Interactive Technology Resources for Teaching Statistics in the Common Core

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Overview

- Statistical problem solving & Common Core Statistics Standards
- Census at School & statistical problem solving with U.S. & international Census at School student data
- Software resources
- Applets
- Gapminder
- Video resources
- Lessons and activity resources
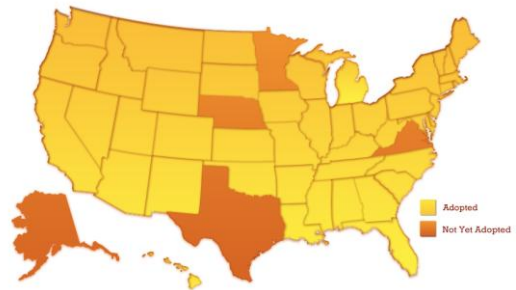- Data sources
- ASA K-12 statistics education resources

Statistical Problem Solving

Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K–12 Curriculum Framework

1. Formulate Questions
   - Clarify the problem at hand
   - Formulate one (or more) questions that can be answered with data

2. Collect Data
   - Design a plan to collect appropriate data
   - Employ the plan to collect the data

3. Analyze Data
   - Select appropriate graphical and numerical methods
   - Use the methods to analyze the data

4. Interpret results
   - Interpret the analysis (in context)
   - Relate the interpretation to the original question

Source: *www.amstat.org/education/gaise*

Common Core State Standards for Mathematics

Source: *corestandards.org*


Measurement & Data Strand - Grades 4 & 5
• Represent and interpret data

Statistics & Probability Strand – Grades 6 to High School
• Develop understanding of statistical variability (Grade 6)
• Summarize & describe distributions
• Use random sampling to draw inferences about a population (Grade 7)
• Draw informal comparative inferences about two populations
• Investigate patterns of association in bivariate data (Grade 8)
• Summarize, represent, and interpret data on a single count or measurement variable (High School)
• Summarize, represent, and interpret data on two categorical and quantitative variables
• Interpret linear models
• Understand and evaluate random processes underlying statistical experiments
• Make inferences and justify conclusions from sample surveys, experiments, and observational studies

Source: *corestandards.org*

US Census at School Program
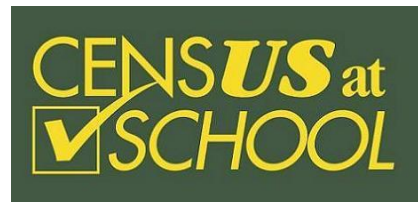
www.amstat.org/censusatschool

US Census at School Program

Free international classroom project that engages students in grades 4-12 in statistical problem solving

- Students complete an online survey, analyze their class census data, and compare their class results with random samples of participating students in the United States and other countries.
- The project began in the United Kingdom in 2000 and includes Australia, Canada, New Zealand, South Africa, Ireland, Japan, South Korea, and now the United States. U.S. program launched by ASA and Population Association of America.
- Teach statistical concepts in the Common Core Standards, measurement, graphing, data analysis, and statistical problem solving in context of students' own data and data from their peers in the participating countries

www.amstat.org/censusatschool

US Census at School Program

- Students complete a brief online survey (classroom census)
  - 13 international questions plus additional U.S. questions
  - 15-20 minute computer session
- Analyze your class results
  - Use teacher password to gain immediate access to class data
  - Formulate questions of interest that can be answered with Census at School data, collect/select appropriate data, analyze the data with appropriate graphs and numerical summaries, internet the results, and make appropriate conclusions in context relating to the original questions
- Compare your class with samples from the U.S. and other countries
  - Download a random sample of Census at School data from U.S. students
  - Download a random sample from participating international students
- International lesson plans are available, along with instructional webinars and other free resources

www.amstat.org/censusatschool

US Census at School Program

www.amstat.org/censusatschool

US Census at School – Student Section

www.amstat.org/censusatschool

US Census at School – Student Section

www.amstat.org/censusatschool

US Census at School – Teacher Section

www.amstat.org/censusatschool

US Census at School – Resources

www.amstat.org/censusatschool

US Census at School Random Sampler

www.amstat.org/censusatschool

International Random Sampler

www.amstat.org/censusatschool

Statistical Investigations - Census at School

- Formulate statistical questions of interest that can be answered with the Census at School data.
- Collect/select appropriate Census at School data and write down the variable names and type for this investigation.
- Analyze the data. Include appropriate graphs and numerical summaries for the corresponding variables.
- Interpret the results and make appropriate conclusions in context. Be sure to justify your results using your graphs and numerical summaries and relate your interpretation to the original question.

For a demonstration of this process and software resources (some free) to analyze the data, watch the Census at School webinars posted under Resources at *www.amstat.org/censusatschool.*

Formulating a Statistical Question

Common Core Standards – Grade 6 (6.SP)

1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. *For example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because one anticipates variability in students' ages.*

A well-written statistical question anticipates answers that will vary and includes:
- Population of interest
- Measurement of interest

Example from Common Core: *How old are the students in my school?*
- Population of interest: Students in my school
- Measurement: Age (measured in years)
- Student ages will vary

Formulate Statistical Questions

Example Statistical Questions with Census at School

- How much time per week do students participating in U.S. Census at School spend on the computer?
  - Population of interest: Students (grades 4-12) participating in U.S. Census at School
  - Measurement: Time on the computer each week (measured in hours)
  - Time (hours per week) will vary by student
- What is the favorite sport /activity of students in Australia participating in Census at School?
  - Population of interest: Students in Australia participating in U.S. Census at School
  - Measurement: Favorite sport (baseball, basketball, bowling, etc.)
  - Favorite sport/activity will vary by student
- Is there a difference between the reaction times of boys and girls (participating in U.S. Census at School)?
  - Populations/groups of interest: Boys and girls participating in U.S. Census at School
  - Measurement: Reaction time (measured in seconds)
  - Reaction times will vary by student

Formulate Statistical Questions

Example Statistical Questions with Census at School

- Is there a relationship between height and arm span for students participating in Census at School?
  - Population of interest: Students participating in U.S. Census at School
  - Measurements: Height (measured in cm) and arm span (measured in cm)
  - Measured heights and arm spans will vary by student
- Does the preferred superpower of U.S. Census at School students differ by gender?
  - Populations/groups of interest: Boys and girls participating in U.S. C@S
  - Measurement: Preferred superpower (categories: fly, freeze time, invisibility, super strength, telepathy)
  - Preferred superpower will vary by student
- Does travel time to school vary by country for the students participating in Census at School?
  - Populations/groups of interest: Students participating in C@S in the various countries
  - Measurement: Travel time to school (measured in minutes)
  - Measured heights and arm spans will vary by student

Collect/Select Census at School Data

- Download your class data
- Download random samples of other students in the U.S. participating in Census at School with the online U.S. Census at School Random Sampler
- Download random samples of students in other countries participating in Census at School with the online International Census at School Random Sampler
- Select the variables of interest needed to investigate the statistical question and write down the variable names and type for this investigation
- Because the Census at School data comes from real students and is entered online by these students, there will be some mistakes and inappropriate data values in the data sets. Before analyzing your data and making conclusions, make sure to take time to observe and clean your data. Create a graph for each variable of interest to look for inappropriate or unusual values that do not make sense in context of the variable and original survey question.

Analyze & Interpret C@S Data

For the statistical questions:

- Create appropriate graphs
- Create numerical summaries
- Apply the concepts in the Common Core State Standards with real student data
- Interpret the results and make appropriate conclusions in context. Be sure to justify your results using your graphs and numerical summaries and relate your interpretation to the original question.
- Optional review appropriate graphs, numerical summaries, and interpretations in context of Census at School data in following slides

Example Student Posters with C@S Data
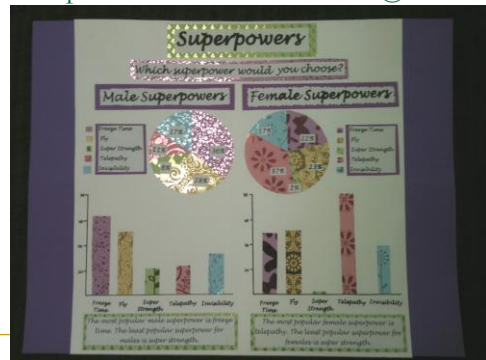
Example Student Posters with C@S Data

Example Student Posters with C@S Data
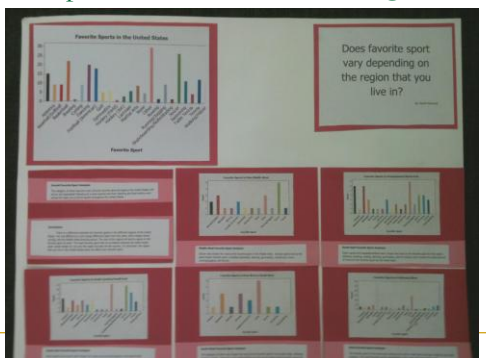
Optional Review: Variables

- Variable – Any characteristic whose value may change from one individual/object to another.

- **Quantitative (Numerical, Measurement) Variable:**
  - Census at School Examples:
    - **Age:** 13 years
    - **Height:** 138 cm (measured in cm since it is an international program)
    - **Travel time to school:** 15 minutes

- **Categorical (Qualitative) Variable:**
  - Census at School Examples:
    - **Country:** Australia/Canada/New Zealand/South Africa/United Kingdom/USA
    - **Gender:** Male/Female
    - **Handed:** Right handed/Left handed/Ambidextrous

- Why does the type of variable matter?

Graphical Displays by Type of Variable

- **One Quantitative Variable**
  - Dot plot
  - Stem & leaf plot
  - Histogram
  - Box & whisker plot (box plot)

- **One Categorical Variable:**
  - Bar graph (preferred)
  - Circle graph/Pie chart
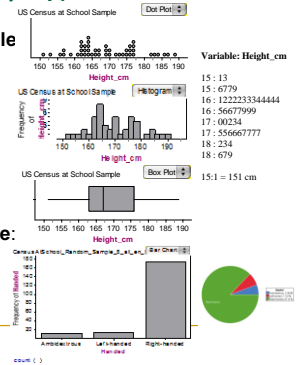
Bar Charts vs. Histograms
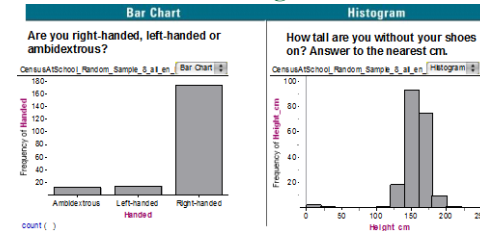
- •Horizontal axis is categorical.
- •Shape, center, and spread have no meaning in a bar chart.
- •Space usually separates each bar.

- •Horizontal axis is quantitative.
- •Histograms are described by shape, center, and spread.
- •Bars are usually adjacent.

Numerical Summaries by Type of Variable

- Quantitative data:
  - Mean (measure of center appropriate for symmetric data)
  - Median (measure of center not as influenced by skewness & outliers as the mean)
  - Standard deviation (measure of spread appropriate when using mean as a measure of center)
  - Interquartile range (measure of spread appropriate when using median as a measure of center, less influenced by skewness and outliers)
  - Range (measure of spread)
  - Others

- Categorical data:
  - Counts/frequencies
  - Percentages
  - Modal category

Use the graphs and numerical summaries appropriate for your grade level(s).

Interpreting Graphs for One Quantitative Variable
(Histogram, Dot Plot, Stem & Leaf Plot, Box & Whisker Plot)
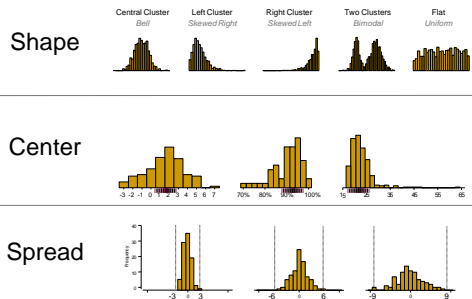
Interpreting Graphs (One Quantitative Variable)

- Shape (bell-shaped, skewed, flat/uniform, etc.)
- Center (mean, median)
- Spread/Variability (standard deviation, mean absolute deviation, interquartile range, range)
- Possible outliers
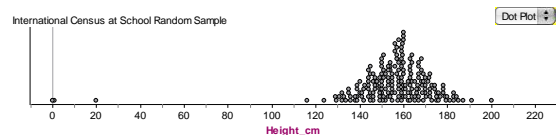
Interpreting Graphs (One Quantitative Variable)

- Shape
- Center
- Spread/Variability
- Possible outliers
  - These values (0, 1 and 20 cm) fall outside the overall pattern and are not plausible heights (the world's shortest person is 50 cm).
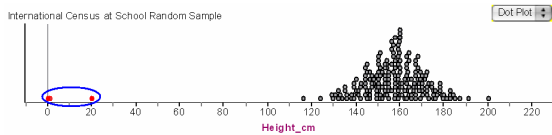
Interpreting Graphs (One Quantitative Variable)

- Shape
  - symmetric, bell-shaped
- Center
- Spread/Variability
  - Possible outliers
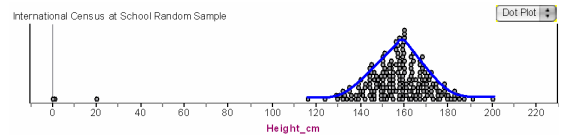
Interpreting Graphs (One Quantitative Variable)

- Shape
- Center
  - mean ≈ median since shape approx. symmetric
- Spread/Variability
- Possible outliers
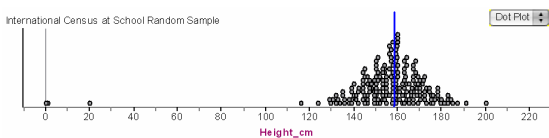
Interpreting Graphs (One Quantitative Variable)

- Shape
- Center
- Spread/Variability (standard deviation, interquartile range, range)
  - Range – distance between the maximum and minimum values
    - The outliers were not included in this case since they are not possible height values
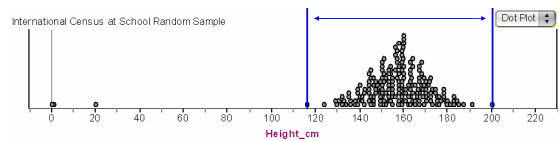
Interpreting Graphs (One Quantitative Variable)

- Shape
- Center
- Spread/Variability (standard deviation, interquartile range, range)
  - Interquartile range = Q3 – Q1, range of the middle 50% of values
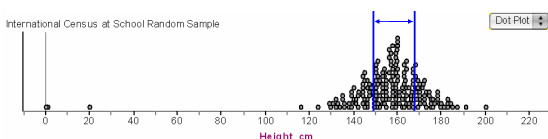
Interpreting Graphs (One Quantitative Variable)

- Shape
- Center
- Spread/Variability (standard deviation, interquartile range, range)
  - Standard Deviation – an average distance of observations from the mean (similar to mean absolute deviation)

Interpreting Graphs for One Quantitative Variable
Census at School Example Variable: Height

Shape

Bell-shaped, symmetric
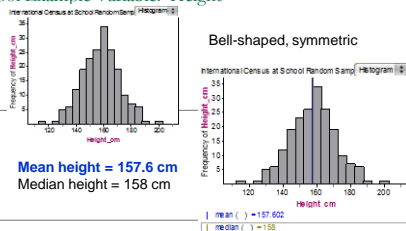
Center

Mean height = 157.6 cm
Median height = 158 cm

| mean ( ) =157.602
| median ( ) =158

Spread

Standard deviation of heights = 13.5 cm (an average distance from the mean height is 13.5 cm)
Interquartile range of heights = Q3 – Q1 = 167 – 149 = 18 cm
(range of the middle 50% of heights is 18 cm)
Range of heights = Max – Min= 200 – 116 = 84 cm

Interpreting Graphs for One Quantitative Variable
Census at School Example: Importance of Saving Energy Rating
Scale 0 to 1000

Shape

Left-skewed
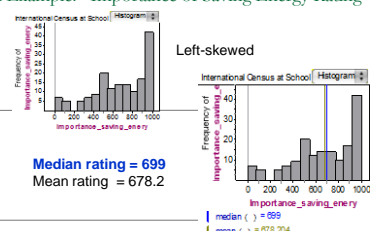
Center

Median rating = 699
Mean rating = 678.2

| median ( ) = 699
| mean ( ) = 678.204

Spread

Standard deviation of ratings = 282.1 (an average distance from the mean rating is 282.1)
**Interquartile range of ratings = Q3-Q1 = 999–500= 499
(range of the middle 50% of ratings is 499)**
Range of ratings =Max-Min= 1000–0= 1000

Interpreting Graphs for One Quantitative Variable
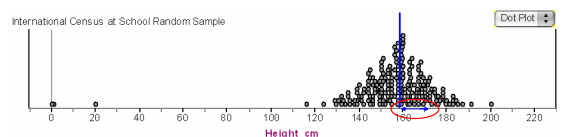Census at School Example Variable: Travel Time to School

Shape

Right-skewed
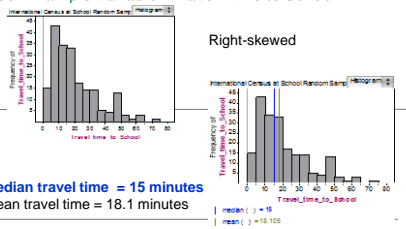
Center

Median travel time = 15 minutes
Mean travel time = 18.1 minutes

| median ( ) = 15
| mean ( ) = 18.105

Spread

Standard deviation = 14.3 minutes (an average distance from the mean travel time is 14.3 minutes)
**Interquartile Range = Q3-Q1= 25–7= 18 minutes
(range of the middle 50% of travel times is 18 minutes)**
Range =Max-Min= 70–1= 69 minutes

Graphical Displays for Two Variables

- **Two Quantitative Variables**
  - Scatter plot

- **Two Categorical Variables**
  - Tables
  - Two variable bar charts

- **One Quantitative and One Categorical Variable**
  - Side by side dot plots
  - Side by side box & whisker plots (works well for multiple groups – strength of box plots)
  - Back to back stem & leaf plots (Compare distribution of quantitative variable for two groups)

Two Quantitative Variables

- Scatter Plot Examples:
  - Is there a relationship between height (cm) and arm span (cm)?
  - Is there a relationship between age (years) and travel time to school (minutes)?
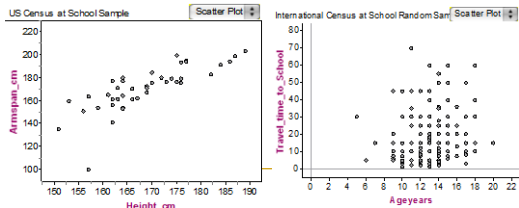
Interpreting Graphs (Two Quantitative Variables)

- Interpreting Scatter Plots
  - Form (linear, curved, etc.)
  - Direction (positive, negative, etc.)
  - Strength (strong, weak, etc.)
  - Note possible outliers

Association does not imply causation.

Numerical Summary: Correlation Coefficient r = 0.80
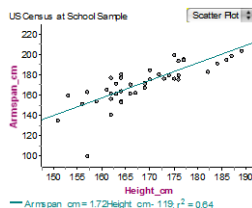
Form: Linear (appropriate to model with a line)
Direction: Positive (those who are taller tend to have larger arm spans and those who are shorter tend to have smaller arm spans)
Strength: Moderately strong (points fairly tight about the linear form)
Correlation Coefficient r = 0.80 (positive and moderately strong relationship since correlation near +1)
Possible outlier: There is an individual with a shorter arm span that expected based on her height.

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Interpreting Graphs (Two Quantitative Variables)

- ### Interpreting Scatter Plots
  - Form (linear, curved, etc.)
  - Direction (positive, negative, etc.)
  - Strength (strong, weak, etc.)
  - Note possible outliers

Numerical Summary: Correlation Coefficient r = 0.19
Note: Correlation Coefficient is not part of the Common Core Standards for Middle School

International Census at School Random Sample — Scatter Plot

— Travel_time_to_School = 1.14 Age years + 3.7; r^2 = 0.036

Form: No apparent form
Direction: No apparent association, possibly slightly positive
Strength: Weak
Correlation Coefficient r = 0.19 (slightly positive and very weak association since correlation near 0)

Two Categorical Variables

- Two-way Table & Two-variable Bar Chart Example: Frequency of preferred superpower (categorical variable) by gender (categorical variable)

Census at School Sample

		Gender		Row Summary
		Female	Male	
Superpower	Fly	30	11	41
	Freeze time	19	17	36
	Invisibility	13	11	24
	Super strength	4	14	18
	Telepathy	26	5	31
	Column Summary	92	58	150

S1 = count ( )

count ( )
Gender
☐ Female   ☒ Male

Because there are more females than males in this sample (92 versus 58), we need to be careful comparing the frequencies of gender across the superpower categories. It is more meaningful to compare percentages than frequencies since the count of males and females differ in this sample of school children participating in Census at School.

Two Categorical Variables

- Two-way Table & Two-variable Bar Chart Example: Percentage of preferred superpower (categorical variable) by gender (categorical variable)

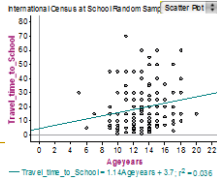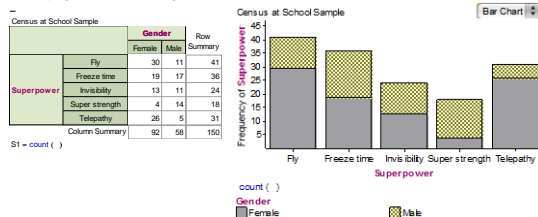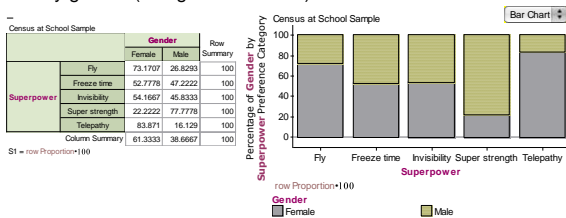Census at School Sample

		Gender		Row Summary
		Female	Male	
Superpower	Fly	73.1707	26.8293	100
	Freeze time	52.7778	47.2222	100
	Invisibility	54.1667	45.8333	100
	Super strength	22.2222	77.7778	100
	Telepathy	83.871	16.129	100
	Column Summary	61.3333	38.6667	100

S1 = row Proportion•100

row Proportion•100
Gender
☐ Female   ☒ Male

Use proportions/percentages to investigate association between two categorical variables. If the gender percentages are the same across the superpower categories, we do not have evidence of association. Since they do differ in this case, we have evidence of potential association between gender and superpower preference.

Two Categorical Variables

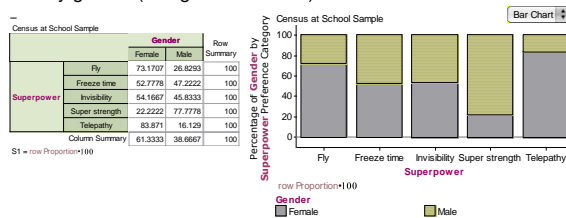- Two-way Table & Two-variable Bar Chart Example: Percentage of preferred superpower (categorical variable) by gender (categorical variable)

Census at School Sample

		Gender		Row Summary
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Superpower	Fly	73.1707	26.8293	100
	Freeze time	52.7778	47.2222	100
	Invisibility	54.1667	45.8333	100
	Super strength	22.2222	77.7778	100
	Telepathy	83.871	16.129	100
	Column Summary	61.3333	38.6667	100

S1 = row Proportion•100

row Proportion•100
Gender
☐ Female   ☒ Male

Of those who prefer super strength, the largest percentage are males. Of those who prefer to fly or telepathy (read minds), the largest percentage are females. Of those who prefer invisibility or to freeze time, the percentages of males and females are more similar.

One Quantitative and One Categorical Variable

- Census at School Examples: Travel time to school in minutes (quantitative variable) by country (categorical variable)
- Discuss/compare the shape, center, and spread of the quantitative variable for each category of the categorical variable

International Census at School Random Sample — Dot Plot / Box Plot

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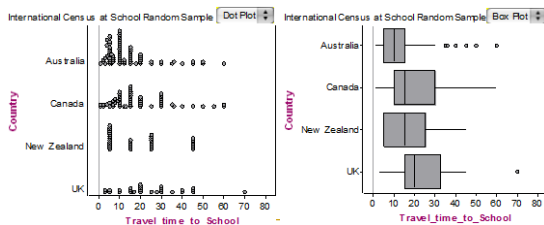
Statistical Investigations - Census at School

- Formulate questions of interest that can be answered with the Census at School data.
- Collect/select appropriate Census at School data and write down the variable names and type for this investigation.
- Analyze the data. Include appropriate graphs and numerical summaries for the corresponding variables.
- Interpret the results and make appropriate conclusions in context. Be sure to justify your results using your graphics and summaries and relate your interpretation to the original question.
- Let's do this together using real C@S data!

  For a demonstration of this process and software resources (some free) to analyze the data, watch the Census at School webinars posted under Resources at *www.amstat.org/censusatschool.*

Software Resources

- Fathom & Tinkerplots (Key Curriculum Press)
  - Great data visualization and intuitive analysis tools
  - Free C@S webinars demonstrate using Fathom to analyze Census at school data under resources link at www.amstat.org/censusatschool
  - Other webinars demonstrate Fathom through activities at www.amstat.org/education/k12webinars

- StatCrunch (www.statcrunch.com)
  - Intuitive, web-based software
  - Free for instructors, inexpensive for students
  - Free C@S webinar demonstrates using StatCrunch to analyze Census at school data under resources link at www.amstat.org/censusatschool
  - Other webinars demonstrate StatCrunch at www.amstat.org/education/k12webinars
  - Free StatCrunch Facebook Friend Data app

Software Resources

- Core Math Tools (www.nctm.org/coremathtools/)
  - Free software including statistics and simulation capabilities compatible with the Common Core State Standards

- New Zealand free data visualization software
  - Visual Inference Tools (including randomization tests rationale)
  - http://www.stat.auckland.ac.nz/~wild/VIT/index.html
  - InZight (Free, simple data analysis system)
  - http://www.stat.auckland.ac.nz/~wild/iNZight/

- Rcommander (free software through R)
  - Free C@S webinar demonstrating how to download, install, and use Rcommander to analyze C@S data under resources link at www.amstat.org/censusatschool
- Others

Applets

- Rossman/Chance Applets
  - http://www.rossmanchance.com/applets/
  - Randomization tests (Common Core high school inference based on simulation and randomization tests)
- USU Applets
  - http://www.math.usu.edu/~schneit/CTIS/
  - Webinar by Kady Schneiter at www.amstat.org/education/k12webinars
- National Library of Virtual Manipulatives (Pre-K – 12)
  - http://nlvm.usu.edu/
- Consortium for the Advancement of Undergraduate Statistics Education (CAUSE)
  - www.causeweb.org
  - Lists applets under resources link
  - Some appropriate for middle or high school under Common Core
- Journal of Statistics Education lists applets linked to articles
  - http://www.amstat.org/publications/jse/jse_computing_archive.htm

Gapminder.org

Free world data visualization software

Gapminder Videos

- www.gapminder.org

eCOTS

- Electronic Conference on Teaching Statistics May 14-18, 2012
- Hans Rosling (Gapminder) and other prominent statisticians and statistics educators will present
- eCOTS registration only $15

- www.causeweb.org/ecots

Other Free Video Resources

- Against All Odds: Inside Statistics
  - A video instructional series on statistics for college and high school classrooms and adult learners; 26 half-hour video programs and coordinated books
  - Can watch free online (some dated, but good material)
  - http://www.learner.org/resources/series65.html
- ASA Video competition
  - High school student video entries among winners
  - View at http://www.amstat.org/youtube/
  - Consider incorporating videos as student projects
  - Jing www.techsmith.com/jing (free five-minute screen cast software)
- World Statistics Day videos (Census Bureau, world videos) http://unstats.un.org/unsd/wsd/
- Careers in Statistics videos (www.amstat.org/careers)
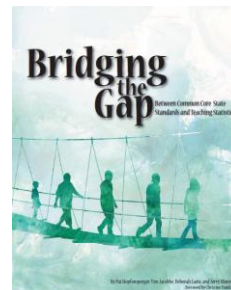
Lesson Resources & Activities

- Statistics Education Web (STEW) – Free online K-12 peer-reviewed lesson plans tied to the Common Core
  - www.amstat.org/education/stew
- Statistics Teacher Network (STN) newsletter (ASA/NCTM Joint Committee)
  - www.amstat.org/education/stn
  - Articles, activities, announcements for K-12 statistics education
- Illuminations
  - http://illuminations.nctm.org/
- AIMS activities
  - http://www.tc.umn.edu/~aims/
  - Great hands-on introductory statistics activities tied to GAISE that can be adapted for Common Core
- SAS Curriculum Pathways
  - http://www.sascurriculumpathways.com/portal/
- Webinars demonstrating activities
  - www.amstat.org/education/k12webiknars

Data Sources

- International Census at School data
  - www.censusatschool.com
  - Also linked from U.S. Census at School at www.amstat.org/censusatschool
- Data and Story Library (DASL)
  - http://lib.stat.cmu.edu/DASL/
- FedStats
  - Statistics available from over 100 federal agencies
  - www.fedstats.gov
- Journal of Statistics Education Data Archive
  - http://www.amstat.org/publications/jse/jse_data_archive.htm
- Data Games project (www.kcptech.com/datagames/)
  - collect data while playing games

Now Available (www.amstat.org/education/btg)

ASA and NCTM co-published a series of twenty investigations in statistics and probability for Grades K-8. Each activity cites its connection to specific content and mathematical practice standards in the Common Core State Standards (CCSS) (www.corestandards.com) as well as connections to NCTM's *Principles and Standards in School Mathematics* (2000). Each of the five major topic areas contains four investigations.

- Section 1 - Looking at Data
- Section 2 - Comparing Groups
- Section 3 - Describing Distributions
- Section 4 - Discovering Quantitative Relationships
- Section 5 - Investigating Probability

The activities are modeled through hands-on and active learning while emphasizing that statistical analysis is a problem-solving investigative process that consists of four components: formulating a question that can be answered with data; designing and implementing a plan to collect appropriate data; analyzing the collected data by graphical and numerical methods; and, interpreting the results of the analysis to reflect light on the original question asked.

ASA K-12 Statistics Education Resources
www.amstat.org/education

- Student Poster and Project Competitions
  - www.amstat.org/education/posterprojects
- GAISE Pre-K – 12 Report (free PDF download)
  - www.amstat.org/education/gaise
- Statistics Teacher Network (STN) newsletter, ASA/NCTM Joint Committee (free)
  - www.amstat.org/education/stn
- Free Statistics Education Webinars
  - http://www.amstat.org/education/webinars
- *Making Sense of Statistical Studies* publication (free lesson and webinar available)
  - http://www.amstat.org/education/msss/
- Statistics Education Publications (some free, including Journal of Statistics Education)
  - http://www.amstat.org/education/publications.cfm
- Other websites useful to teachers
  - www.amstat.org/education, visit the K-12 link
- Information on careers in statistics
  - www.amstat.org/careers
- Statistics Education Web (STEW) – Free online K-12 peer-reviewed lesson plans for
  - www.amstat.org/education/stew
- Free Trial ASA K-12 Membership
  - www.amstat.org/membership/k12teachers/

Meeting Within a Meeting Statistics Workshop for K-12 Mathematics and Science Teachers

- San Diego, California, July 31 - August 1, 2012
- Held in conjunction with the Joint Statistical Meetings (JSM)
- Enhance K–12 educators' understanding of statistics and provide interactive activities to strengthen teaching of statistics within the math and science curriculum.
- Teachers will apply concepts in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K–12 Curriculum Framework* (www.amstat.org/education/gaise) and the Common Core State Standards by exploring problems that require them to collect, organize, analyze, and draw conclusions from data.
- Visit www.amstat.org/education/mwm for more information and to register online.
- Optional graduate credit and limited lodging reimbursement available
- Beyond AP Statistics Workshop , San Diego, August 1, 2012 (www.amstat.org/education/baps)

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Stop by ASA booth 1135 in the Exhibit Hall to
receive additional information on free K-12
statistics education resources or visit
www.amstat.org/education