How to Read and Interpret Graphs

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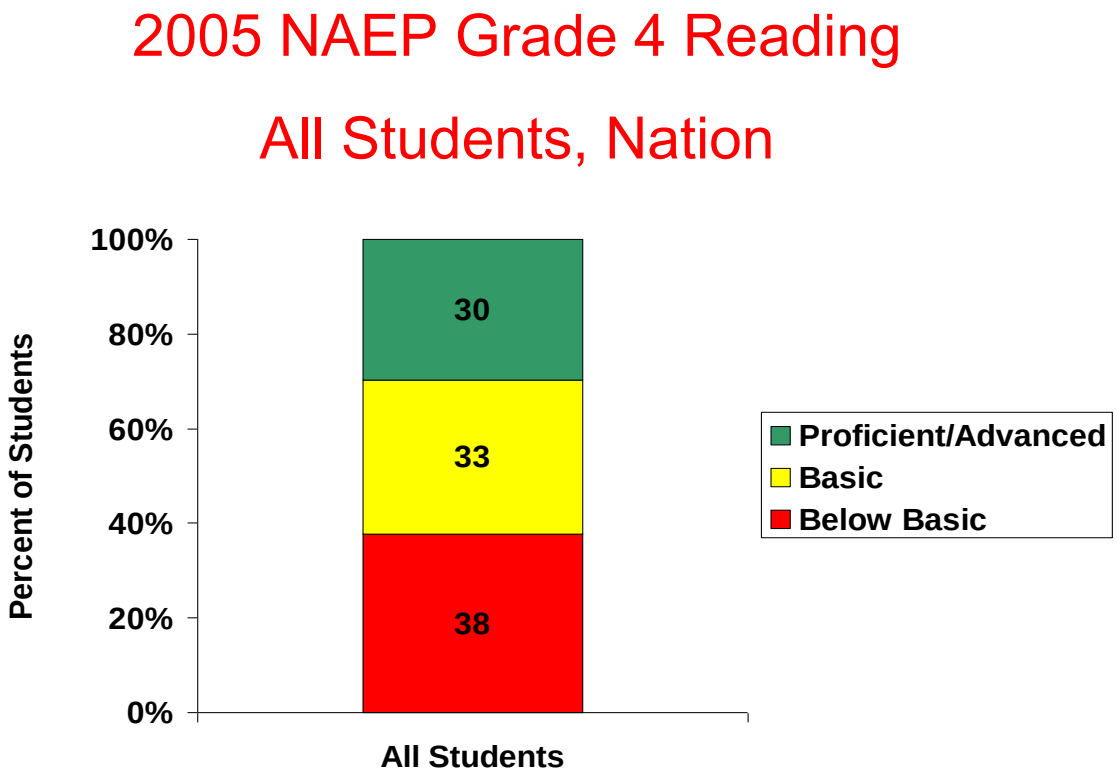
This document will teach you some of the main concepts and skills in reading and interpreting graphs. However, the concepts (vocabulary) and skills will be useful for other aspects of research as well.

Checks of your learning are provided. Please respond to these checks.

This is slide 3 from the Powerpoint presentation "Closing the Achievement Gap," Washington, DC: The Education Trust. 2005.



1. This graph shows data on a VARIABLE---a variable is something that has a ***value*** (an amount) that can vary in how much of it there is. Just as weight, and height, and room temperature, and the number of books you read in a year

are variables. You can read 0 books---the value of the variable Number of Books Read Each Year—is 0. Or you can read 50 books a year---the value of the variable Number of Books Read Each Year—is 50.

Imagine that you have information on 100 persons. You know how many books each person read last year. Let's say the ***lowest*** number of books read---the lowest value of the variable Number of Books Read Last Year---is 2. And let's say the ***highest*** number of books read---the highest value of the variable Number of Books Read Last Year---is 80. We would say that the RANGE of the value of this variable---or the range of SCORES on this variable---is from 2 to 80

Check. If you know the ages of the same 100 people, and the youngest person is 12 and the oldest person is 105, what is the RANGE for the value of this variable, Age?...
The range is from 12 to 105.

Check. If you know the income of each person (the amount of money they make each year), and the lowest income is $28,000 and the highest income is $88,000, what is the range for the variable Income?....

2. The above graph shows three VALUES or levels of the variable Reading Achievement in fourth graders. What are the three values or levels…
"Below basic," "Basic," and "Proficient/advanced."

This would be like taking all of the values of the variable Income and grouping them like this.
$28,000 to $48,000 is called "Moderate Income."
$49,000 to $68,000 is called "High Income"
$69,000 to $88,000 is called "Very High Income."
It is NOT NUMBERS---like 59 books is a number---but it is still a VALUE (an amount of money).

So, students took the NAEP reading test. Their specific number scores were grouped as "below basic," "basic," and "proficient/advanced."

3. "All Students" means all students in the sample. This includes all social classes and ethnic groups.

As you can see, the red area goes from 0 to 38 on the percentage line—on the left. That is why it is labeled 38%. 38% of the total sample (all students) scored in the below basic range of scores.

The yellow area (basic) goes from 39 to 72 on the percentage line. That is why it is labeled 33%.

Check. What percentage of all students scored in the proficient/advanced ***range*** of scores? [Give students a chance to answer.]……
30%

4. Now let's INTERPRET the data, or findings. Compare the percentage of students in each of the three levels of achievement. What percentage read below basic……38%.

Check. What percentage read at a proficient or advanced level?.....
30?

SO A HIGHER PERCENTAGE of fourth graders read BELOW the basic level than the percentage of fourth graders who read at a proficient or advanced level.

Check. Is this a bad thing? How bad would you say it is?

Check. Is it anything to be concerned with?

Check. Do you think that all these students who read below the basic level after three or four years of reading instruction have some kind of disorder? Could it have to do with instruction?

Check. Think of some disease. Is it better to treat each person who gets sick, one at a time? Each family, one at a time? Each neighborhood, one at a time? Or the whole community at once?

If you treat the individual, family, and neighborhood levels one at a time, lots of persons, families, and neighborhoods will be waiting for treatment, and will be getting sicker. ***If you treat the illness at the community level, no one has to wait and get sicker in the meantime.***

Let's apply that to improving reading instruction.

Check. At what level do you think instruction should be improved?

a. Only for students who don't read proficiently by fourth grade.
b. The whole fourth grade class in a school.
c. The whole school at all grades.
d. The school district, with all elementary education teachers using more effective curriculum materials and instructional methods.

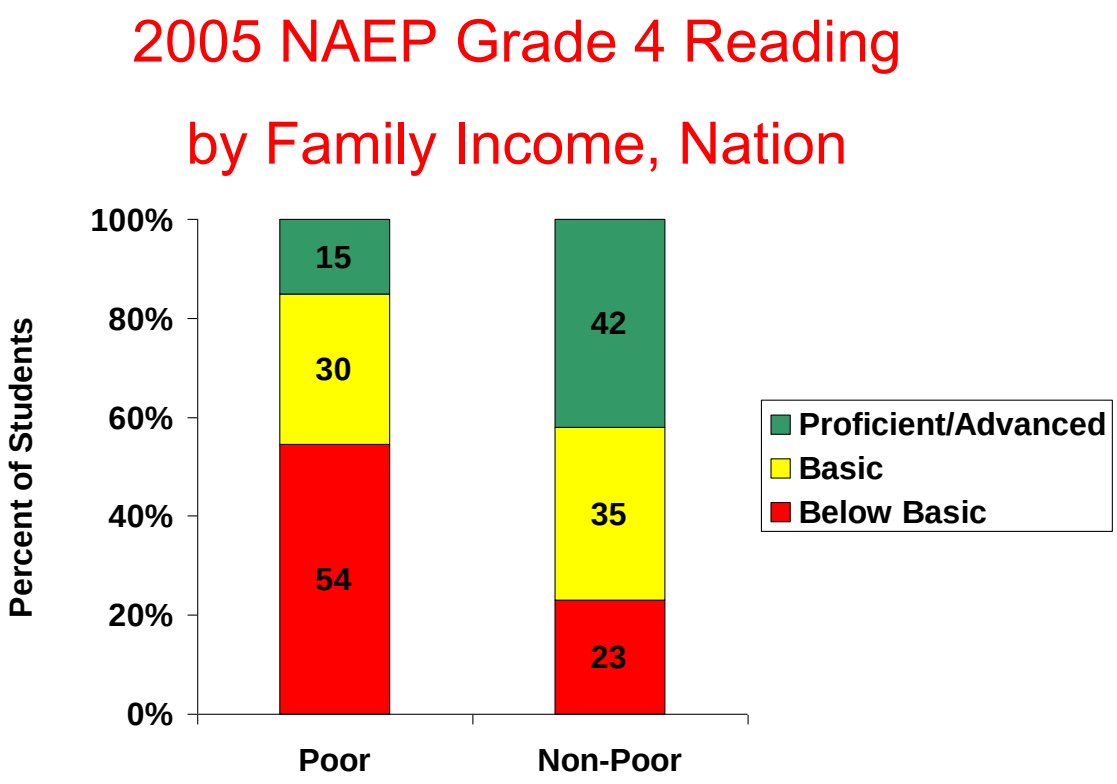
d. is the better answer. If you improve reading (or any) instruction at the ***district level****, all teachers will have the same knowledge of reading; all teachers at each grade level will improve and teach reading the same way; students will receive uniformly and improved instruction at each grade; you will be able easily to identify teachers who teach proficiently vs. teachers who teach less proficiently and therefore need timely assistance; and (since you will be using tested and effective curriculum materials and instructional methods), you will be able to tell which students really DO have some kind*

learning difficulties or diverse needs that require EXTA materials and instructional time.

4. ***Check.*** What do you think the future will be for children reading at the basic and below basic level? Do you think they will read any better in higher grades? If so, what do you think will make than happen?

Check. If not, how well do you think these students will do in subjects that require proficient reading, such as math and literature and history?

5. This next graph is slide 5 from "Closing the Achievement Gap."



This graph ***"disaggregates"*** or ***breaks down*** the sample of "All Students" into two groups. Many groupings are possible. Boys and girls. Students in rural and

urban schools. Large schools and small schools. This one disaggregates (or analyzes) the data by social class—poor vs. not poor. It then shows the percentage of poor vs. not poor students whose achievement is in the below basic, basic, and proficient/advanced range.

Check. Why is the red area for "poor" labeled 54?.....
Because the area goes from 0 to 54% on the percentage line. 54 minus 0 is 54.

Check. Why is the yellow area for poor labeled 30%.....
Because the yellow area goes from 55% to 85% on the percentage line. 85 minus 55 is 30.

Check. Why is the green area for poor labeled 15%.....
Because the green area begins at 85% on the percentage line and ends at 100%.

Check. Why is the yellow area in the non-poor column labeled 35%? Hint: Where does the yellow area start (bottom) and where does it end (top) on the percentage line?.....
It starts at 25% and ends at 60%. 60 minus 25 is 35.

Check. Why is the green area in the non-poor column labeled 42%?.....
Because the green area begins at 58% on the percentage line and ends at 100%. 100 minus 58 is 42.

Compare the three levels of achievement (below basic, basic, and proficient advanced) by social class (poor vs. not poor).

Check.

1. What percentage of economically poor students are basic?

54%

2. What percentage of not poor students are basic?
   23%

3. So, students in which social class have lower achievement at the below basic level?
   Poor students.

6. Compare 23% and 54%. This tells you the ***achievement gap*** between economically poor and not poor students at the below basic level. Subtract 23 from 54%. 31. So at the below basic level, the achievement gap between poor and not poor students is 31%.

It is bad that 23% of **not** poor students read below the basic level. But it is even worse that 54% (more than half!) of economically poor fourth graders read below the basic level.

7. Now compare the percentage of students (poor and not poor) at the basic level.

1. What percentage of poor students read at the basic level?.....
   30%
2. What percentage of not poor students read at the basic level?.....
   35%
3. So, students in which social class (poor vs. not poor) have ***more*** students reading at the basic level (which is not great but is better than reading below basic)?....
   Not poor.

4. Is the percentage difference between poor and not poor students reading at the basic level very large?....

No. 5%.

7. Now let's look at the proficient/advanced level. This is where you WANT fourth graders to be reading.

Check.

1. What percentage of poor students read at the proficient/advanced level?.....
   15%

2. What percentage of not poor students read at the proficient/advanced level?.....
   42%

3. What is the achievement gap between poor and not poor students at the proficient/advanced level?....
   Subtract 15 from 42. 27%.

   And if you divide 42 by 15, you find that almost three times more not poor students read at the proficient/advanced level than poor students.

8. **Let's interpret these findings, or data.** Does it look like poor and not poor students have **disorders** that explain why they don't learn to read well after four or five years of instruction? Or could it be that instruction could be better (better designed) for ALL students and especially for some not poor students and for many poor students ("diverse learners")?

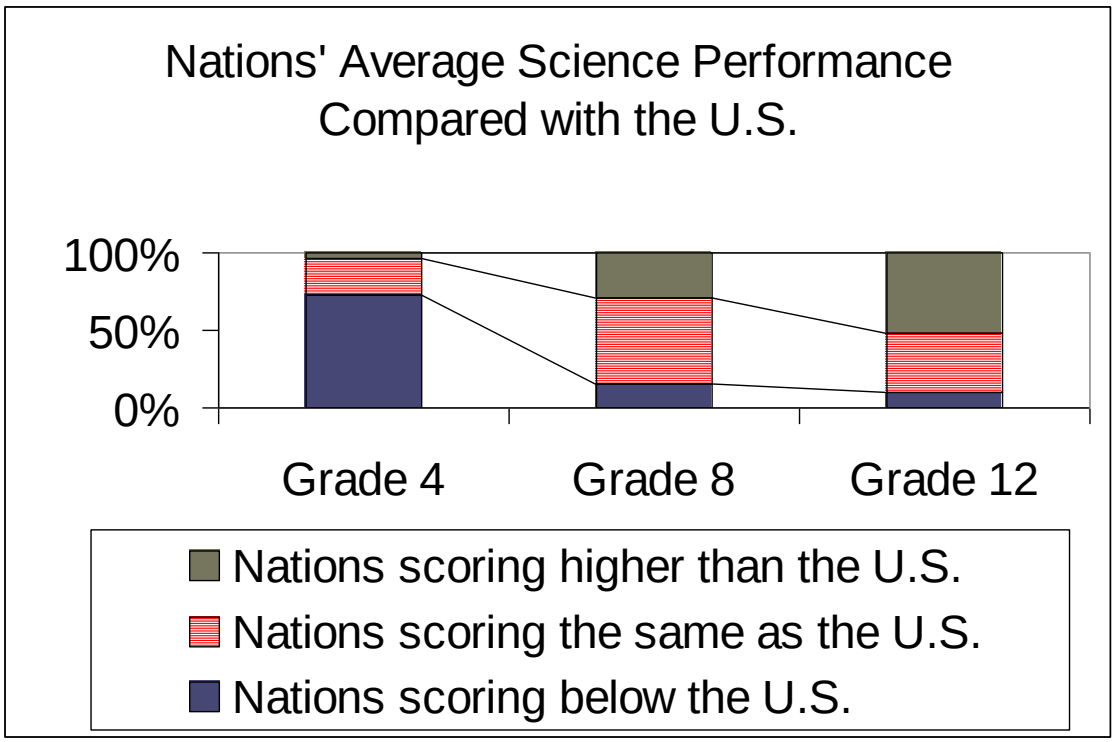
If you think that teachers, principals, and districts need to improve reading instruction, how will they go about this?.....

They will:

1. Examine the scientific research, and reading experts on what are the important features of curriculum materials and instructional methods.

2. Select curriculum materials and instructional methods that have those features.
3. Select curriculum materials and instructional methods that have been field tested in a scientific way, and are shown to be effective again and again (that is, are reliably effective with students who are like the ones in the schools that will use the materials and methods).
4. Train teachers to use the curriculum materials and instructional methods proficiently.
5. Provide timely supervision and assistance to improve proficiency.
6. Frequently assess students' progress and adjust instruction accordingly; for example, give some students extra reading sessions; use additional curriculum materials that focused on weak prior knowledge; increase the amount of practice on new skills.

9. The next graph is slide 33 from "Closing the Achievement Gap."



This graph does not show science *scores*. It shows the ***percentage of nations*** (out of a sample of nations that have scores in science proficiency) whose students' ***average scores*** on a science test are higher than students in the U.S.

Let's start with grade 4. Look at the grey area---nations scoring ***higher*** than the U.S. The grey area begins at about 95% on the percentage line and ends at 100%. 100 minus 95 is 5. So ONLY approximately 5% of other nations' students have higher average science scores.

Check. What is the interpretation?
The U.S. appears to be teaching science pretty well in grade 4.

But now move to grade 8. The grey area (nations scoring higher than the U.S) starts at about 80% on the percentage line and stops at 100%. 100 minus 80 is 20.

Check. So what percentage of nations' students have higher average scores in science?.....
20%

Check. What is the interpretation? What may be happening as science instruction (across the world) moves from grade 4 to grade 8?....
The scope of what is taught in the U.S. may be narrower. Instruction may not be ensuring that students have solid knowledge of basic concepts and cognitive routines (such as solving problems). So, U.S. students don't retain knowledge and can't generalize it to new examples---the kind that are on tests.

And now let's look at grade 12. The grey area starts at 50% on the percentage line and goes to 100%.

Check. So, what percentage of other nations' students have higher average science scores than students in the U.S.?....
Around 50%.

Check. So, as we move from grades 4 to 8 to 12, what is happening regarding students' knowledge of science as measured by the test?.....
More and more U.S. students' knowledge falls behind the knowledge of students from other nations.

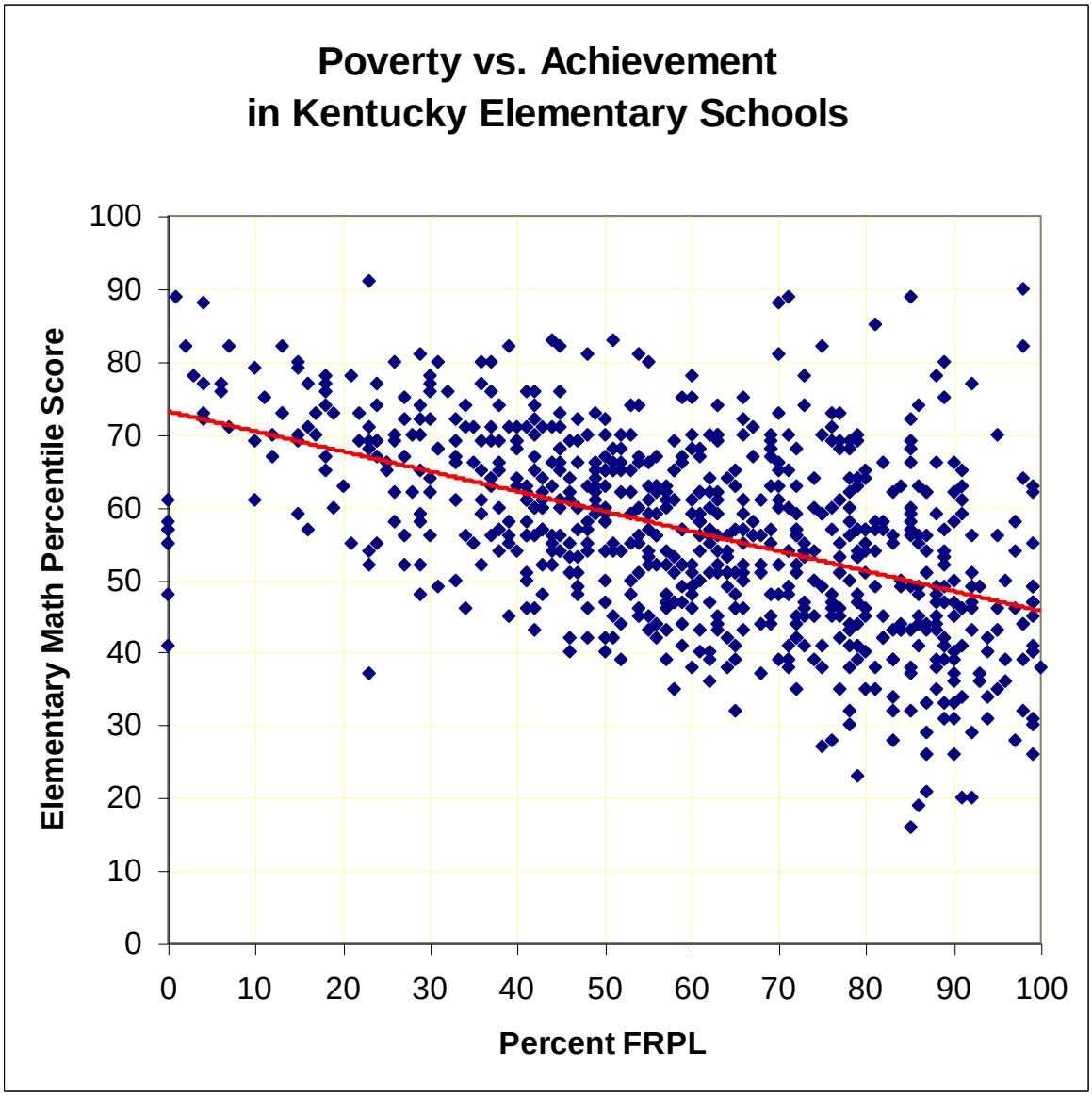
What does this say? Do students in the U.S. have some kind of science disorder? Is it likely that U.S. science instruction is not as robust---does not teach as much, does not teach well enough that students learn it and remember it and generalize it---as science instruction in other nations?

If you think it has to do with curriculum and instruction, what should we do?.... How about doing the same thing as we thought of to improve reading achievement? Specifically, teachers, principals, district and state and federal administrators will

1. Examine the scientific research, and consult science experts on what are the important features of curriculum materials and instructional methods.
2. Select curriculum materials and instructional methods that have those features.
3. Select curriculum materials and instructional methods that have been field tested in a scientific way, and are shown to be effective again and again (that is, are reliably effective with students who are like the ones in the schools that will use the materials and methods).
4. Train teachers to use the curriculum materials and instructional methods proficiently.
5. Provide timely supervision and assistance to improve proficiency.

6. Frequently assess students' progress and adjust instruction accordingly; for example, gave some students extra science sessions; use additional curriculum materials that focused on weak prior knowledge; increase the amount of practice on new skills.

10. This next graph is slide 34 from "Don't turn back the clock." Washington, DC: The Education Trust, 2003.



First notice that the graph has two outside lines: across and up.

The across line is called the X axis, or abscissa. It is the value of the input, such as how much time has gone by or the amount of resources available to families whose children go to a school (another way of saying social class).

The up line is called the Y axis or ordinate. It displays the value of the outcome or output, given a value of an input. For example, given an input of few family resources (measured by the percentage of children on free or reduced lunch), a school produces a certain amount of achievement as an outcome.

In this graph, the across line is for the percentage of students in a school that have free or reduced lunch. ***This is one way to measure poverty***. The higher the percentage of students who receive free or reduced lunch, the greater the poverty on the school.

The up line is for scores on an elementary math test. ***Percentile is a measure of how well a student did compared to the rest of the students who took the test***. A student whose score puts her in the 50^{th} percentile has about 50% of the other students who received higher scores and about 50% who received lower scores. A student whose score puts him in the 1^{st} percentile has about 99% of the rest of the students (that is, all of the rest of the students) who received higher scores. A student who scored in the 98^{th} percentile has only 1% of students who scored higher.

So, the person who made this graph found data on hundreds of schools. ***For each school, the person knew two things***: the percentage of students receiving free and reduced lunch (or poverty), from low very low poverty (for example 0 to 15%) to very high poverty (80 to 100%).

The person also had data on the percentile rank (from the first percentile to the 99^{th} percentile) of the school's students in an elementary math test.

Now, the person looks at the two bits of information on a school. 20% of the school's students receive free and reduced lunch. So, the person slides her finger across the poverty line (bottom line) and locates the spot for 20%. Then she looks at the percentile rank of the math scores for students in that school. Let's say it's the 60th percentile. So, with her finger on the line that says "20" on the across (poverty) line, she then moves her finger up and stops when it gets to "60" on the percentile line (on the left side). **Then *she <u>plots</u> (marks the spot for) these two values*---20% free and reduced lunch; and 60th percentile---at the spot where her finger stopped. That is, she makes a small blue diamond.**

She does this with all of the schools.

11. Now let's interpret the "data." What does the arrangement (display) of dots say?

Check. Look on the left, at around 10% poverty. What are the percentile scores for schools that have about 10% poverty (free and reduced lunch)?
One school is at the 60th percentile; another at the 70th percentile; another at the 75th percentile; and another at the 80th percentile.

So, there are four schools with 10% poverty, and their students' percentile ranking RANGES from 60 to 80.

Now look at the right side of the across (poverty) line. Look at 90% (high) poverty. Now slide your finger up the 90% line. There are many schools.

Check. What is the lowest percentile score?.....
About the 20th percentile.

Keep moving your finger up. You can see that some schools with 90% poverty have students who scored in the 30th, 40th, 50th percentile.

Check. What is the HIGHEST percentile score or rank for schools with 90% poverty?....
The 80th percentile.

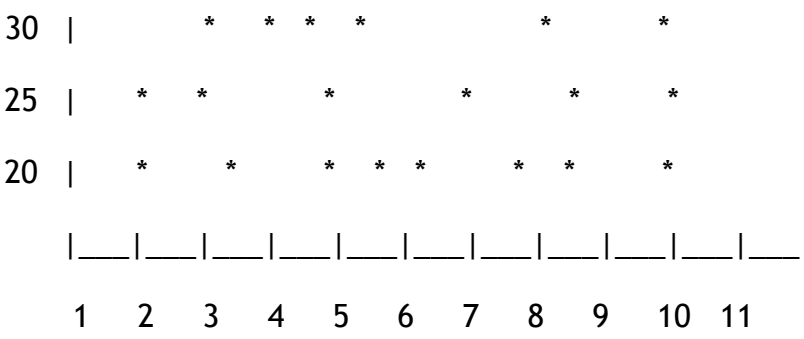
Check. So, what is the RANGE of percentile scores for schools with 90% poverty?....
It goes from 20 to 80.

So, the range is from the 20th to the 80th percentile.

Now look at the spot on the poverty line for 50% poverty. Move your finger up the 50% poverty line. These schools' students start at the 40th percentile. The highest percentile rank for schools with 50% poverty is about 83.

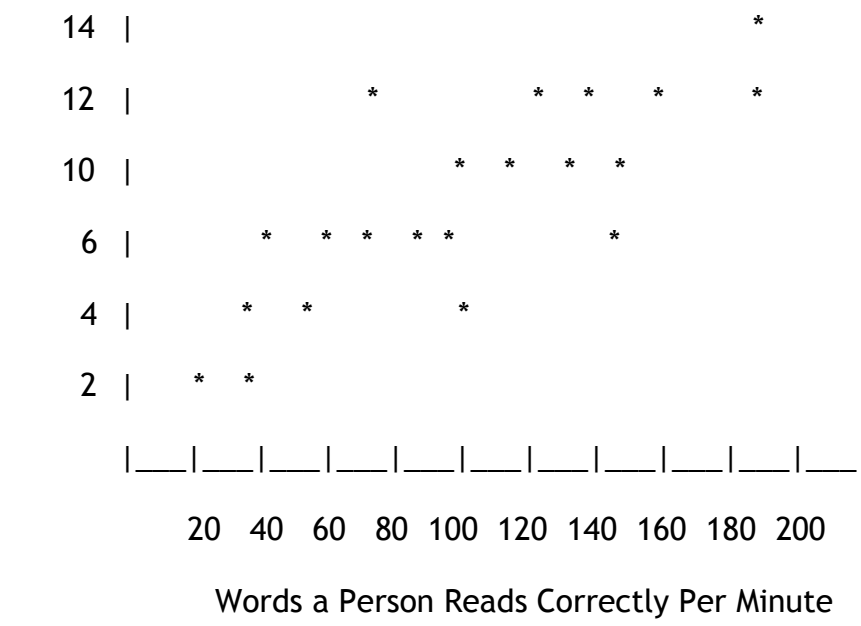
Check. So what is the RANGE of percentile ranks for schools that are 50% poverty?....
50 to 83.

13. Trends and relationships.
On a graph, **a trend means that there is regular change.** The graph below shows data for 21 persons---21 data points. We know the shoe size of each person, and we know how many books each person read last year.



Is there a trend here? For example, is it the case that the larger the shoe size the more (or less) books a person reads? NO. Persons with a size 2 shoe read 20 and 25 books. But persons with a size 10 shoe ALSO read 20 and 25 books. So, shoe size is NOT correlated with and does not PREDICT the number of books read.

Here's another graph.

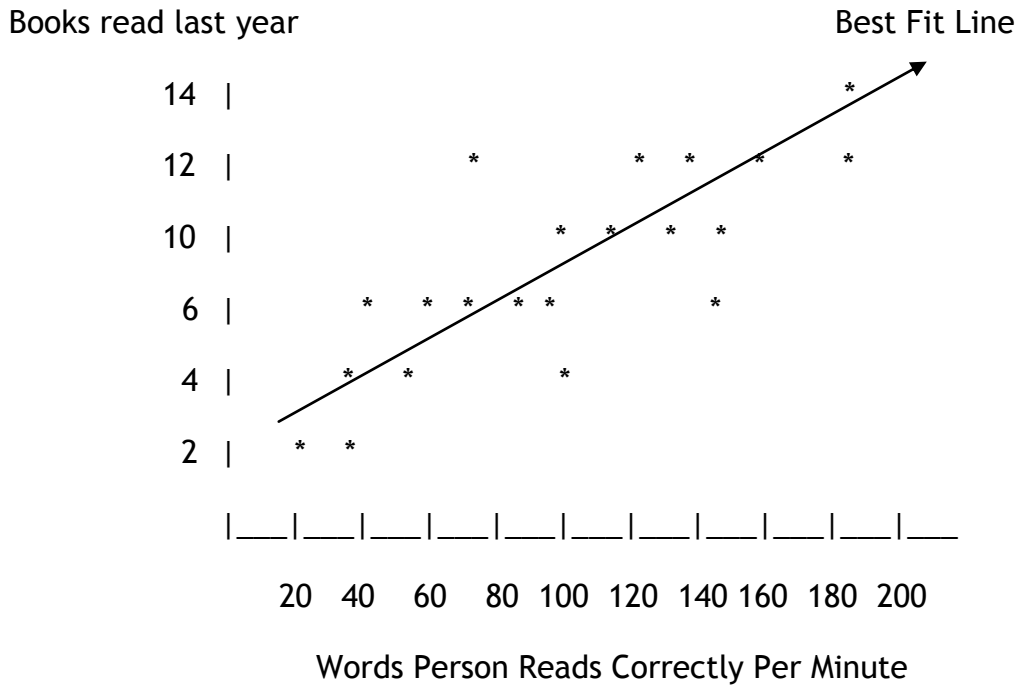


It shows data for 21 teenagers. We know two things about each person: how many books they read last year and how many words they read correctly per minute (reading fluency). So, if you look at the bottom left corner, it PLOTS the data for one person. He reads 20 correct words per minute (very slow) and he read 2 books in a year.

Now look at the right side of the graph. Two persons read at a rate of 200 correct words per minute; one read 12 books and the other read 14 books.

Do you see a trend? For example, **does the number of books per year change as the fluency increases?** Yes. You can see that the higher the fluency, the more books persons read. Fluency IS correlated with, and it predicts, the number of books read.

Here is one more graph---or **plot of data**. It is the same graph as above, but a line is drawn through the data points in a way that best **fits the points**, and also SHOWS the correlation between the two variables.



The best fit line does NOT connect the plotted data points. It **cuts through them so that there are about as many above it as below it.**

12. **Now back to the graph on math achievement in relation to poverty, above.** Is there a **relationship** (association, correlation) between poverty and percentile ranking in math? If there were NO relationship, a school with 10% poverty could have math scores that RANGE from the 10^{th} to the 90^{th} percentile. And a school with 90% poverty could ALSO have math scores that range from the 10^{th} to the 90^{th} percentile. In other words, poverty would not affect math scores. You could have high poverty and high scores. High poverty and low scores. Low poverty and low scores. Low poverty and high scores. The DOTS would be all over the chart. They would form a square.

Go ahead and show this to yourself. Add dots so that the whole thing is filled in. For example, add dots on the line for 10% poverty. Add a dot at the spot for 10% poverty and 10^{th} percentile score; 10% poverty and 15^{th} percentile score; etc. Then do the same thing for 20% poverty…. Now you can see that poverty does NOT PREDICT the percentile scores in math. The math scores can be **anything**—they can range from 10^{th} to 90^{th} percentile when poverty is high OR low.

Check. But what does the PLOT of the two values for each school (%poverty/percentile score) show? If poverty is only 10%, are there any very low percentile ranks?...

No, math percentile starts at the 60^{th} percentile.

Check. But where do the math percentile scores start when schools are at 90% poverty?...

At the 20^{th} percentile.

Check. Make a general statement about the relationship between poverty and math percentile?....

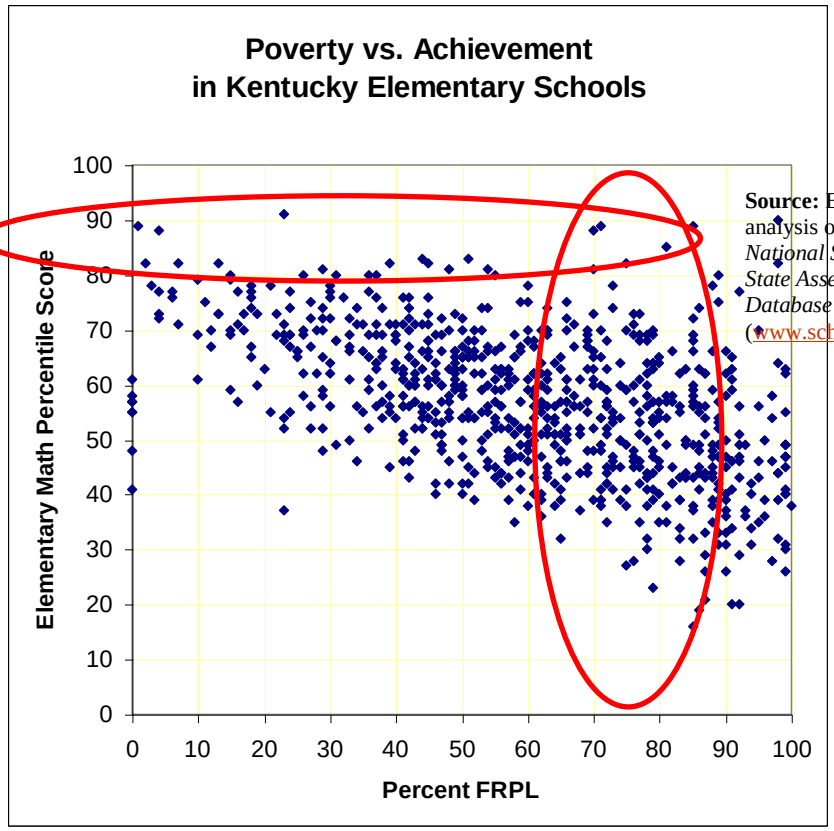
"The lower the percentage of students in poverty (measured by free and reduced lunch), the higher the percentile rankings in math. But the higher "The lower the percentage of students in poverty (measured by free and reduced lunch), the lower the percentile rankings in math."

Check. Now make a general statement about the RANGE of percentile score in math in relation to low (10%) and high (90%) poverty. What are the lowest and highest percentile ranking for schools with 10% vs. schools with 90% poverty?....
"Schools with low poverty (10%) have percentile scores in math that range from 60 to 80th percentile, or 20 points. Schools with high poverty (90%) have percentile scores in math that range from 20 to 80th percentile, or ***60 points****.* ***So the range of scores is larger for high poverty schools."***

13. **We can show the relationship between poverty and math scores by drawing a line (a best fit line) that BEST FITS the data—the plotted points.** Notice how the red line **cuts through the points** so that about half are above it and half are below it. This line shows the GENERAL relationship or the TREND. It says, "The lower the poverty the higher the math scores, and the higher the poverty the lower the math scores."

Check. But does poverty COMPLETELY PREDICT and CONTROL math achievement?...
NO!
Check. Why?
Because there are some high-poverty schools whose students have high percentile math ranking.

This is shown on the graph below, which is slide 35 from "Don't turn back the clock." Washington, DC: The Education Trust, 2003.



Source: Education Trust analysis of data from *National School-Level State Assessment Score Database* (www.schooldata.org).

The red oval on the right surrounds high poverty schools. **It shows that their math scores have a wide range, from low to high percentile.**

But look at the red oval across the top…. It shows that ***some high poverty schools have math scores that are just as high as the low poverty schools!*** Do you see that? Some low poverty schools have math scores in the 90th percentile, and some HIGH poverty schools ALSO have students who score in the 90th percentile.

Also notice that there are some LOW poverty schools that have low math scores.

Check. What does this say? Does poverty ENSURE that students WILL NOT learn math? Does going to a school whose students are mostly middle and upper class and ensure that students will learn math?...
NO.

Check. Well, if some high poverty schools have students who have high math scores, HOW COME?...
The likely answer is well-designed curriculum, instruction, and classroom environments. Specifically, it is very likely that teachers and administrators:

1. Examined the scientific research, and consulted math experts on what are the important features of curriculum materials and instructional methods.
2. Selected curriculum materials and instructional methods that have those features.
3. Selected curriculum materials and instructional methods that have been field tested in a scientific way, and are shown to be effective again and

again (that is, are reliably effective with students who are like the ones in the schools that will use the materials and methods).

4. Trained teachers to use the curriculum materials and instructional methods proficiently.
5. Provided timely supervision and assistance to improve proficiency.
6. Frequently assessed students' progress and adjusted instruction accordingly; for example, gave some students extra math sessions; used additional curriculum materials that focused on weak prior knowledge. increased the amount of practice on new skills.

Check. And if some LOW poverty schools have students who received LOW math scores, how come?...

The likely answer is poorly-designed curriculum, poorly-designed instruction, and poorly-designed classroom environments.