nctm.org/ActivityDetail.aspx?ID=77>

- Various box plots can be analyzed

Amount Spent Per Student

Gas Mileage for year 2000 cars by size

Colleges' SAT Math Scores

NBA Team Payrolls

Horsepower of Cars

Body Fat % of 252 Men

My Data

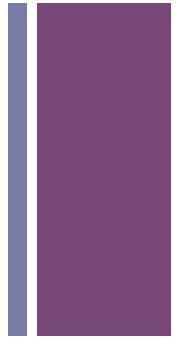
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Create online box and whisker plots

- <http://www.alcula.com/calculators/statistics/box-plot/>
- <http://www.shodor.org/interactivate/activities/BoxPlot/>
- <http://easycalculation.com/statistics/box-plot-grapher.php>
- <http://www.mrnussbaum.com/graph/bw.htm>
- <http://www.mathwarehouse.com/charts/box-and-whisker-plot-maker.php#boxwhiskergraph>



Dropbox Link for all files



■ nctm philadelphia 2012
hartweg

■ [https://www.dropbox.com/
sh/3f1lp4xh9a4fzts/
ArGnYV8KFM](https://www.dropbox.com/sh/3f1lp4xh9a4fzts/ArGnYV8KFM)