Data Explorations in Ecology: What do students know, and need to know, in order to make environmental citizenship decisions?

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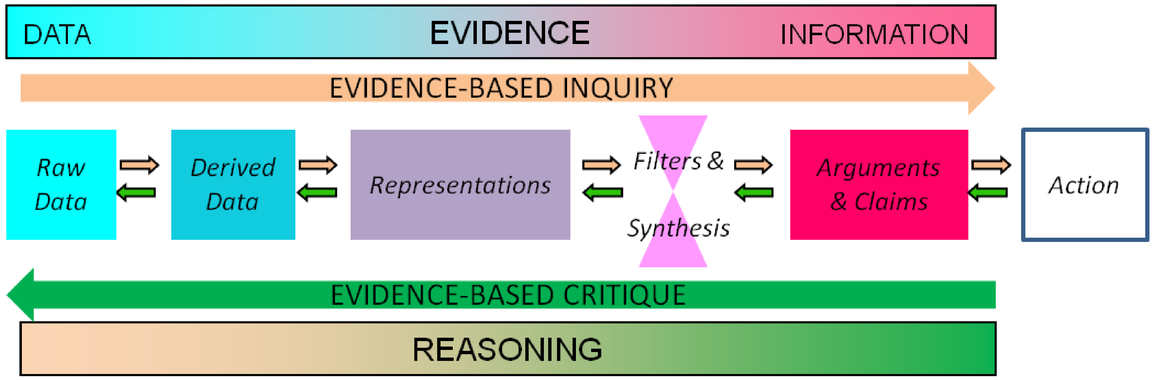
Background

We are exploring how to help high school teachers and students make sense from data they collect themselves (first hand data) and get from the internet or other sources (second hand data). Our conceptual framework recognizes two "directions" of data exploration (inquiry and critique) and the distinct but interacting facets of the process (collecting and dealing with raw data, data transformations, analyses and representations, filtering evidence, making claims based on data). This framework helps teachers and their students see the context of their explorations when dealing with first versus second hand data. We have formed a professional learning community (PLC) of seasoned biology and environmental science teachers to help us investigate different sequences and types of supports for student data exploration. To date, we have piloted several instructional modules, and continue to revise and refine our instructional materials, professional development plans, and assessment tools.

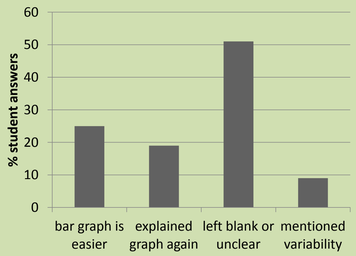


Our diagram is used in professional development to help teachers gain a conceptual understanding of how scientists use data to develop information. We have found this diagram to be very helpful in focusing teachers' attention to where in the data exploration process they spend most of their classroom time, and how to better help students gain an appreciation for the ways in which scientific arguments can be critiqued.

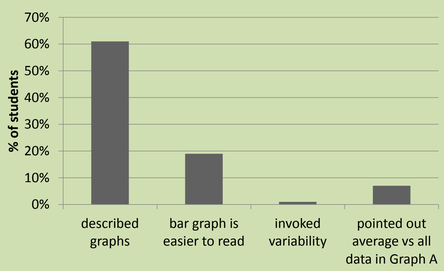
Results

What do students understand about data exploration?

1. When asked to identify which period in Figure 1 had the most variability, 86% of students were able to correctly do so.
2. When asked what variability is (open-ended question), 72% of students were able to explain it.
3. However, when asked to apply these ideas (using Figure 2), 77% of students did not invoke variability. Instead, when asked to explain **"How does a bar graph compare with a scatter plot, in terms of variability?"** they thought that :



1. When we asked students to explain the differences between the scatter plot and the bar graph, they:



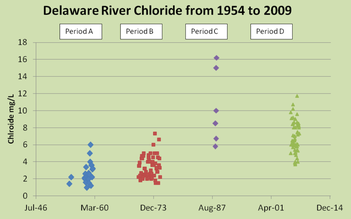


Figure 1: Which period has the most variability?

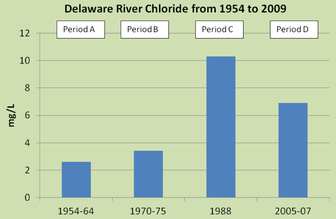


Figure 2: How does the scatter plot compare with bar graph in terms of showing variability?

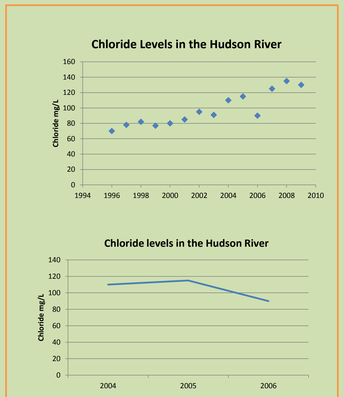
How does data exploration relate to environmental citizenship?

When students were asked to interpret the second graph on the right, and explain whether they agreed or disagreed with the salt company's claim that there are no problems with salt pollution in the river, 43% of students disagreed, while 30% agreed.

Of those who **disagreed**, the most common reasons were:

1) The graph shows a shorter time period OR student pointed out that the dataset is smaller (30%)
2) Induced error (21%)

For students who **agreed**, the most common reason (47%), was that the graph showed a decrease in chloride levels.



A member of a local trucking company, who is employed to spread salt on the town's roads, comes to the town council meeting and says that the town does not need to stop spreading salt. The trucking company employee shows the town council data from your study, shown at right. According to the trucking company employee, this evidence supports his claim that the town does not need to stop spreading salt. Do you agree or disagree with his claim? Explain your answer.

How does data exploration affect students' interest, attitudes and motivation? (N= 142)

Interest in and influence of salt module on… (scale: 0 to 4, 0=not at all, 4=extremely interested or influenced	Median
Interest in Making sense of my own data	3
Influence of salt lesson on interest in Making sense of my own data	3
Influence of salt lesson on ability to Making sense of my own data	3
Interest in Identifying sources of variability in my data	2
Influence of salt lesson on interest in Identifying sources of variability in my data	2
Influence of salt lesson on ability to Identifying sources of variability in my data	2
Interest in Using my own or other people's data to evaluate a scientific claim or argument	3
Influence of salt lesson on interest in Using my own or other people's data to evaluate a scientific claim or argument	2
Influence of salt lesson on ability to Using my own or other people's data to evaluate a scientific claim or argument	2

Attitudes and Motivation (scale: 1 to 5 scale, 1=strongly disagree, 5=strongly agree)	Median
learning about salt levels in our water sources is relevant to my life	4
i enjoyed the salt lesson because we learned in several different ways	4
the salt lesson made me think about the importance of understanding causes and effects of pollution	4
i enjoyed the salt lessons because we were involved in discussions	3
learning about salt levels in our water sources has practical value for me	3
the salt lessons made me think about the importance of collecting my own data	3
i enjoyed the salt lessons because the activities were challenging	3
the salt lessons made me think about the importance of participating in experiments or investigations in science	4
Learning about chloride (salt) levels in our water sources is relevant to my life	4
the salt lessons gave me an opportunity to learn from other people's data	4

Current teaching modules include:

- Salt pollution in Freshwater Streams
- Ecological Consequences of Hydrofracking
- Biodiversity of Hudson River Fish
- Acidity Changes in Local Waters
- Soil Lead Contamination

Conclusions

…about data exploration

- Students know what variability is, and how to identify it, but they don't know how to apply that information or why it is important in scientific studies.
- Students find bar graphs easier to read than scatter plots.
- Students are very comfortable invoking induced error as opposed to real error.
- Students believe that graphs = truth, and are not critical of data that are supplied to justify a claim.

…about motivation and engagement

- Students enjoy working with their own, and with others' data.
- Students felt that the teaching modules helped them learn about something relevant, gave them an opportunity to learn from others' data, and made them think about the causes and effects of pollution.
- Students thought that the teaching module helped them make sense of their own data, and taught them the importance of conducting scientific investigations.
- Students became interested in using data to evaluate a scientific claim or argument.

Acknowledgements
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