Quantitative Literacy Should not be Optional: Implications for Statistics Educators and for IASE

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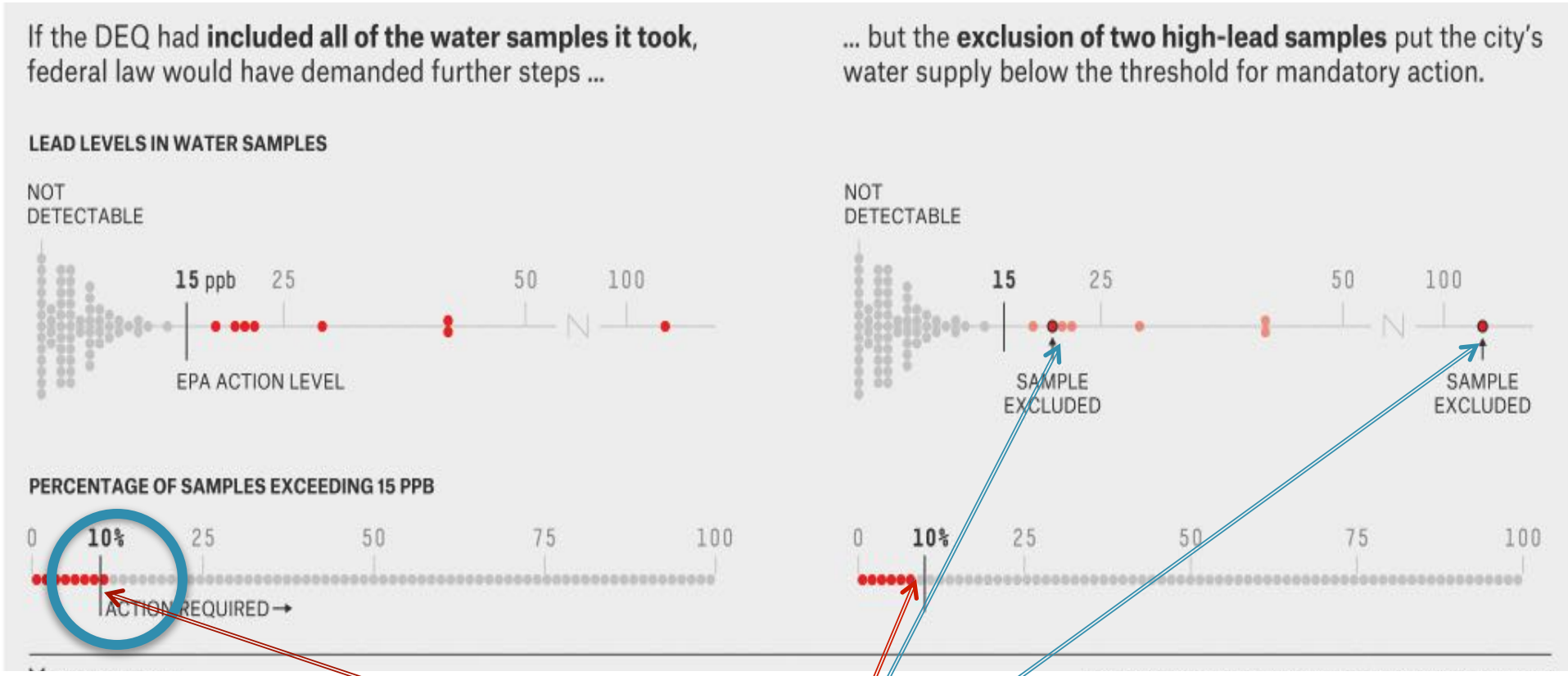
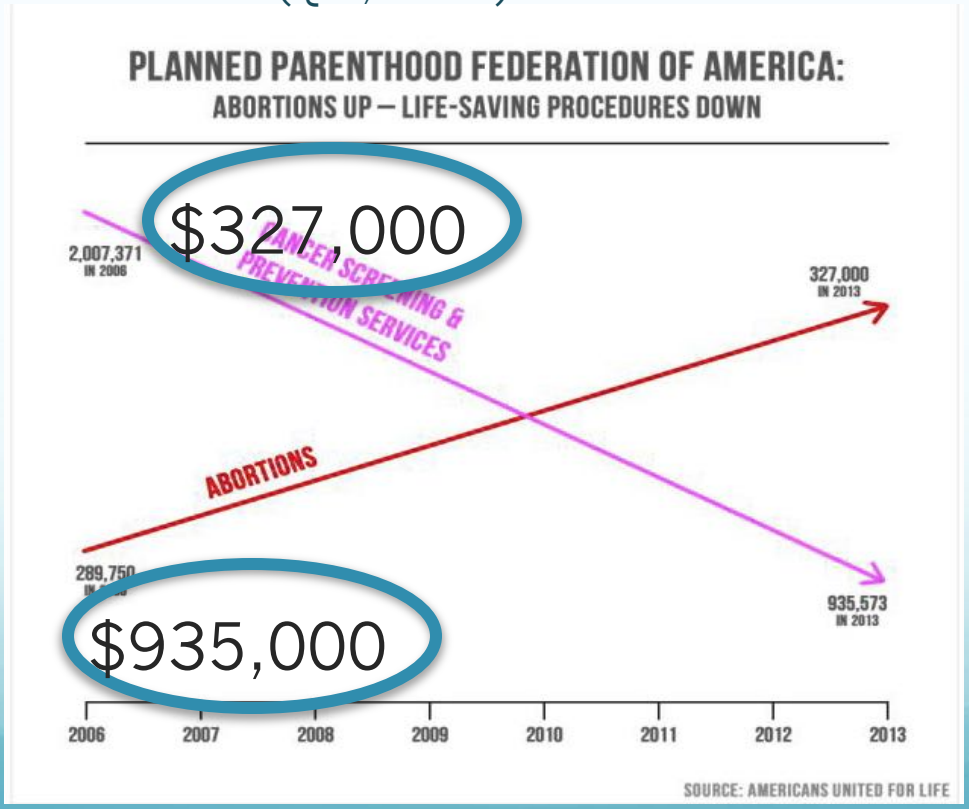
Understanding variability in the world



Analysis of Flint MI water supply, June 2015.
Source: Barry-Jester, A. (2016).

When do outliers matter?

At a hearing on Sept. 29, 2013 Republicans in Congress grilled the president of Planned Parenthood accusing her of misusing the organization's $500 million in annual federal funding. To drive home the point, Rep. Jason Chaffetz of Utah pulled out the chart (Qiu, 2015):



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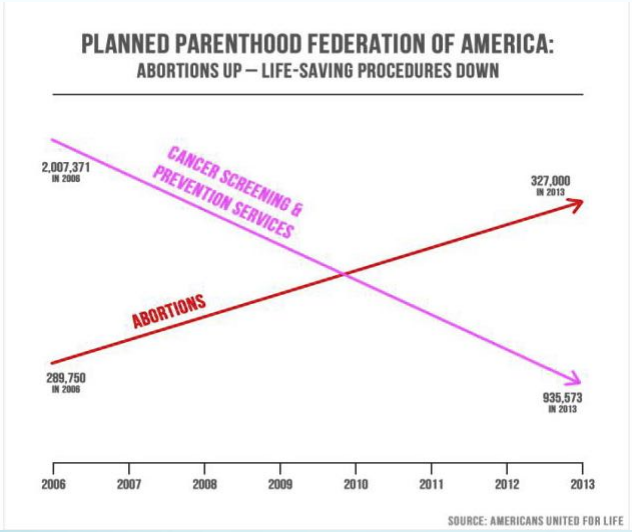
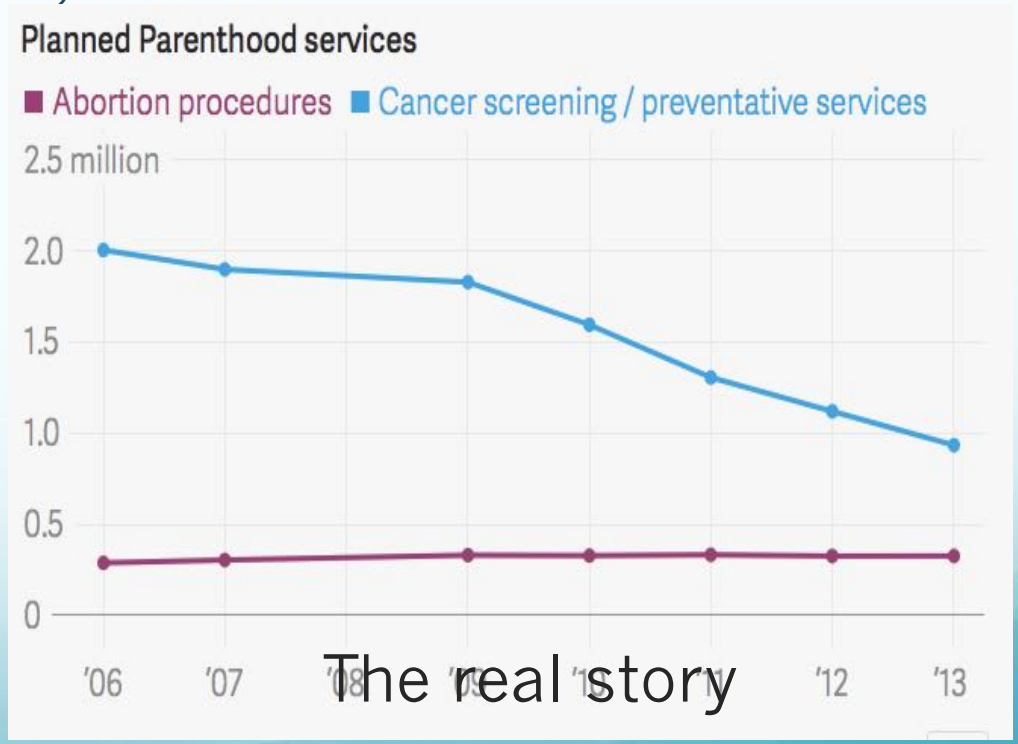




The real story

Statistical Literacy (reasoning, thinking- Schaeffer, Garfield, et al); Quantitative Reasoning (literacy, fluency, numeracy and data fluency- Steen, Gal); Data Science (De Veaux; Vehkalahti)

Decision Making Based on Data:

Decision Making can become a complex process, but giving people the right tools can help them successfully move through that process.

Being numerically and statistically – data – literate

is more important than ever in our world awash with data; for

- Managing and processing information related to nearly every profession and career
- Making sense of the world
- Making personal decisions about life style and life choices

In my work as an educator

Our scores are improving!

But so are the gaps

Michigan NAEP grade 8 scores

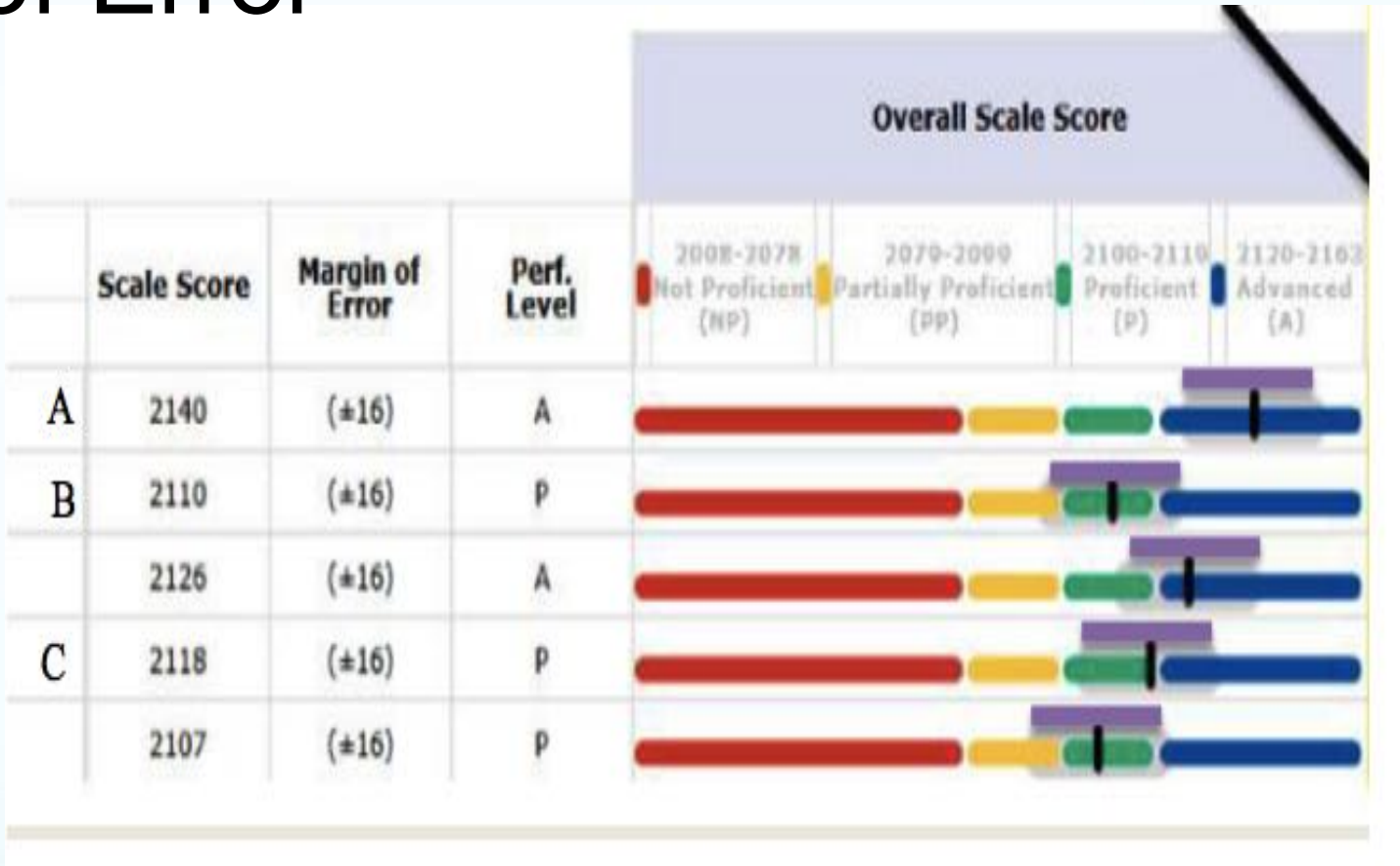
Year	Average scale score
2017	280
2015	278
2013	280
2011	280
2009	278
2007	277
2005	277
2003	278
2000	273
2000[1]	270
1996[1]	272
1992[1]	268
1990[1]	264

Year	Average scale score	Standard deviation
2017	280	39
2015	278	36
2013	280	36
2011	280	35
2009	278	36
2007	277	36
2005	277	36
2003	278	36
2000	273	38
2000[1]	270	37
1996[1]	272	36
1992[1]	268	36
1990[1]	264	34

NAEP Data Explorer

Margin of Error

What should you wonder /worry about?

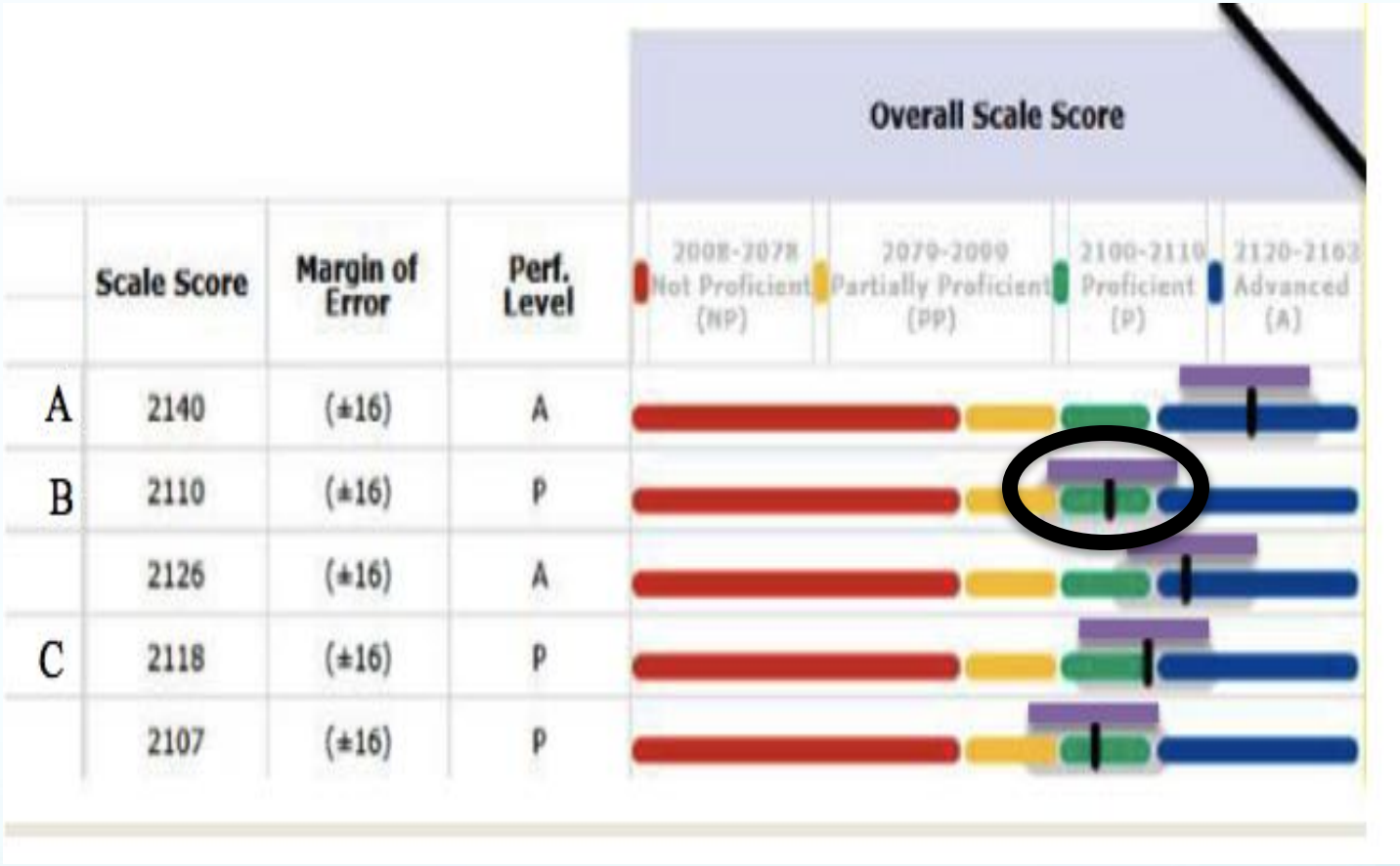


	Scale Score	Margin of Error	Perf. Level
A	2140	(±16)	A
B	2110	(±16)	P
	2126	(±16)	A
C	2118	(±16)	P
	2107	(±16)	P

Margin of Error— "The margin of error around the student score is an estimate of the range or scores one would expect if the same student was to be measured repeatedly with parallel assessments." (Michigan M-Step Final Reports Webcast 2016)

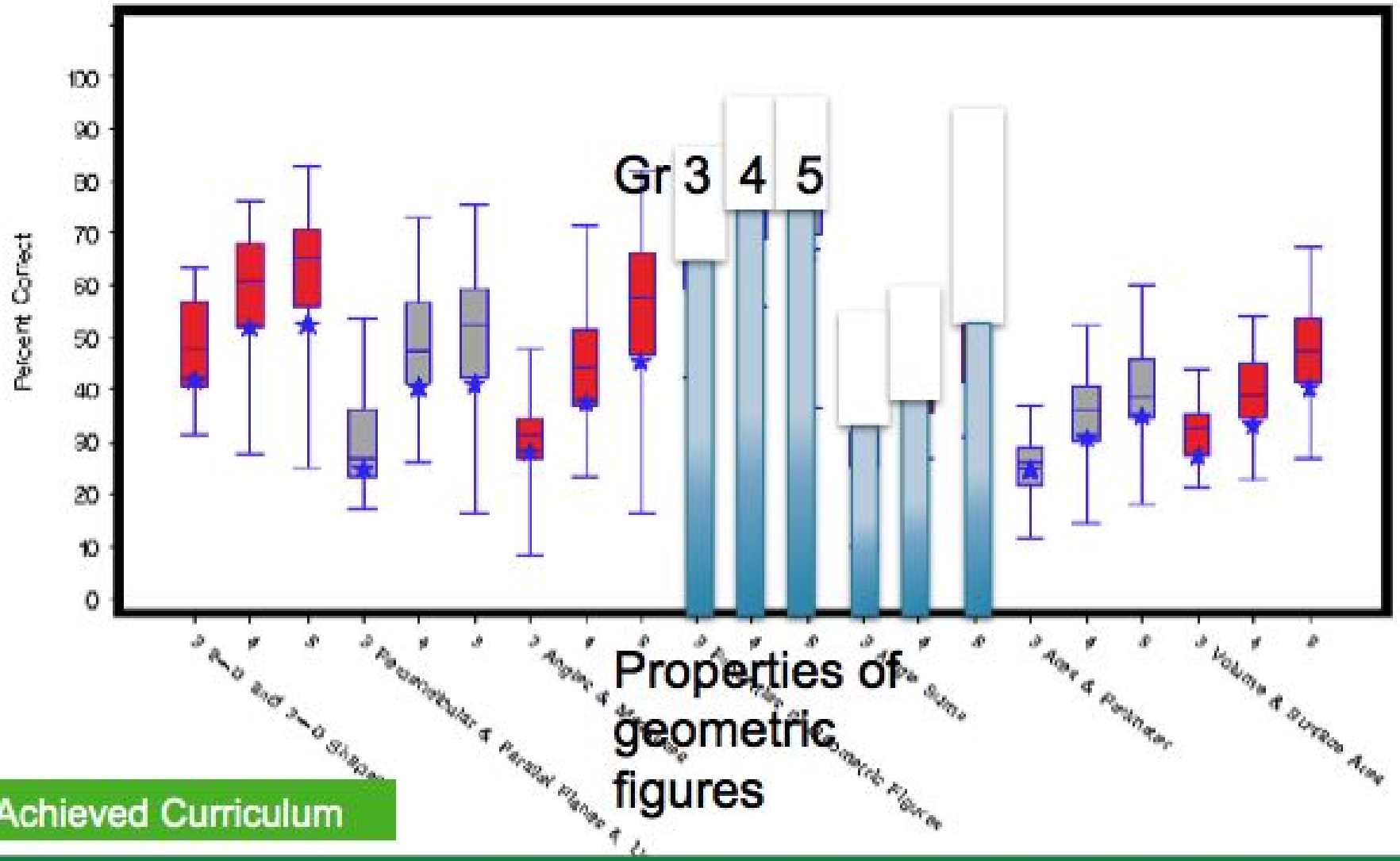
Making decisions about student placement

What do you notice? Wonder?



Margin of Error— "The margin of error around the student score is an estimate of the range or scores one would expect if the same student was to be measured repeatedly with parallel assessments." (Michigan M-Step Final Reports Webcast 2016)

Display 13: Boxplots of Average Percent Correct on Select PROM/SE Elementary Mathematics Strands (Set 3) for All PROM/SE Districts at Each Grade

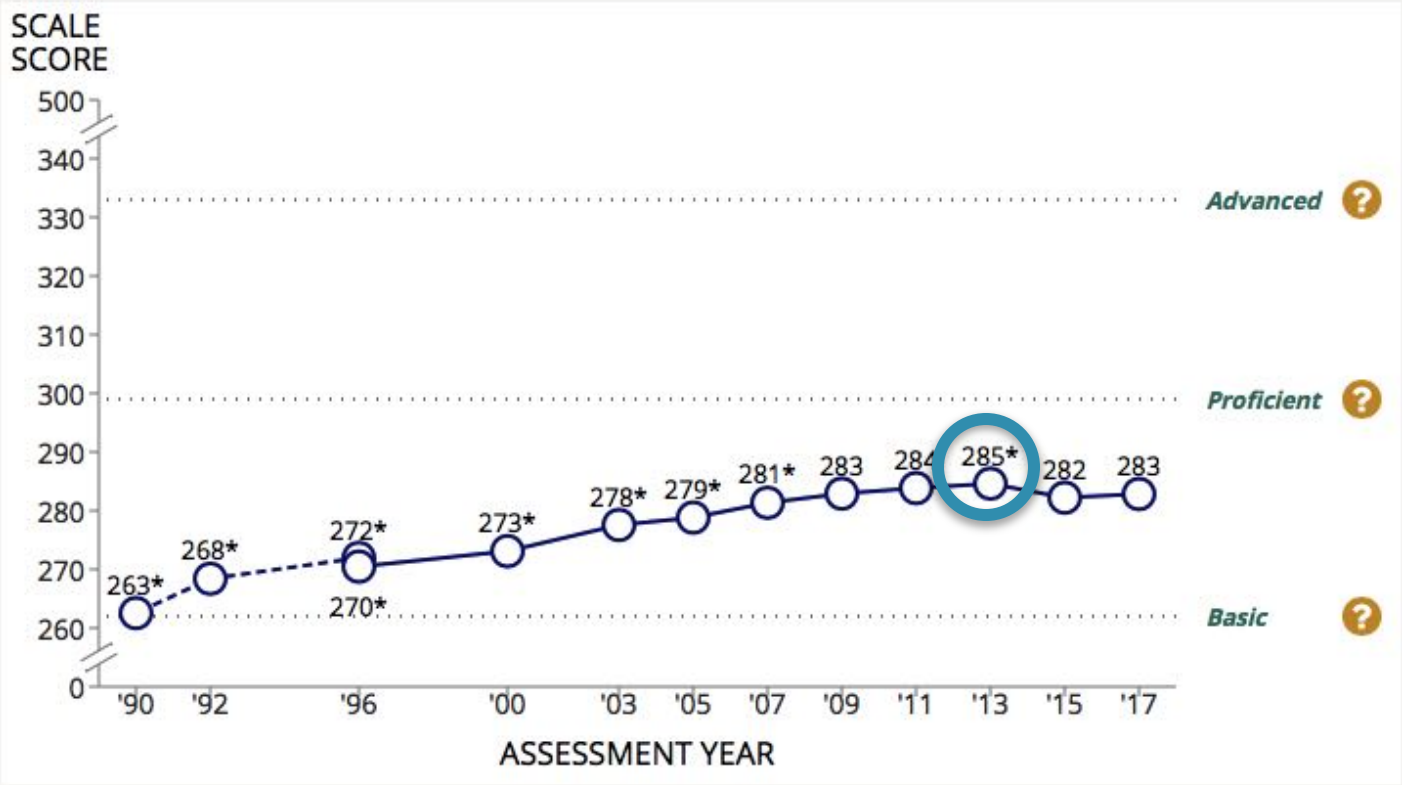


Achieved Curriculum

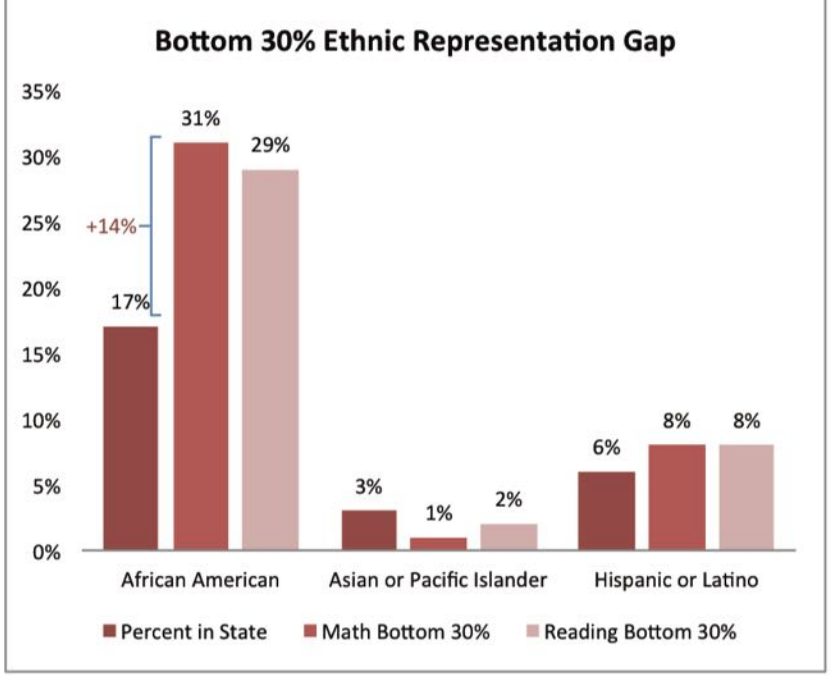
© 2006 MSU PROM/SE Promoting Rigorous Outcomes in Mathematics and Science Education, Supported by NSF Cooperative Agreement EHR-0314866 www.promse.msu.edu

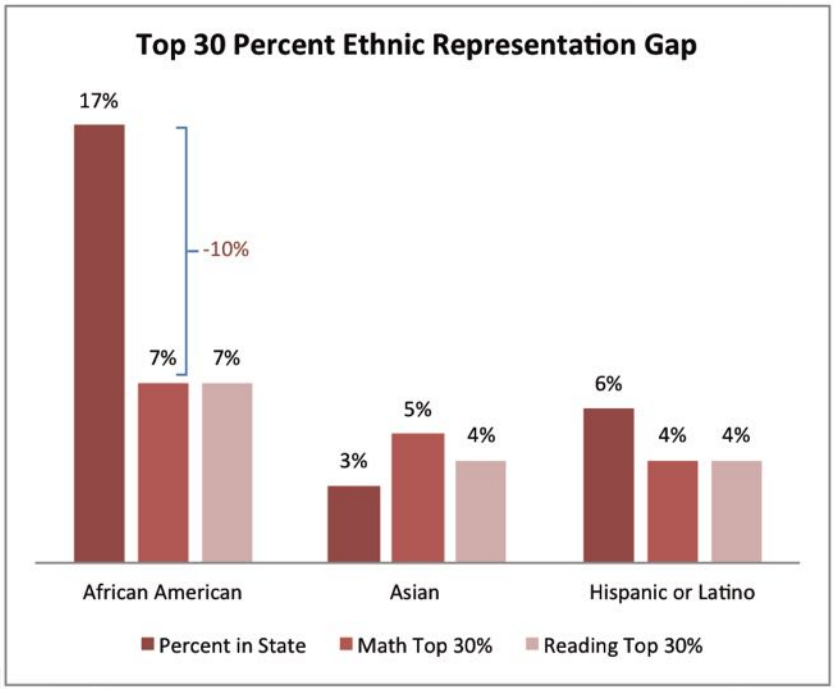
National Assessment of Educational Progress Scores Eighth Grade Mathematics

Trend in eighth-grade NAEP mathematics average scores



* Significantly different ($p < .05$) from 2017.
Accommodations not permitted
Accommodations permitted





1. Ethnic representation of students statewide scoring in the Top 30 Percent in Math and Reading

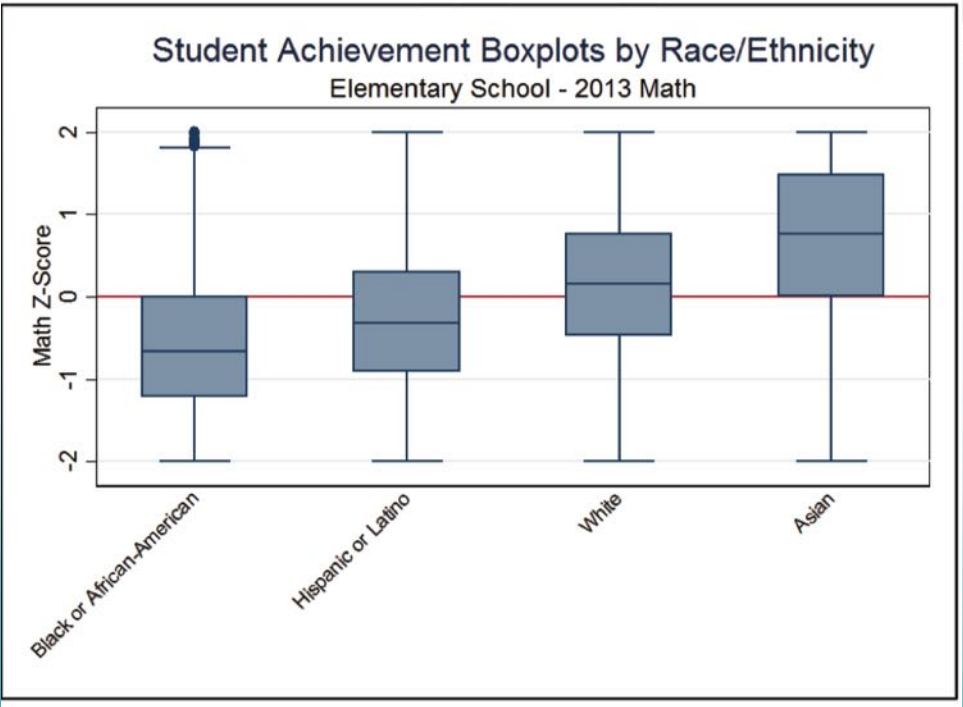
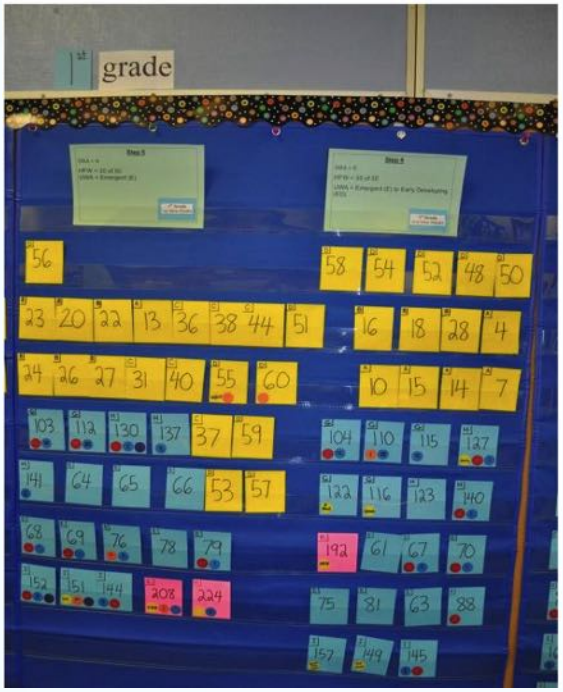


Figure 4. Student achievement box plots by race/ethnicity, elementary school math

Flores, S. (2014). Quantifying the Achievement Gap: Baseline characteristics of African-American Student Achievement in Michigan



Where is the knowledge that is lost in information? TS Eliot

"We are completely data driven"

- "Guidelines for data walls - Connecticut State Department of Education"
- "CSD1 data wall encourages student success"

These decisions or predictions would be easy if the data always sent a clear message, but the message is often obscured by variability. CCSS, 2010

Really?

"Key to college success is eighth grade algebra"

"'Looping' With Students Boosts Learning, Especially for Kids of Color, Study Says (Isevoli, 2018)"

"students who are not reading by the fourth grade most likely will grow up to be essentially non-readers (Lubell, 2017)"

"...students who had taken Algebra II in high school were twice as likely to earn a bachelor's degree as students who had not taken this course but had also enrolled in college (Adelman 2006)."

Quantitative Literacy in the Geosciences

What is the probability of having two hundred year floods in one hundred years?

Quantitative Literacy in the Geosciences

What is the probability of having two hundred year floods in one hundred years?

- "These owners won't sell after the first flood: they think they have another 99 years to go," he said, "But they will sell after the second flood."

- Property owners are resistant because of the cues they get from weather forecasters and governments officials who still employ such terminology as "100 year "floods .Despite its name, a 100 year flood doesn't mean once in a lifetime. Instead it means a level of flooding that has a 1 percent chance of happening in any particular year..' People are not good at understanding probability," Lansing State Journal Feb 18, 2019

Quantitative Literacy in the Geosciences

What is the probability of having one hundred year floods in the next one hundred years?

- Probability of a 100 year flood happening next year is 0.01. probability of a flood **not** happening in the next 100 years is 0.99^{100} or about 0.36
- "There is about a 35% chance that a single 100-year flood will occur in 100 years, an 18% chance that 2 100-year floods will occur, and even a nearly 2% chance that we will get four 100-year events within a given 100 year time period."

Bauer, https://serc.carleton.edu/quantskills/methods/quantlit/floods.html

Quantitative Literacy in the Geosciences

Essential Concepts students struggle with when studying recurrence intervals:

- the concept of a recurrence interval
- the idea that random events that are independent of previous events
- the difference between recurrence intervals and forecasting
- how to calculate recurrence intervals when data have variable magnitudes and when they don't.

Bauer, https://serc.carleton.edu/quantskills/methods/quantlit/floods.html

Quantitative literacy in the Geosciences

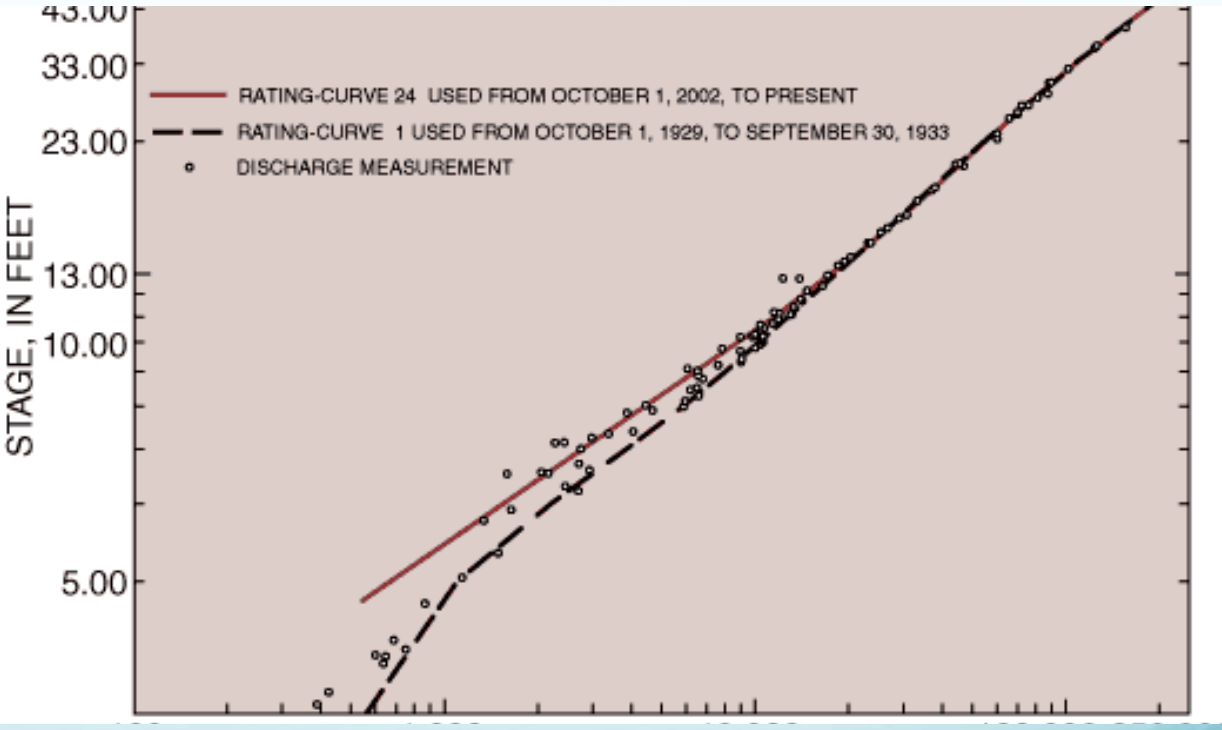
What is meant by "random"? Random events have a probability of occurring that do not depend on the past. While this may not always be true, for many geologic events this is a robust model. Students

- misunderstand random events
- Think events are "due," usually when the time without an event exceeds the recurrence interval.
- think that because an event has occurred recently it cannot happen again.
- See random events as truly random; many people are convinced that streaks exist ("the dice are hot so I should keep going") or in luck ("I have lost the last 10 times, so my luck HAS to change.")

Bauer, https://serc.carleton.edu/quantskills/methods/quantlit/floods.html

Measuring and plotting discharge

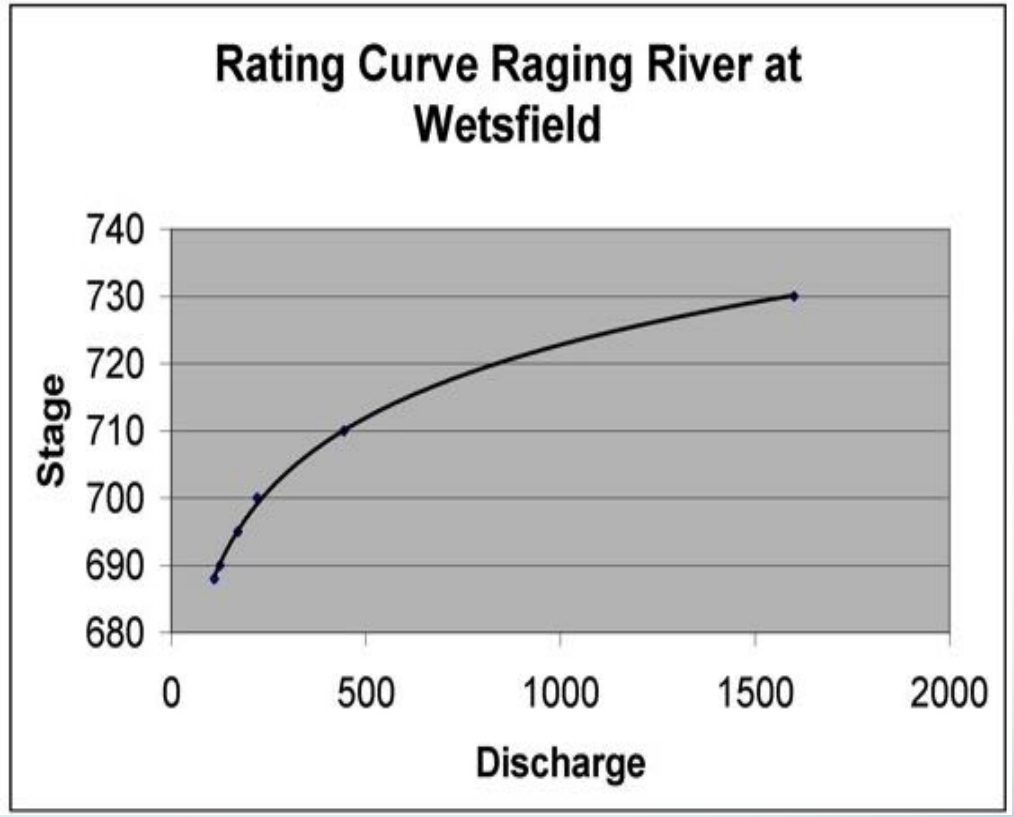
Mercer Creek – Data Set 1				Mercer Creek – Data Set 2			
Year	Peak Flood Discharge	Rank (1 = greatest)	Recurrence interval	Year	Peak Flood Discharge	Rank (1 = greatest)	Recurrence Interval
1957	180			1979	518		
1958	238			1980	414		
1959	220			1981	670		
1960	210			1982	612		
1961	192			1983	404		
1962	168			1984	353		
1963	150			1985	832		
1964	224			1986	504		
1965	193			1987	331		
1966	187			1988	228		
1967	254			1989	664		
Green River – Data Set 1				**Green River – Data Set 2**			
Year	Peak Flood Discharge	Rank (1 = greatest)	Recurrence interval	Year	Peak Flood Discharge	Rank(1 = greatest)	Recurrence Interval
1941	9310			1976	4490		
1942	10900			1977	9920		
1943	12900			1978	6450		
1944	13600			1979	8730		
1945	12800			1980	5200		
1946	22000			1981	9300		
1947	9990			1982	10800		
1948	6420			1983	9140		
1949	9810			1984	10900		
1950	11800			1985	7030		
1951	18400			1986	11800		



Bauer, https://serc.carleton.edu/quantskills/methods/quantlit/floods.html

Forecasting Inundations

Year	discharge		ranking
2004	134	3	5.66666
2003	119	8	2.125
2002	118	9	1.88888
2001	137	2	8.5
2000	111	14	1.214286
1999	125	5	3.4
1998	114	12	1.416667
1997	111	15	1.133333
1996	171	1	17
1995	117	10	1.7
1994	130	4	4.25
1993	121	7	2.428571
1992	123	6	2.833333
1991	115	11	1.545455
1990	112	13	1.307692
1989	110	16	1.0625



Bauer, https://serc.carleton.edu/quantskills/methods/quantlit/floods.html

Quantitative literacy in Medicine

- The first problem that doctors (and thus, patients) face is a basic misunderstanding of probability. Say that Disease X has a prevalence of 1 in 1,000 (meaning that 1 out of every 1,000 people will have it), and the test to detect it has a false-positive rate of 5 percent (meaning 5 of every 100 subjects test positive for the ailment even though they don't really have it). If a patient's test result comes back positive, what are the chances that she actually has the disease? In a 2014 study, researchers found that almost half of doctors surveyed said patients who tested positive had a 95 percent chance of having Disease X. (Morgan, Washington Post, Oct 2018)

Quantitative literacy in Medicine

- In one study, gynecologists estimated that a woman whose mammogram was positive had a higher than 80 percent chance of having breast cancer; the reality is that her chance is less than 10 percent.
- Researchers found after a battery of exams, about 5 of every 1,000 women will have a false-positive result and told they have breast cancer when they do not.
- Nearly 90 percent of the patients received at least one unnecessary test and that, overall, nearly one-third of all the tests were superfluous.
- Nearly 80 percent of our subjects [doctors] overestimated the benefits. (Morgan, Washington Post, Oct 2018)

Quantitative Literacy in Economics

TABLE 6
OLS Results for the difference in correct answers on the pre and post surveys

Variable	coefficient	tstat
Constant	2.168	2.855*
BUSINESS	–2.128	–3.130*
OTHER	–1.499	–2.203**
HSECON	0.079	0.371
MACRO	–0.155	–0.390
MAC HAD MIC	–0.837	–2.450**
MIC HAD MAC	0.033	0.074
MIC HAD SUR	1.914	1.256
MAC HAD MIC AND SURVEY	–1.403	–1.212
TMATHDIFF	0.254	3.851*
MWC	0.994	2.357**
UNCW	0.252	0.543
UN	0.697	1.451
RSURV	0.152	0.531
R^2	0.136	

*, **, *** indicates significance at the 1, 5, and 10% levels, respectively.

and whether or not students had taken high school calculus were also estimated. Consistent with previous research, we anticipated positive coefficient estimates for these variables; however, these variables were not significant when TMATHPRE and TMATHPOST were included in the pre and post course models, respectively. In the pre course model, the coefficient estimates were not significant even *without* the TMATHPRE variable. In the post course model, only the high school calculus variable was significant *without* the inclusion of the TMATHPOST variable. In addition, these variables did not impact economic learning.

VIII. Conclusions

Using a survey administered on the first and last days of principles of economics courses at four U.S. universities, the current study set out to determine the important influences on economic literacy and economic learning, measured, respectively, as the number of correct responses on a 10 question economics questionnaire and the difference in the number of correct economics responses on the first day and the last day of class.

Generally, students do not fare well on simple quantitative questions and hence do not possess an adequate working knowledge of the "language" we often speak during our economics courses. Our analysis shows, however, that quantitative literacy is a very important determinant of economic literacy in both the pre and post course surveys. More specifically, we have shown that having skills such as being able to solve a system of equations and compute a percentage, and being able to interpret increases and decreases on a graph will lead to higher economic knowledge at the end of the semester.

We also find that high school economics courses and high school and college math courses do not significantly impact economic literacy or learning. Interestingly, although students who had already taken microeconomics did significantly better on both the pre and post-course economics questions compared to students entering their first microeconomics course (as might be expected), students in the first microeconomics course learned more economics than did students who were in macroeconomics and had already taken microeconomics.

While math literacy improves during an economics principles course, students still performed poorly on quantitative questions at the end of the semester. This is unfortunate; as our paper also shows that quantitative improvement leads to more economic learning. Hence it would seem that in order for students to learn more during economics courses, they need a stronger set of math skills. Moreover, those who teach economics principles should not assume that students have already mastered basic math skills. Indeed, time spent addressing these shortcomings as needed during the course of the semester could prove quite effective in improving economic learning. Providing economics students with a basic math primer or allowing for more in-depth review of basic math concepts and skills, while taking away from the amount of time directly spent on economics content could serve to enhance the amount of economics learning that takes place.

Appendix

Mathematics Questions

1. Solve this system of equations:

$$3x + y = 15$$
$$-x + 2y = 2$$

a. x = 5, y = 5
b. x = 4, y = 3
c. x = 3, y = 4
d. x = 0, y = 0
e. none of the above

2. What is 30% of 200?
a. 30 b. 60 c. 90 d. 33 e. none of the above.

3. Consider Figure 1 where US consumption of oil and US imports of oil are plotted for 1991–2000. Which of the following is true?
a. U.S. domestic oil consumption has been steady while imports have been rising therefore US domestic oil production has been rising.
b. U.S. domestic oil consumption has been steady while imports have been falling therefore US domestic oil production has been falling.
c. U.S. domestic oil consumption has been steady while imports have been rising therefore US domestic oil production has been falling.
d. U.S. domestic oil consumption has been steady while imports have been falling therefore US domestic oil production has been rising.

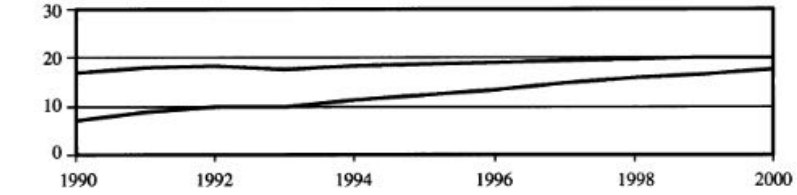


FIGURE 1. US Consumption (top) and Imports (bottom) of Oil, 1990–2000.

4. Refer to the following table.

Economic Growth in Poland, 1990–1994 (percent)

	1990	1991	1992	1993	1994
GDP growth rate	–11.7%	–7.8%	–1.5%	4.0%	3.5%

Which of the following are TRUE?
a. Polish GDP was larger in 1992 than in 1991.
b. Polish GDP was larger in 1994 than in 1993.
c. Polish GDP was larger in 1991 than in 1992.
d. Polish GDP was larger in 1993 than in 1994.
e. b & c are true

5. If U.S. production of corn was 60 million bushels in 1998 and 100 million bushels in 1999, what was the percentage change in corn production from 1998 to 1999?
a. 40% b. 60% c. 66.67% d. 100% e. 200%

6. Which of the following is the correct formula for the following relationship between the price of a good (P) and the quantity that is demanded (Q) shown in Figure 2 below?
a. Q = 10 + 5P
b. Q = 5 + 1P
c. Q = 10 – 1P
d. Q = 10 – 5P
e. None of the above

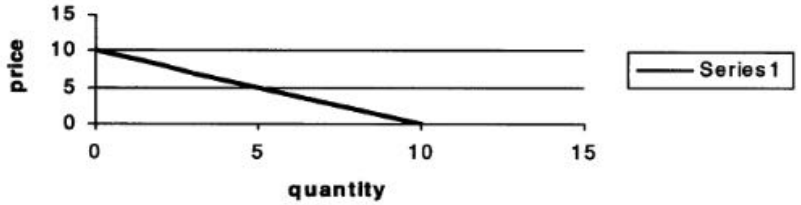


FIGURE 2.

(Schuhmann, et al, 2005)

7. Given the relationship in Figure 3 between x and y, which of the following are true?

a. The solid line has larger x values for given values of y than the dashed line.

b. The solid line has smaller x values for given values of y than the dashed line.

c. The dashed line has smaller y values for given values of x than the solid line.

d. The dashed line has larger y values for given values of x than the solid line.

e. Both b and c

f. Both c and d

8. Referring to figure 3 below, the slope of the line shown is:

a. 1 b. –1 c. 2 d. –2 e. 1/2

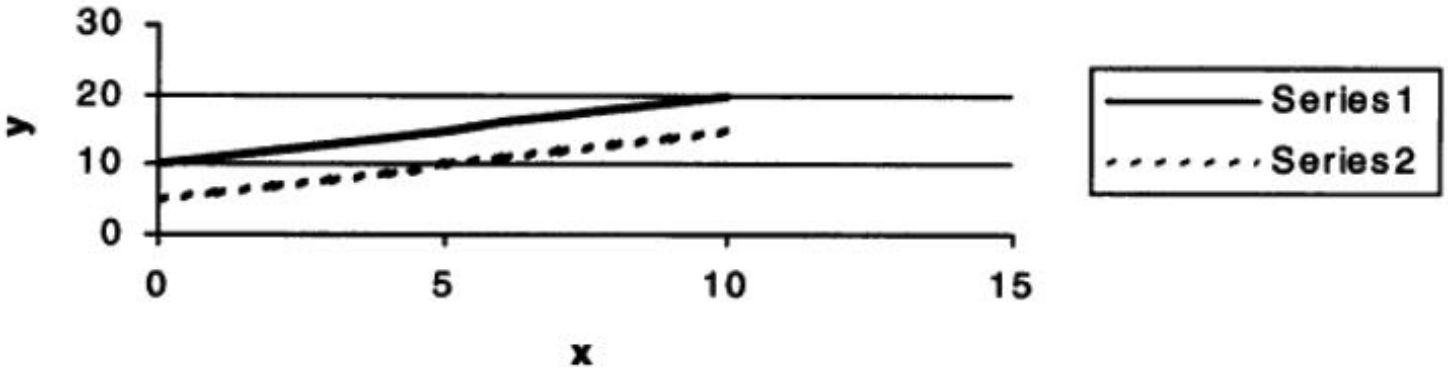


FIGURE 3.

8. Referring to Figure 4 below, the slope of the line shown is:

a. 1 b. –1 c. 2 d. –2 e. 1/2

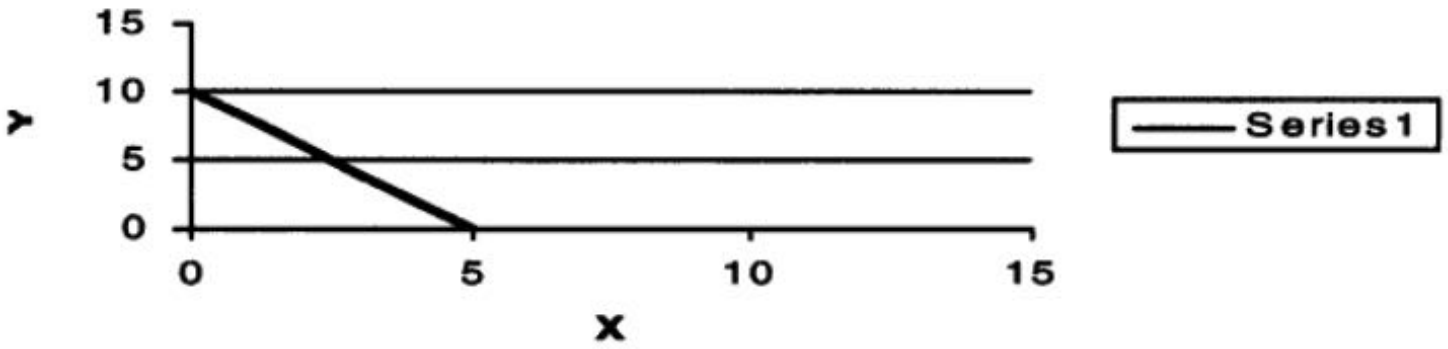


FIGURE 4.

(Schuhmann, et al, 2005)

TABLE 2

Percent of students giving correct answers on math and economics questions.

	Percent of Students with Correct Answer		
Math Questions (n = 344)	*Pre*	*Post*	*Z-stat*
1: solving a system of equations	0.814	0.834	0.701
2: computing a simple percentage	0.936	0.892	–2.042**
3: reading increases and decreases on a graph	0.640	0.666	0.721
4: interpreting meaning of a percentage change	0.244	0.273	0.871
5: calculating percentage change, word problem	0.404	0.419	0.387
6: determining slope and intercept	0.363	0.448	2.252**
7: distinguishing differences across two graphs	0.276	0.308	0.922
8: determining slope	0.567	0.616	1.319
Avg. Percent (questions 1–8)	0.531	0.557	0.689
Economics Questions (n = 344)			
Micro	0.317	0.430	3.042*
Macro	0.264	0.313	1.430
Avg. Percent (all econ questions)	0.291	0.372	2.252**

*, **, *** indicates significance at the 1, 5, and 10% levels, respectively.

(Schuhmann, et al, 2005)

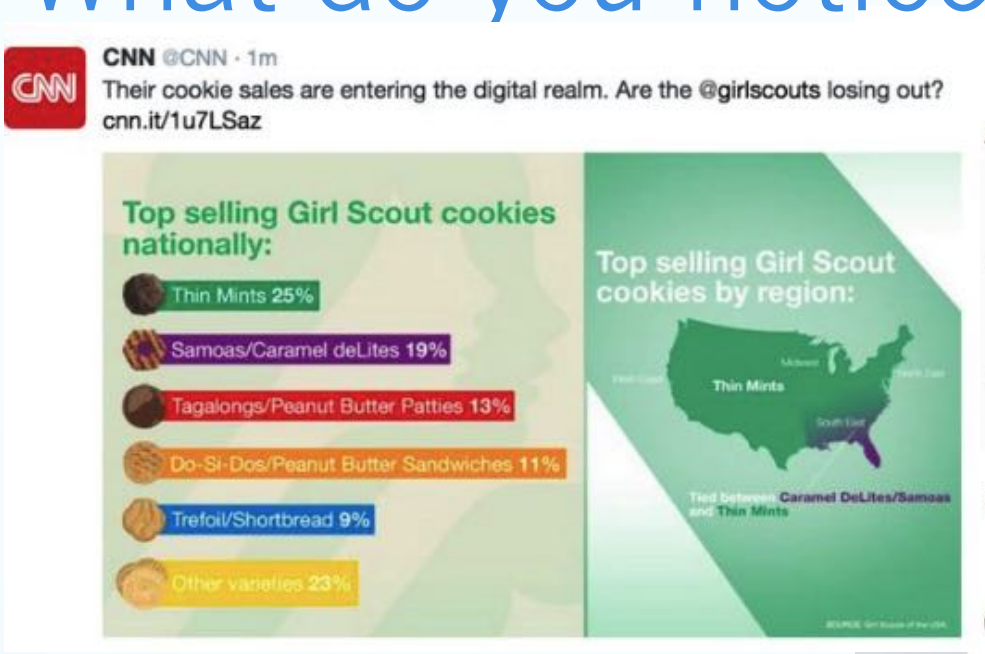
Data Literacy and our World

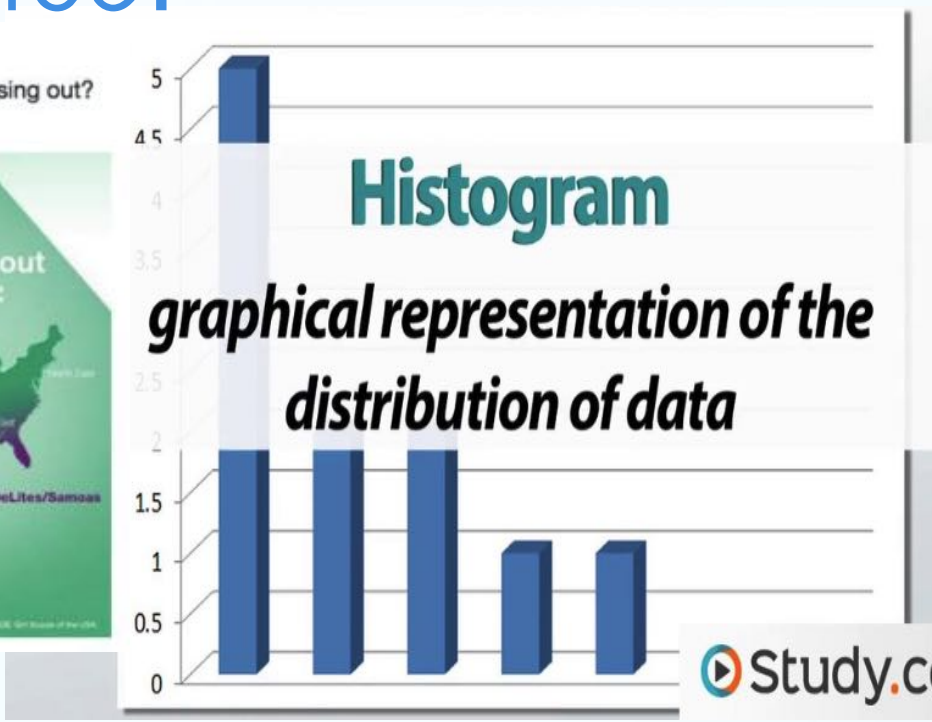
- Making decisions: “An enlightened citizenry that is empowered to study evidence-based facts and that has the capacity to manage, analyze and think critically about data is the best remedy for a world that is guided by fake news or oblivious towards facts.” (Engle, 2017)

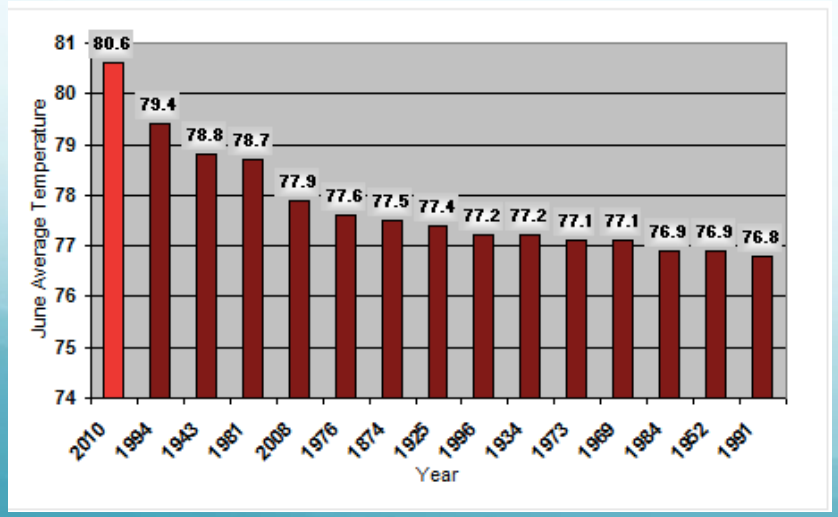
The media

- “The average salary is £24,000, but most people earn less.”
- “Productivity in the UK is below average for the G7 group of leading economies.” “6 out of 7 countries are below average” Blastland
- “The average ACT score is 20. In other words, 20 is the median composite score. …. The ACT scoring scale is designed so that 18 is the average ACT score. A standard deviation on any section is designed to correspond to 6 points.” www.testive.com/average-act-score/

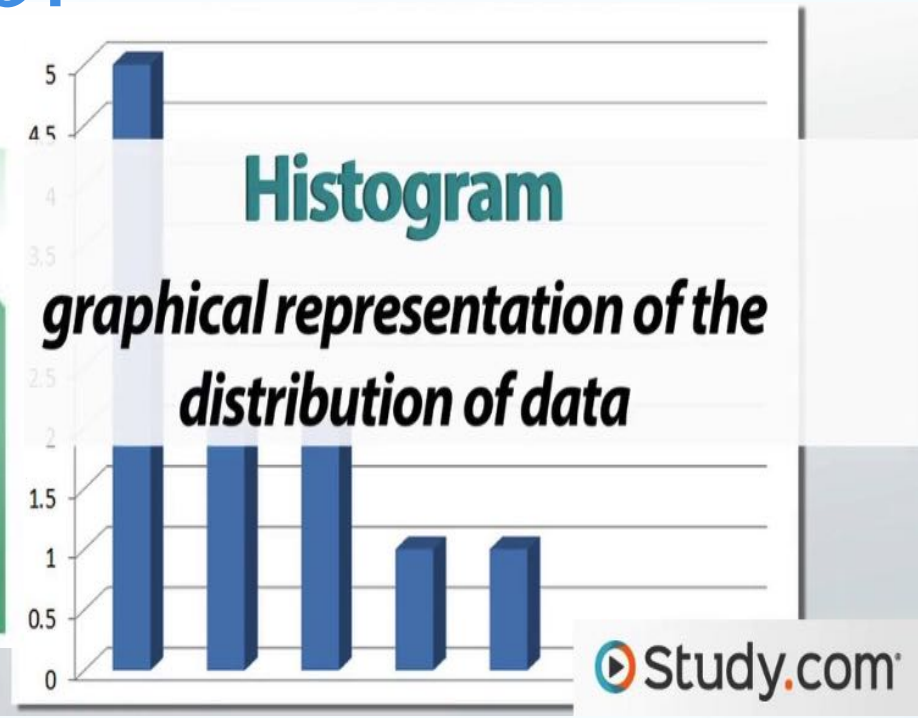
What do you notice?



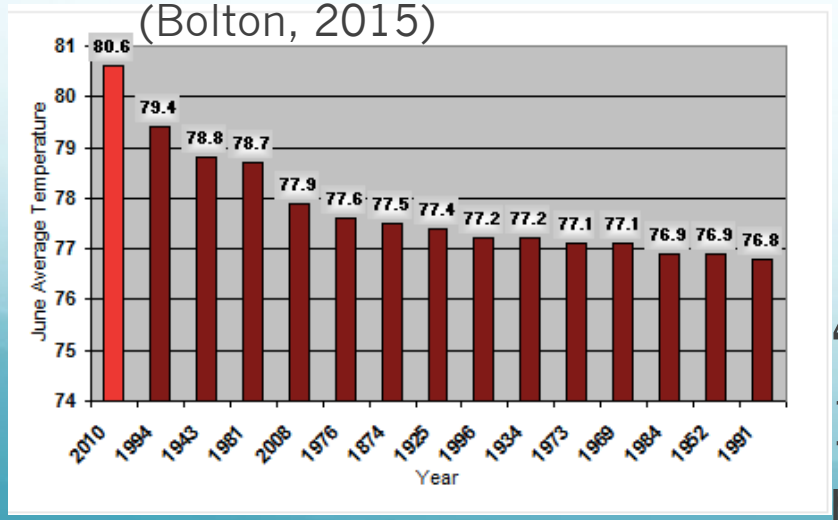




What do you notice?

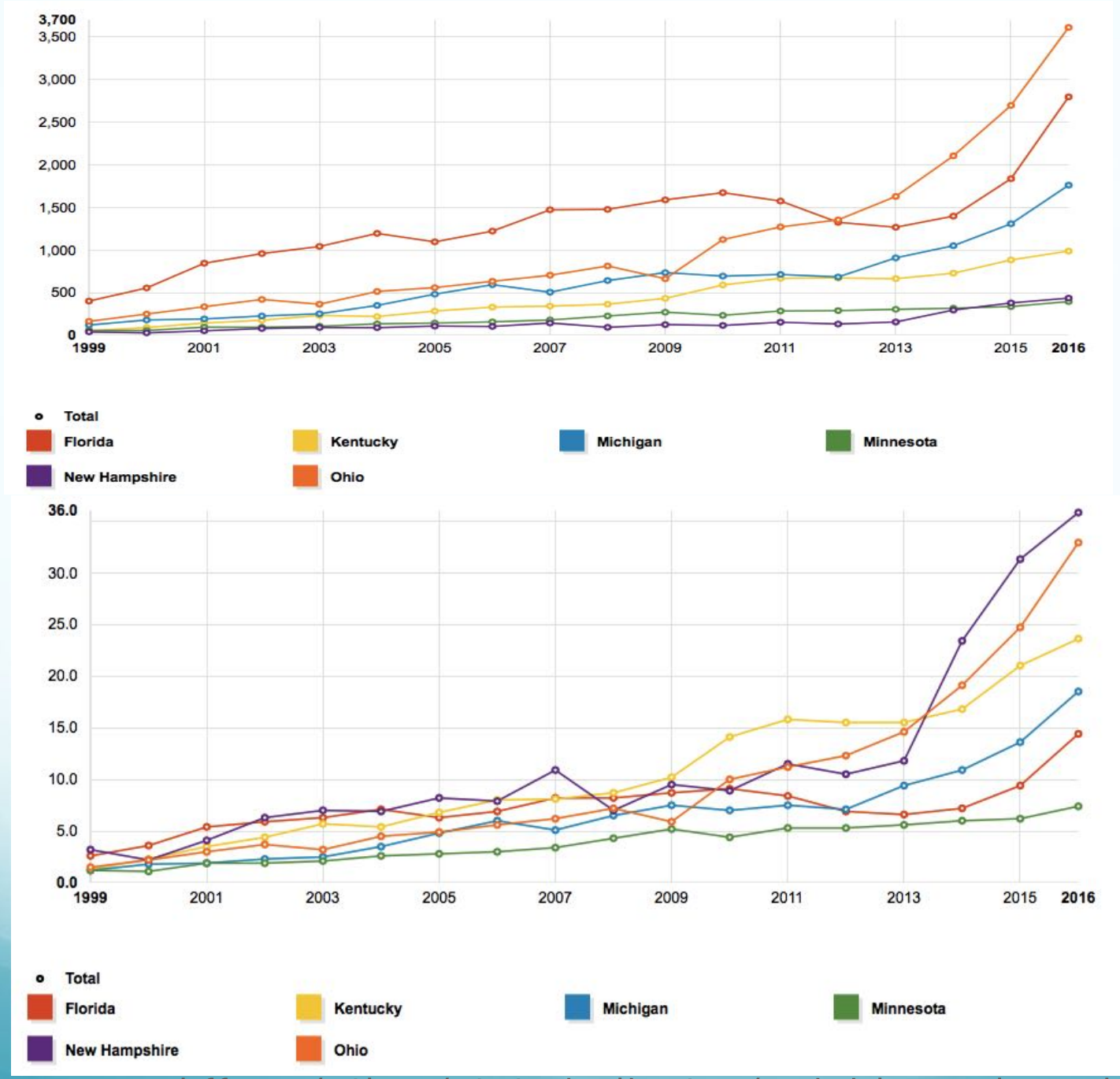


A bar graph?
(Bolton, 2015)



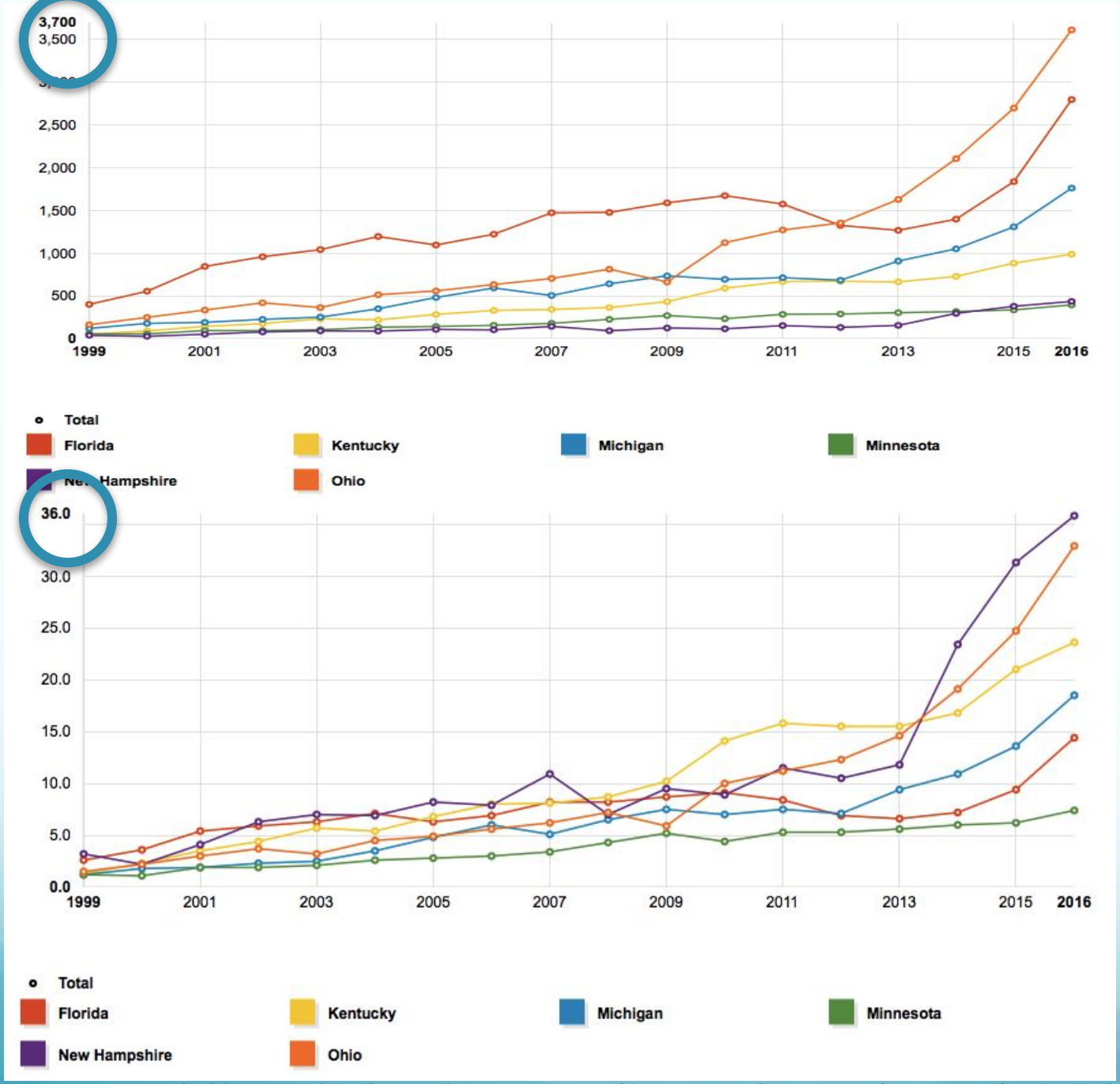
Would you buy software from this company?

"Warmest Junes since 1871 set new record" (Sides, 2010)



Opioid deaths in some US states -- What do you wonder?

www.kff.org/other/state-indicator/opioid-overdose-deaths/?



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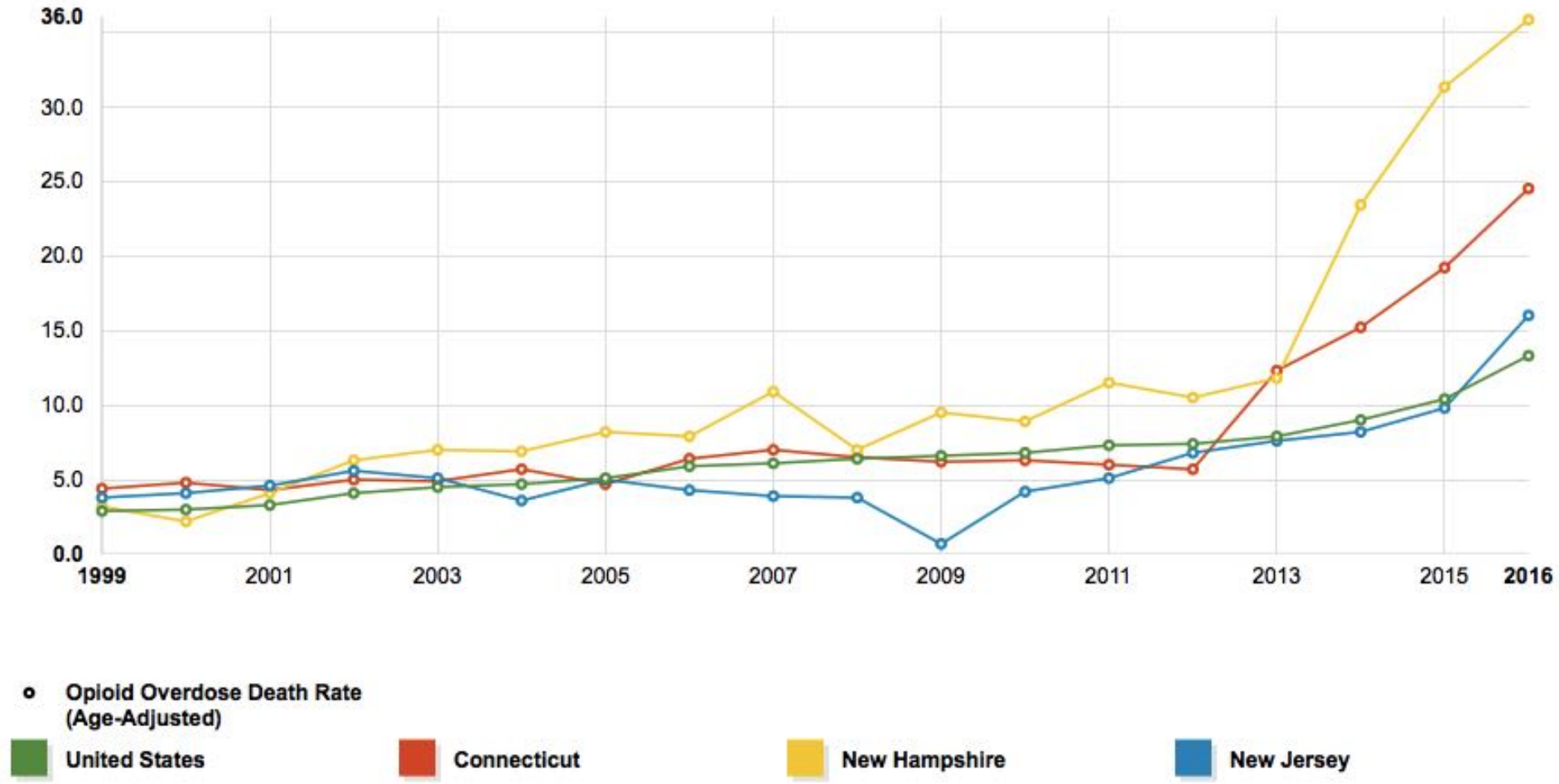
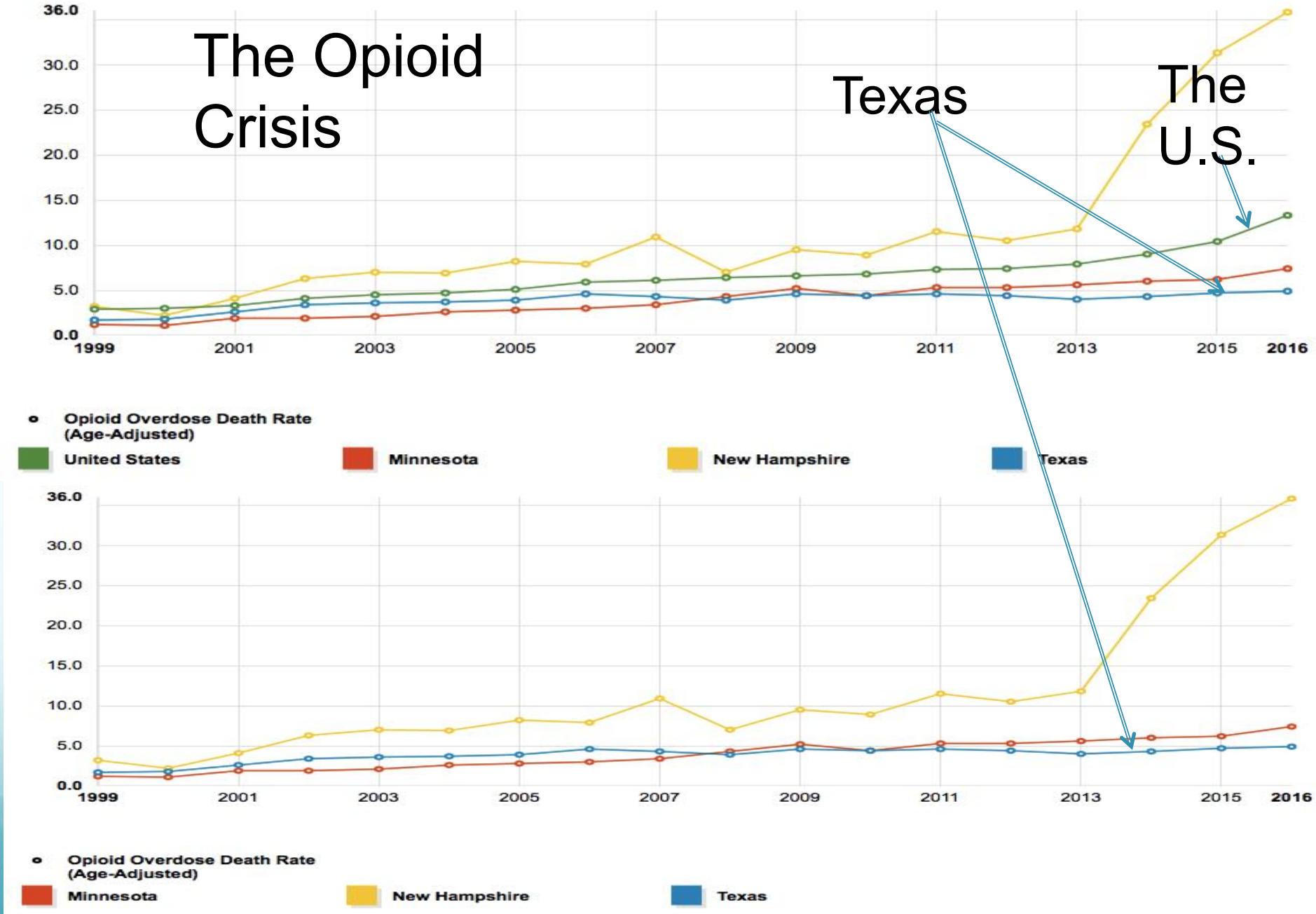
Opioid overdoses



www.kff.org/other/state-indicator/opioid-overdose-deaths/?

The Opioid Crisis



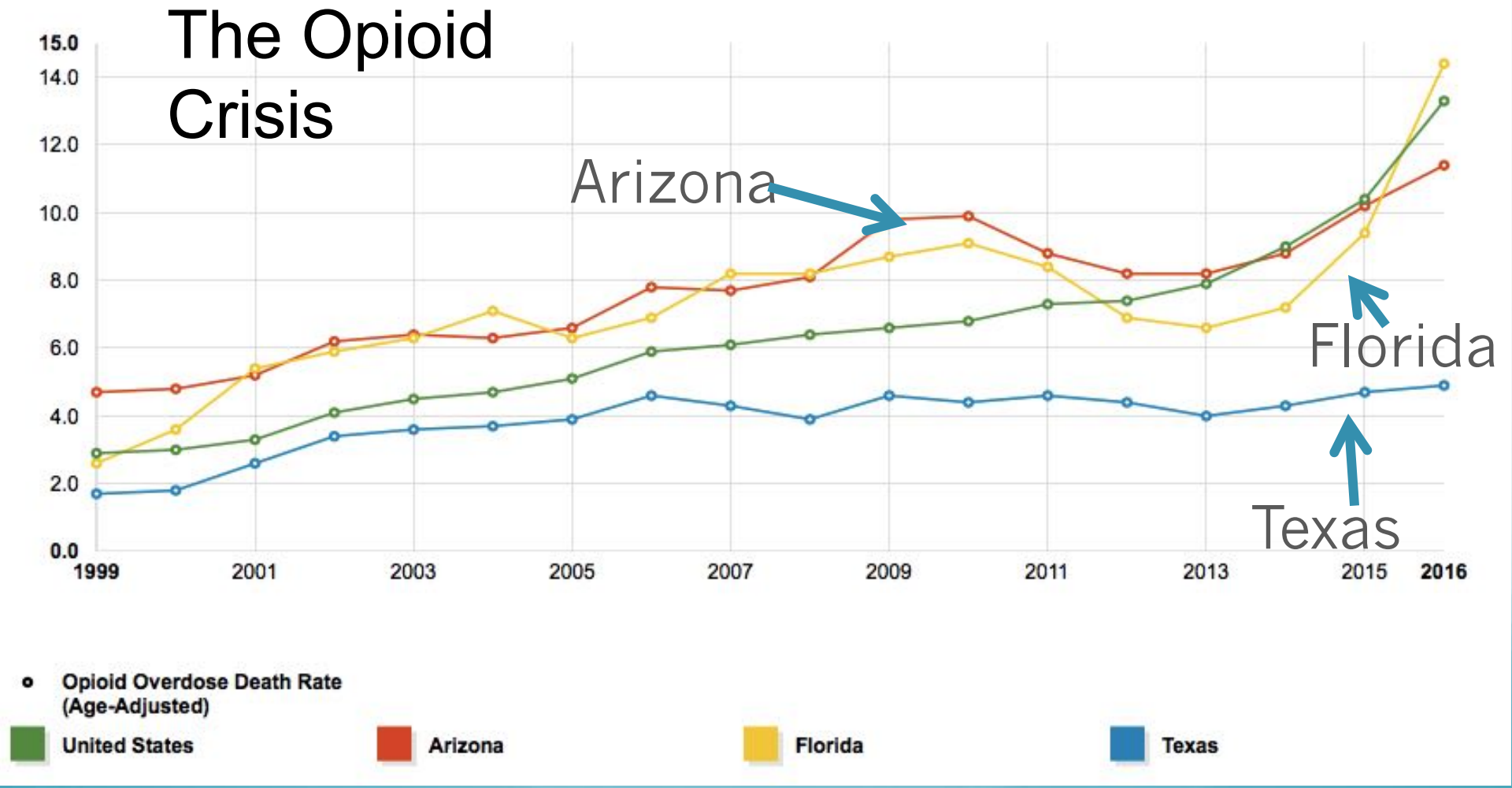
Making sense of the world

- Why so few opioid deaths in Texas?

Making sense of the world

- Why so few opioid deaths in Texas?
- "..... the climate is a possible factor, believe it or not. Arthritis is a much bigger problem in colder places, so it may be that weather has a role to play in the disparity."
- "Traditionally, for whatever reason, the opioid crisis has not affected the Hispanic populations as much. (The CDC estimates whites are four times more likely to die from a drug overdose compared to Hispanics,..."
- https://www.houstonchronicle.com/news/houston-texas/houston/article/Prescription-drug-deaths-in-Texas-vastly-6222850.php

Why so few deaths in Texas?



Making sense of the world

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- "Many Texas counties, even populous suburban ones like Fort Bend, have no medical examiner. In those places, the cause of death is determined by about 860 justices of the peace who also sign death certificates, and their opinions can vary widely." https://www.chron.com/local/prognosis/article/Texas-dishes-out-fewer-opioids-than-most-states-11271151.php

MMR vaccine causes dangerous health effects from autism to death

(The Wor for Natural Health)

The measles shots are safe.

The measles shots are very safe and are effectiv Vaccines, like any medicine, can have side effects. These are usu their own.

Measles on a Comeback

Measles was eliminated from the U.S. in 2000. But

Measles outbreak: Global measles cases triple in one yea UK parents warned

There is no link between the MMR shot and au

Scientists in the United States ar shot. None has found a link bet

A second reason that some people think MMR vaccine may cause autism stems from a 1998 study published in the Lancet in the United Kingdom. One of the authors claimed that MMR vaccine could contribute to the development of autism. This study

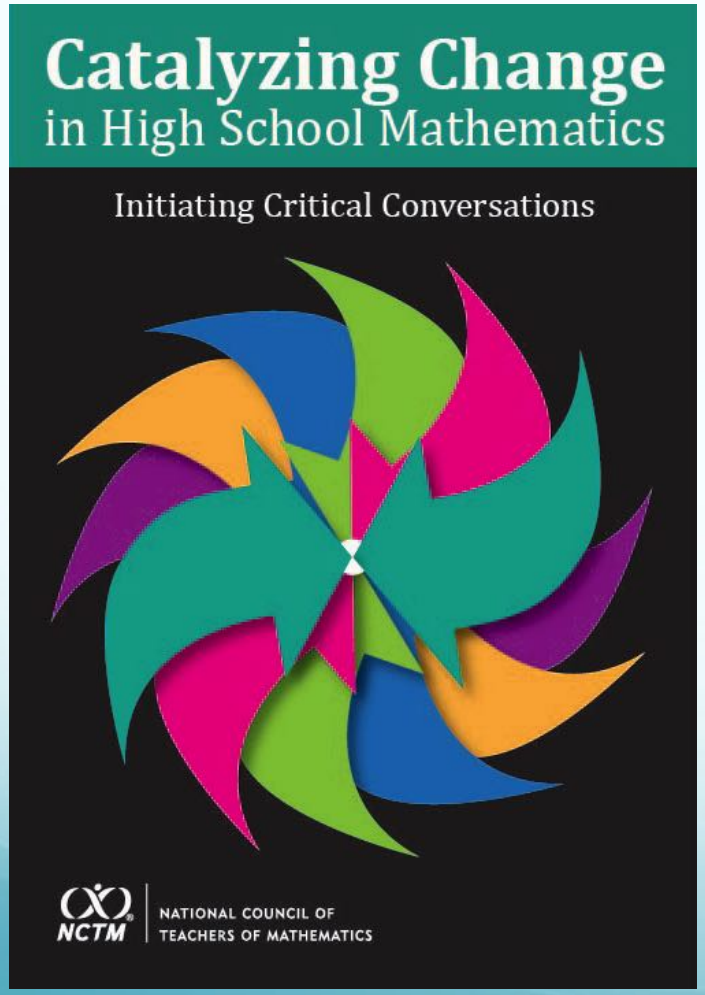
Some vaccines such as, influenza and Hepatitis B vaccines, still con [9], the most neurotoxic element known to science. Studies show a sign thimerosal-containing vaccines and neurodevelopmental disorders including retardation, speech disorders and personality disorders. Scientists Tomljenovic in their study [10]:

Eggertson, 2010

Measles Epidemic: What should you ask?

- Worldwide, the number of reported cases jumped 300% in the first three months of 2019 compared to the same time period in 2018 (Koenig, 2019).
- As of November 30, 2018, there have been more than 93,179 reports of measles vaccine reactions, hospitalizations, injuries and deaths made to the federal Vaccine Adverse Events Reporting System, including 459 related deaths, 6,936 hospitalizations, and 1,748 related disabilities. Over 50% of those adverse events occurred in children three years old and under. However, the numbers of vaccine-related injuries and deaths reported may not reflect the true number of serious health problems that occur develop after MMR vaccination. (National Vaccine Information Center)

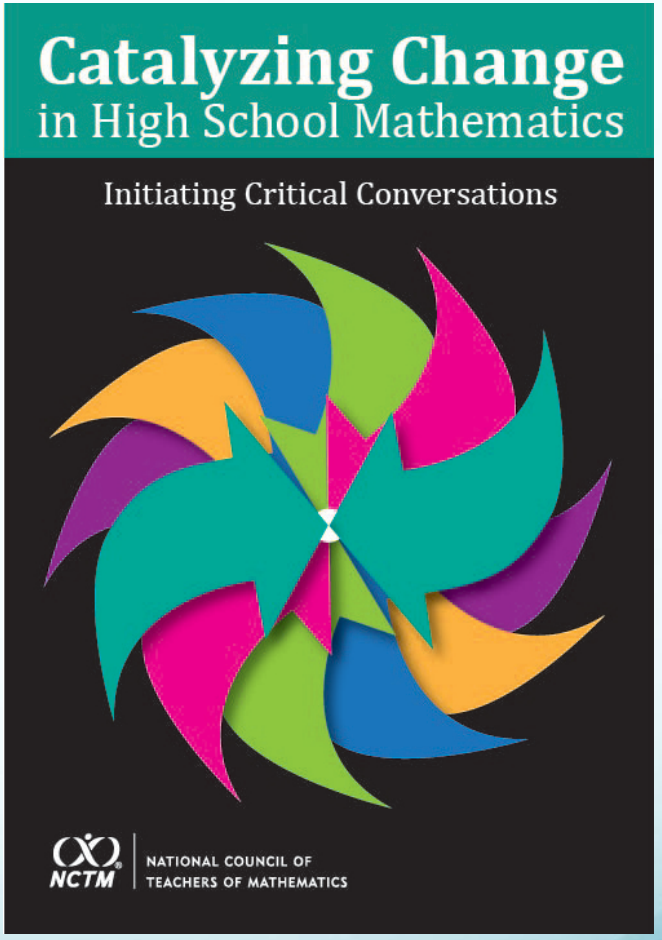
The Purposes of School Mathematics and Statistics



- Expand professional opportunities
- **Understand and critique the world,** and
- Experience the joy, wonder, and beauty of mathematics and statistics.

NCTM, 2018

- **Broaden the purposes** for teaching high school mathematics.
- **Catalyze discussions** of the **challenges** as well as recommendations for implementing actions to overcome those challenges.
- **Define imperatives** in the areas of structures, instructional practices, curriculum, and pathways for students.
- **Identify Essential Concepts for focus** that all students should learn and understand at a deep level.
- **What to consider for common pathways** of mathematical study. Each pathway includes a **common set** of mathematical study expected of high all school students, followed by **alternate paths of study**, differentiated by postsecondary education and career goals.



NCTM, 2018

Essential Concepts

- … outline a **common shared pathway**- a progression of courses **that all students take**- as part of high school mathematics education.
- … experience the **foundational mathematics** that [all students] will need for whatever future path they pursue.
- **Domains**: Number, Algebra & Functions, Geometry & Measurement, Statistics & Probability

NCTM, 2018

Statistics & Probability

- Focus 1: Quantitative Literacy
  - 2 Essential Concepts
- Focus 2: Visualizing and Summarizing Data
  - 6 Essential Concepts
- Focus 3: Statistical Inference
  - 7 Essential Concepts
- Focus 4: Probability
  - 2 Essential Concepts

NCTM, 2018

Quantitative Literacy includes the ability to

- **use estimation and scale** to place quantities in context;
- understand **numbers as used in everyday discussions**;
- create and interpret **visual representations of data**;
- **locate data** and **assess its validity**;
- understand the **difference between association and causation** and the **different ways variables might be linked**; and
- **generate and apply probabilistic information to decision making**, and understand **the limitations of such reasoning.**

National Council of Teachers of Mathematics, 2018

What statistical content is important- number?

- Interpreting percents in terms of a context
  - What is the base?
  - Connecting percents to decimals
- Making sense of fractions in a context
- Making sense of ratios in contexts
- How to read and and interpret data in a two way table (and to organize data in a two-way table)
- What is meant by probability (the basic definition), chance
- Risk and relative risk

What statistical content is important – data?

- Interpreting graphs (standard ones such as histograms, bar graphs, box plots, dot plots, scatterplots and non standard ones)
  - What to look for to make sense of a graph (labels, title, scales, …)
  - What questions to ask about a graph (what are the data, where did they come from, who created the graph, what is the story the graph is trying to tell…)
  - Understanding what is meant by median, mean, standard deviation, outlier
- Correlation
  - What does it tell you and what does it not tell you
- Regression equations
  - Fitting lines to data and what to look for in terms of "fit"
  - Interpreting slope, describing trends

What content is important - sampling

- Recognizing the importance of thinking about and recognizing variability
- Understanding what is meant by words such as random, random chance, random samples, significant
- Accurately interpreting margin of error in different contexts
- Connecting a graph including a sampling distribution to probability of an outcome

Conditional probabilities can be computed from data organized in contingency tables. ...

	Diseased	Not Diseased	(totals)
Test result positive	170	7,830	**8,000**
Test result negative	30	91,970	**92,000**
(totals)	**200**	**99,800**	**100,000**

- Consider the test results and having the disease
- The probability of testing positive given that the person does *not* have the disease can be found by:

$$\frac{\text{Number of Positive Test and Not Diseased}}{\text{Total Not Diseased}}$$

$$= 7830/99{,}800 \approx 0.078$$

NCTM, 2018

Newspaper Headlines

"Women's Income is Catching up to Men's"

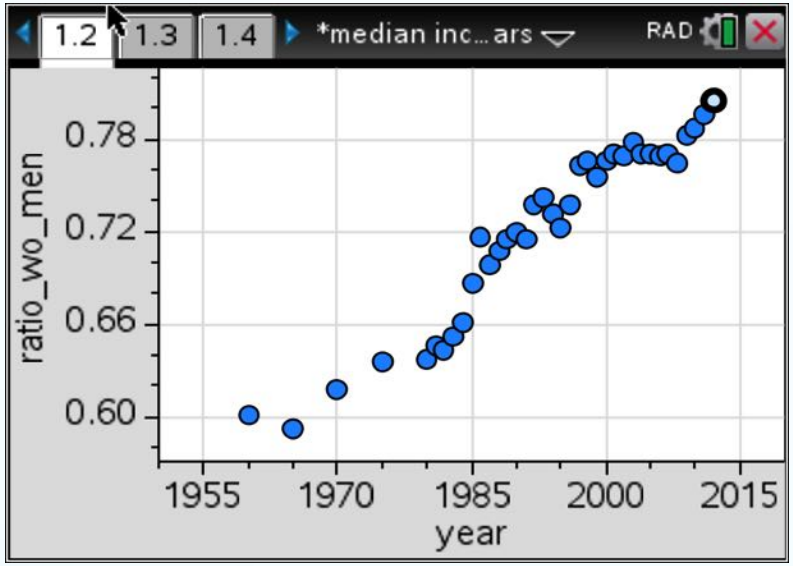
"Women's Income is Catching up to Men's"

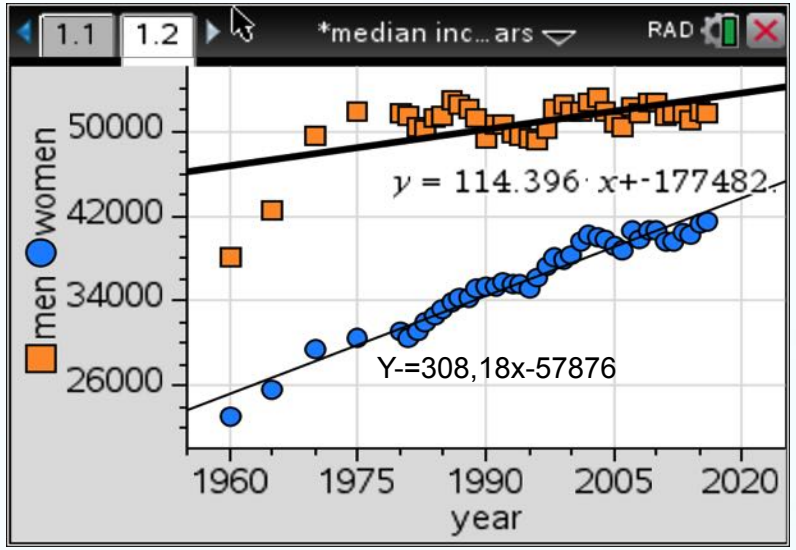
Year	Women	Men	Year	Women	Men	Year	Women	Men
1960	23107	38084	1995	35208	49292	2014	40168	51078
1965	25515	42579	1996	36144	49001	2015	41257	51859
1970	29372	49474	1997	37264	50247	2016	41554	51640
1975	30448	51766	1998	38075	52036	2017		
1980	31063	51633	1999	37935	52459			
1981	30421	51356	2000	38288	51938			
1982	31110	50385	2001	39605	51887			
1983	31901	50164	2002	40309	52622			
1984	32531	51103	2003	40094	53070			
1985	33247	51486	2004	39695	51837			
1986	33947	52819	2005	39153	50863			
1987	34190	52457	2006	38706	50308			
1988	34355	52014	2007	40634	52222			
1989	35090	51097	2008	39847	51688			
1990	35317	49314	2009	40583	52719			
1991	35334	50579	2010	40608	52787			
1992	35855	50654	2011	39600	51425			
1993	35582	49752	2012	39505	51639			
1994	35589	49451	2013	40347	51554			

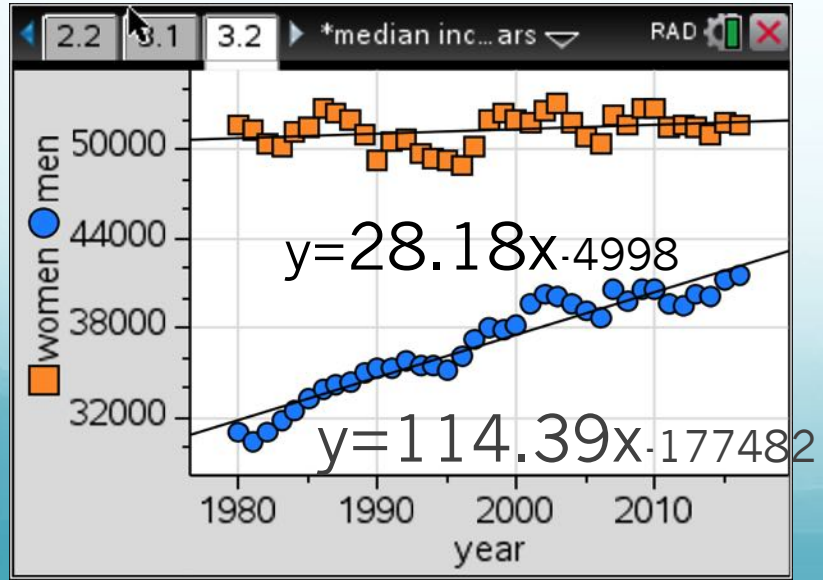
Median Income of fulltime workers (in 2016 dollars)

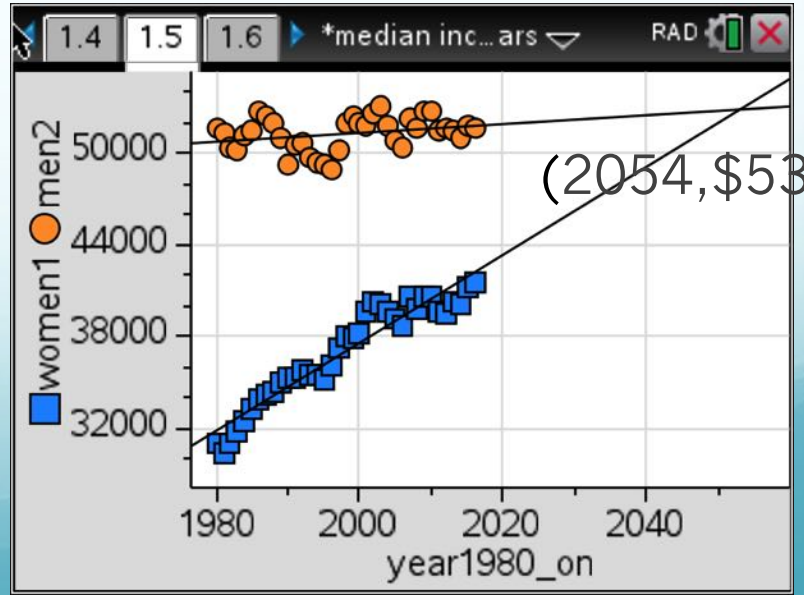
Hegewisch, Phil, & William-Baron, 2017

Is women's income catching up to men's?



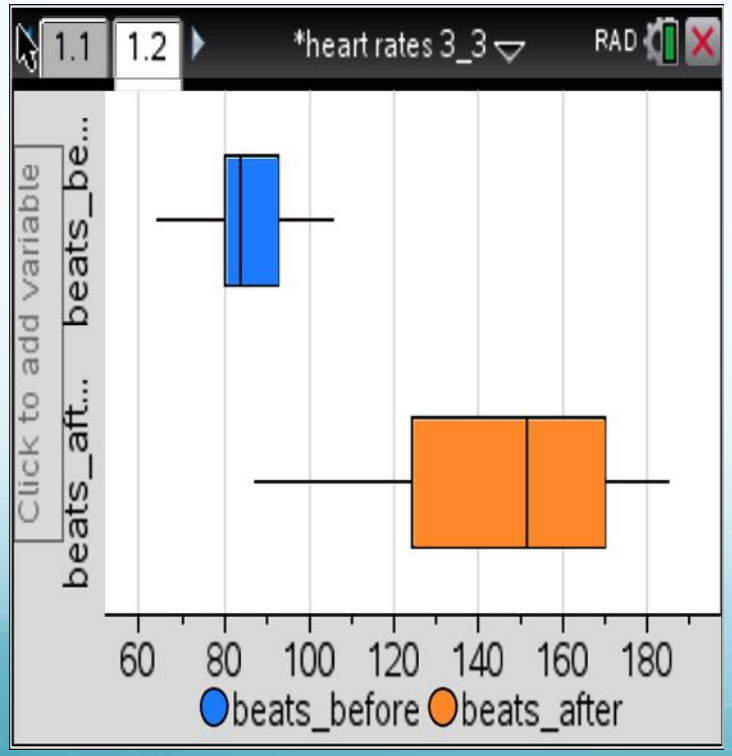


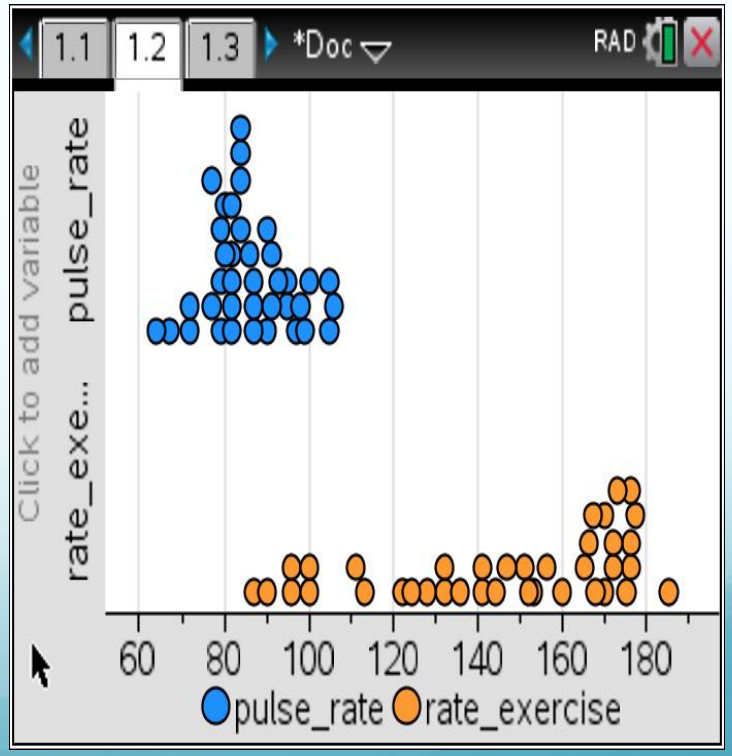




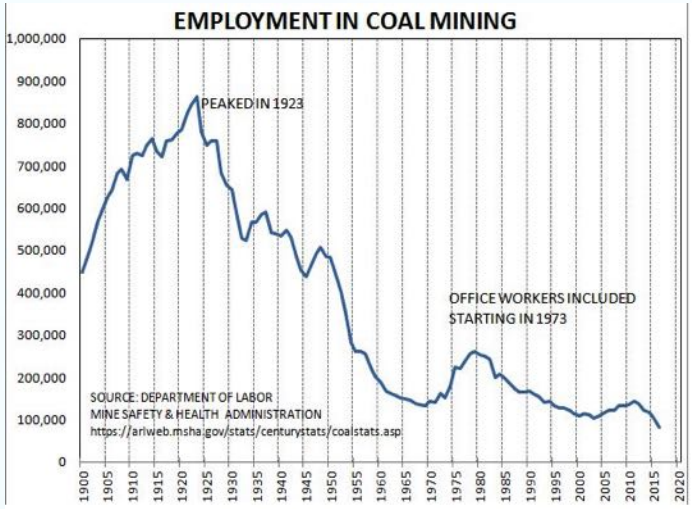
What is typical and what is not can be used to compare two or more subgroups with respect to a variable.

Compare the heart rates of the students before and after exercise.



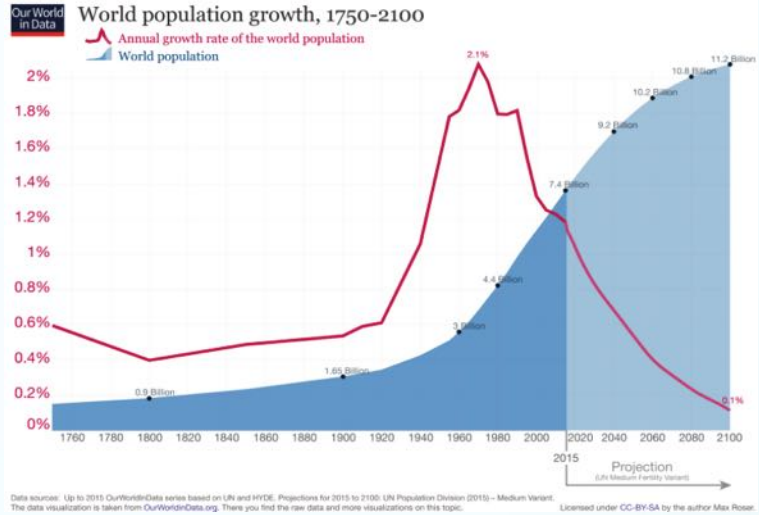


Quantitative Literacy with functions

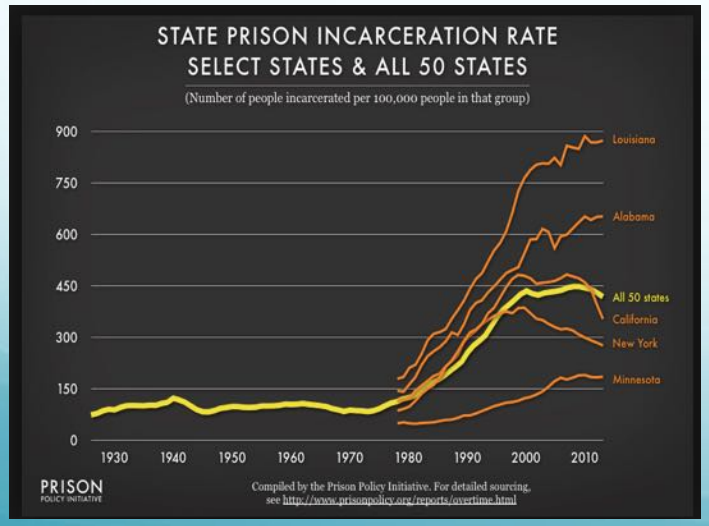


England, 2017

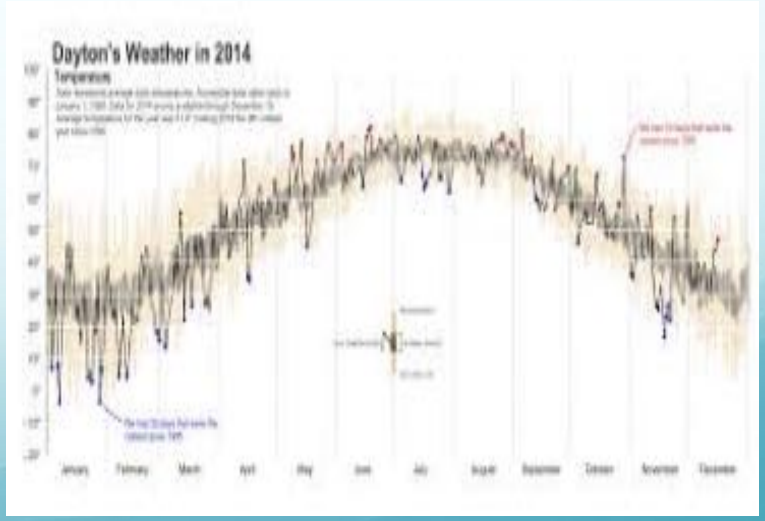
Write three sentences to tell the story described by the graphs.



Roser & Ortiz-Ospina, 2017



Wagner, 2014

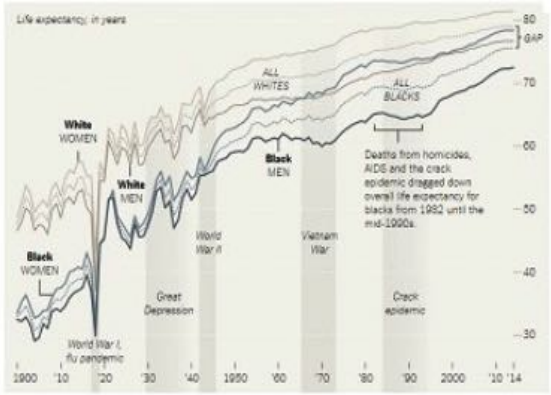


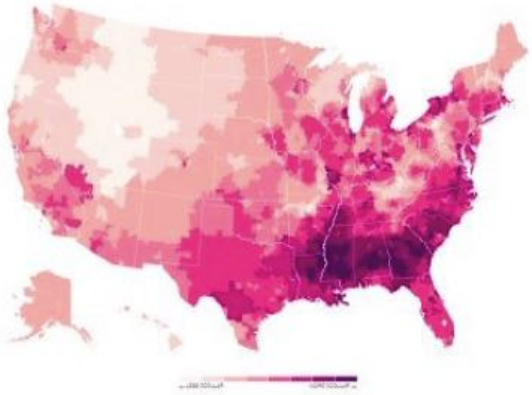
Boehmke, B, 2015

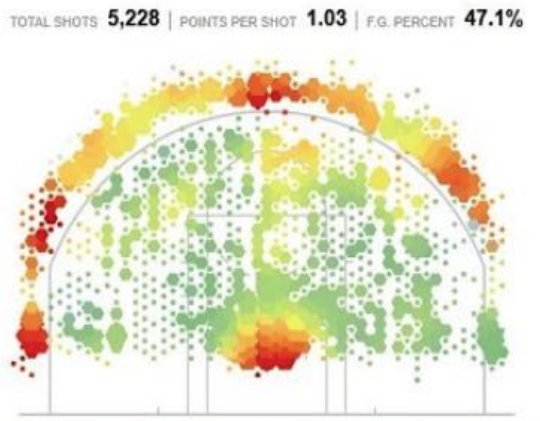
American Statistical Association/ New York Times Partnership

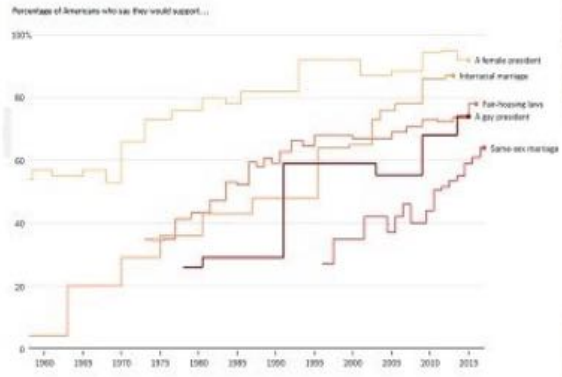
What's Going On in This Graph?

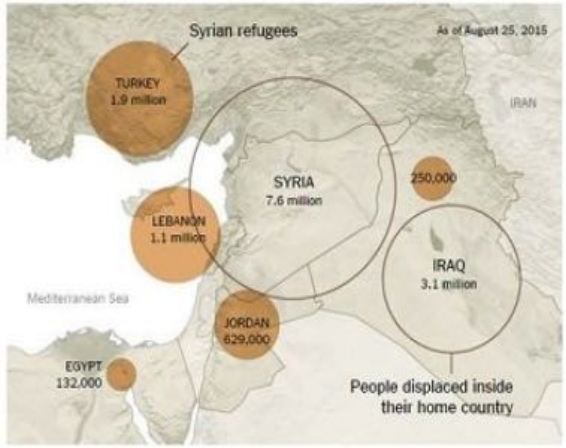
By MICHAEL GONCHAR and KATHERINE SCHULTEN SEPT. 6, 2017









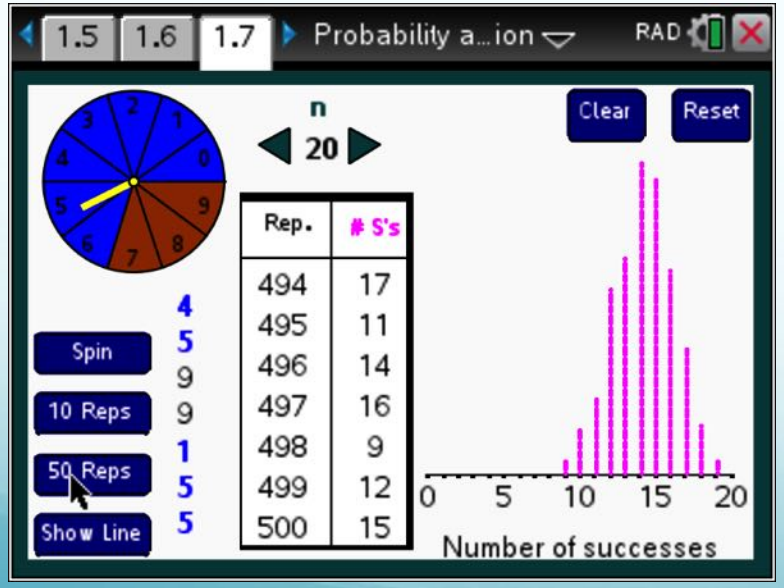


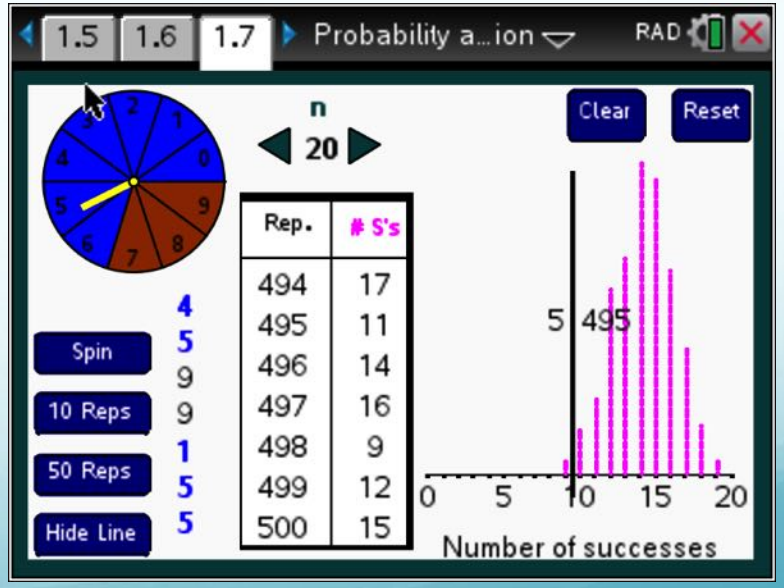
Clockwise, starting in the top left corner: Closing the Gap; Rihanna Fan Map; Where the Heat and the Thunder Hit Their Shots; The Global Refugee Crisis, Region by Region; Changing Attitudes; Is Sushi 'Healthy'? What About Granola?.

https://www.nytimes.com/2017/09/06/learning/announcing-a-new-monthly-feature-whats-going-on-in-this-graph.html & ASA

- Stephen Curry typically makes about 60% of his field goal attempts. In 2017 he went into a slump and was making only about 9 shots in every 20 attempts. Was he really in a slump?

- Stephen Curry typically makes about 60% of his field goal attempts. In 2017 he went into a slump and was making only about 9 shots in every 20 attempts. Was he really in a slump?
- Outcomes vary by chance as well as for other reasons. Is making only 9 shots in 20 attempts **surprising** – or is it just variability due to chance?





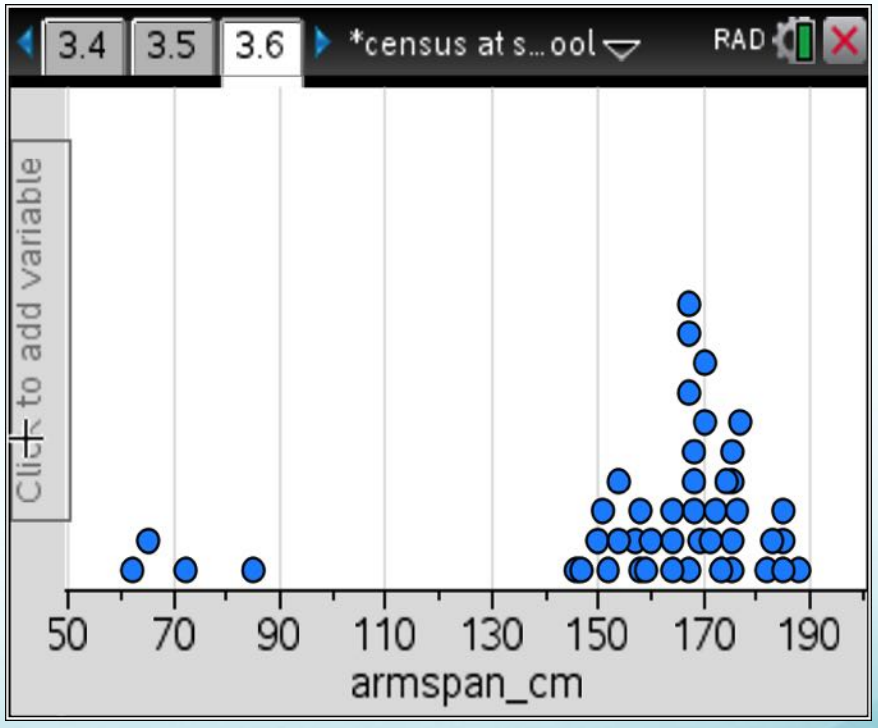
Gender	Age	Handedness	Height (cm)	Foot length (cm)	Arm span (cm)	Favorite subject	Languages spoken	Texts sent yesterday
Male	17	Left	175	24.75	170	Science	2	59
Male	15	Right	173	27	172	Math/stat	1	1
Female	17	Right	175	26.5	178	Science	1	20
Female	16	Right	161	27	162	Math/stat	1	10
Male	18	Right	178	27	169	Phy ED	2	70
Female	18	Right	158	21	164	Art	2	50
Female	17	Right	163	23.5	168	English	1	61
Male	16	Right	169	26	174	Comp Sci	1	70
Female	17	Right	162.6		157.5	Music	2	45
Female	18	Right	166.5	26	170	History	1	100
Male	17	Right	193.4	27.8	189.4	Comp Sci	1	26
Male	16	Left	177	67	128	Comp Sci	1	18
Female	17	Right	154	23	156	Other	1	200
Female	17	Right	148	22.5	149	Comp Sci	2	120
Male	16	Right	183	25	192	Music	2	12
Female	16	Right	165	22	156	Science	1	200
Female	17	Left	154.4	23	124	Science	2	45
Female	16	Right	179	26	174	History	1	16
Female	16	Right	174	25	171	History	2	36
Female	16	Right	158	20.5	165	English	1	15
Female	16	Right	171	25	168	Music	2	32
Female	17	Left	169	24	175	Science	1	25
Female	16	Right	166	25	168	English	1	0
Female	18	Right	170	23	156	Art	1	5

Table 1: Random Sample of Grade 11 students from the United States from Census at School American Statistical Association

Real data are not always clean and usable

Using real data

Technology can be used to "clean" and organize data, including very large data sets, into a useful and manageable structure—a first step in any analysis of data.



Armspan 11th graders from Census at School sample

Table 3: Effect of exercise on heart rate

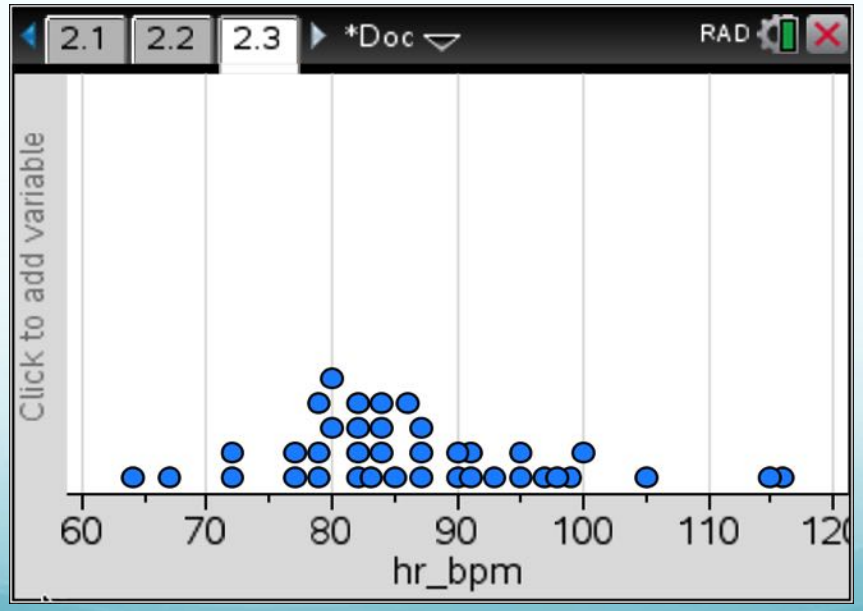
	Rest	Anticipation	Difference	Exercise	Difference
Henry	72	76	4	87	15
Megan	116	120	4	175	59
Laura	79	84	5	96	17
David	97	99	2	100	3
John	90	93	3	176	86
Michael	67	75	8	132	65
Sarah	115	116	1	176	61
Claire	82	83	1	141	59
Rosanna	95	98	3	113	18
Rachel	82	87	5	136	54
Hattie	77	82	5	96	19
Rosie	105	110	5	153	48
Alex	79	82	3	90	11
Katheryn	99	102	3	152	53
Rebecca	82	89	7	156	74
Siobhan	87	94	7	170	83
Mark	82	94	12	128	46
Thomas	98	76	-22	172	74
Lougie	80	92	12	132	52
Richard	95	115	20	141	46
Edward	79	128	49	144	65
Jamie	80	76	-4	100	20
Jacqueline	85	88	3	172	87
Hope	91	130	39	177	86
Holly	83	89	6	168	85
Emma	77	81	4	165	88
James	87	87	0	111	24
Seamus	84	92	8	122	38
Ciaran	93	82	-11	185	92
Ryan	87	92	5	170	83
Christine	91	93	2	124	33
Anne	90	94	4	176	86
Mark	100	101	1	160	60
Alistair	84	85	1	166	82
Anthony	64	108	44	167	103
Patrick	72	88	16	151	79
Tom	84	91	7	147	63
Douglas	86	97	11	173	87

The data: British children ages 9 to 11

Robson, L. (2016). The Human Body – a Lean Mean Exercise Machine, The Heart Teachers notes. Department of Biomedical Science, University of Sheffield www.coursehero.com/file/16351710/Heart-teachers-notes/

What is typical can be used to describe a distribution with respect to a variable.

Describe the resting heart rates of the students in the study.



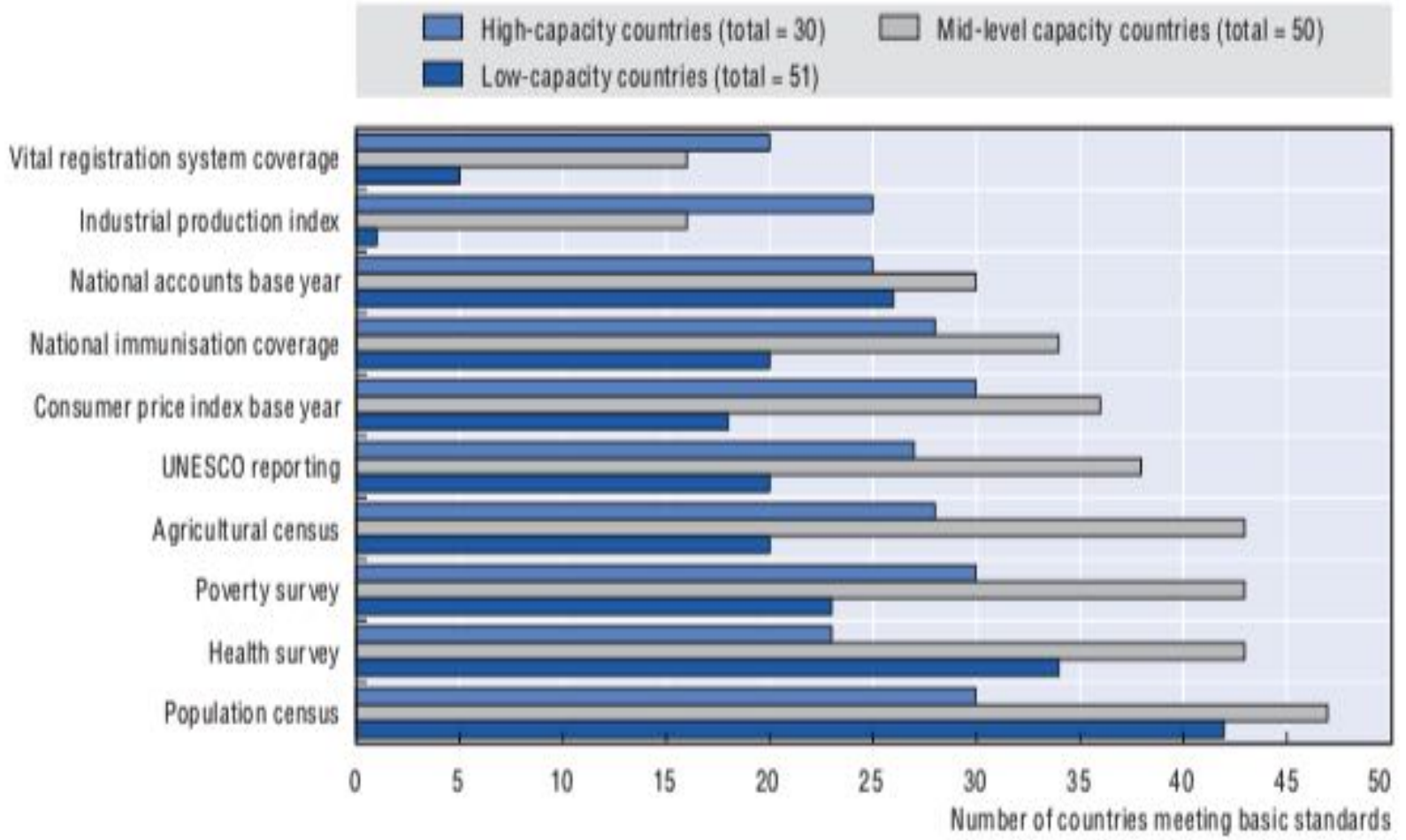
The International Association for Statistical Education

Collecting and analyzing data

- New technology and the so-called data revolution make it easier, faster and cheaper to produce data that decision makers need to make informed choices on policies and priorities. However, simply producing more data is not enough: data must be transformed, analysed and used to be useful for policy making, monitoring and accountability. (OECD, 2017)

In an era of fake news and alternative facts, good data are even more vital. All citizens have the right to true, reliable and accessible information. This is particularly important in the development field, since world leaders adopted the transformative 2030 Agenda for Sustainable Development in September 2015. Achieving the Sustainable Development Goals (SDGs) will require informed choices about priorities and strategies, and for this we will need a better evidence base than we have today.(OECD, p. 3)

Figure 1.1. **Number of countries with capacity to deliver fundamental statistics, 2016**



Source: Calculation by authors of Chapter 3 based on World Bank (2017), *Statistical Capacity Indicators* (database), http://databank.worldbank.org/data/reports.aspx?source=statistical-capacity-indicators#.

StatLink http://dx.doi.org/10.1787/888933591803

Source: OECD (2017), Development Co-operation Report 2017: Data for Development, OECD Publishing, Paris, http://dx.doi.org/10.1787/dcr-2017-en.

Data Actions OECD

- **Data action 3.** *Boost statistical capacity and data literacy through new approaches.*
- New, more comprehensive approaches to statistical capacity development need to be developed and piloted that go beyond building capacity to collect data, to building the capacity of national statistical offices to play an evolving and multifunctional role in the (OECD, 2017)

OECD Data Actions

Boosting statistical capacity and data literacy, for immediate action:

- Developing countries and their partners should develop and pilot new, more comprehensive approaches to capacity development that go beyond the capacity to collect data and build the capacity of national statistical offices to play an evolving and multifunctional role in the data ecosystem and to improve the institutional and enabling environment for data and statistics. This includes improving data dissemination and promoting data literacy to spur the use of statistics and promote active user communities.
- Countries should continue to build capacity for "core" statistics, including censuses, surveys and administrative records – which are essential in the national statistical system.
- National statistical offices worldwide face similar challenges in harnessing the data revolution; they could benefit from a new mechanism for "knowledge solidarity", allowing data stakeholders across the globe to share knowledge and work together in an effective manner.

The International Association for Statistical Education

- How do we give people the right tools to help them successfully make informed decisions based on data?

Your role----

- Give students real and relevant problems with genuine complexity from the start (Parsons, De Veaux, Ocampo)
- Provide “deep learning” not just procedures (Chiesi)
- Build supportive learning environments and learning management (Lee, Vinje, D’Amelio, Berens)
- Recognize that many students will need to be critical consumers while not so many others need to be capable and responsible producers (de Veaux)

Developing a critical attitude

- Helping students learn to communicate and assess statistical thinking, actually using the data in their reasoning or to justify their answers (Ostergaard)
- Enable students to make sense of and reason with data in two-way tables (Puloka)
- Increased attention to critical evaluation and methodology, official statistics, civic knowledge, social policy in framing documents such as GAISE (Ridgeway)
- Work to ensure that assessments measure what we value (Nicholson, Elbehary, Vaiman)

Making statistics useful

- Jay Mandrekar described a project designed to reduce the complexity of collecting information to help doctors diagnose illness in their patients
- Guttorp argued statistical analyses are often simply calculating *p*-values without understanding the importance of sample size; studies are not replicated and single studies are displayed in the media as the final scientific word on a subject.
- Yap described the lack of attention in published articles to the conditions that underlie the inferential techniques used in studies and impact the conclusions

- Capture student's imagination and let them experience statistics as fascinating and useful (Canada, Teran, de Veaux, …)

Our goal

"Students should be able to identify, interpret, evaluate, and critique the mathematics embedded in social, scientific, commercial, and political systems, as well as the claims made in the private and public sectors and in public interest group pronouncements (Ernest 2010)."

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Students should leave our educational institutions with the ability to reason and make sense of information, know what questions to ask when confronted with data and conclusions from data, understand what "evidence" is and why it is important, and know how to deal with alternate truths as well as inconvenient facts.

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