Cary Institute of Ecosystem Studies

Data Explorations in Ecology: Students' understanding of variability and use of data in environmental citizenship

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Acknowledgements

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- Student participants
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- Cary Institute Scientists
  - Dave Strayer
  - Stuart Findlay
  - Bill Schlesinger

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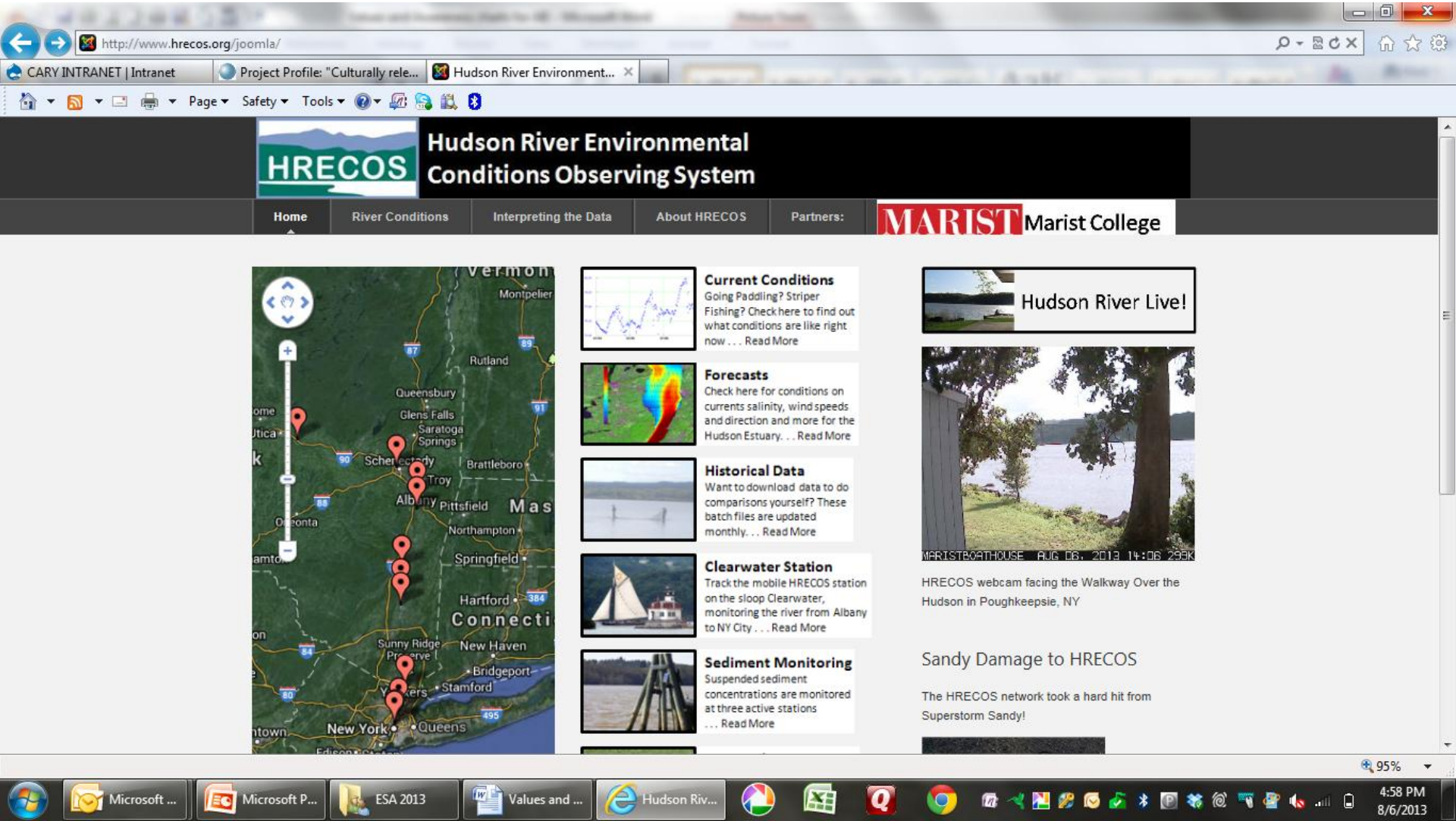
NSF

Data Exploration in Ecology Project (DEEP)

Helping middle and high school teachers and students make sense of data they collect themselves and data they get from other sources.

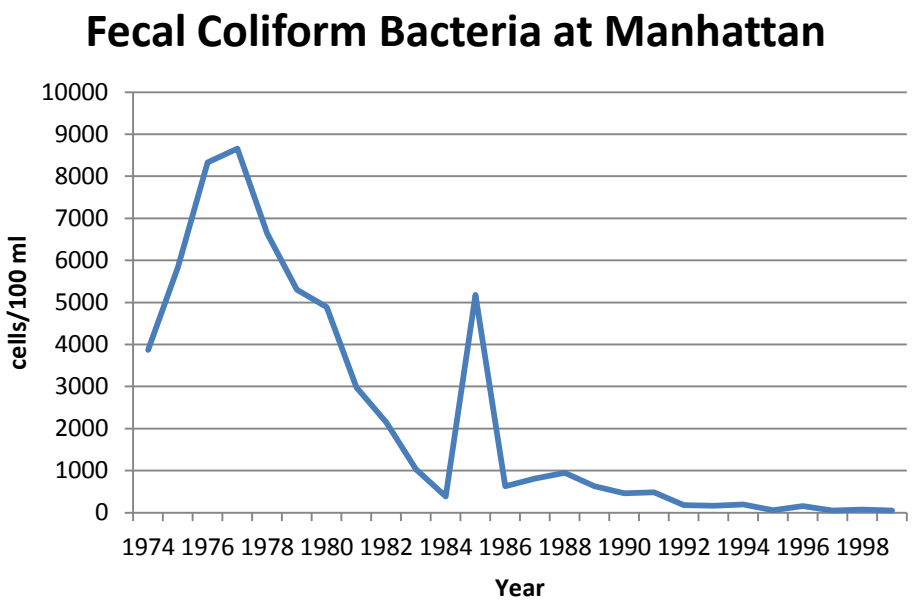
Many sources of second hand data are available …

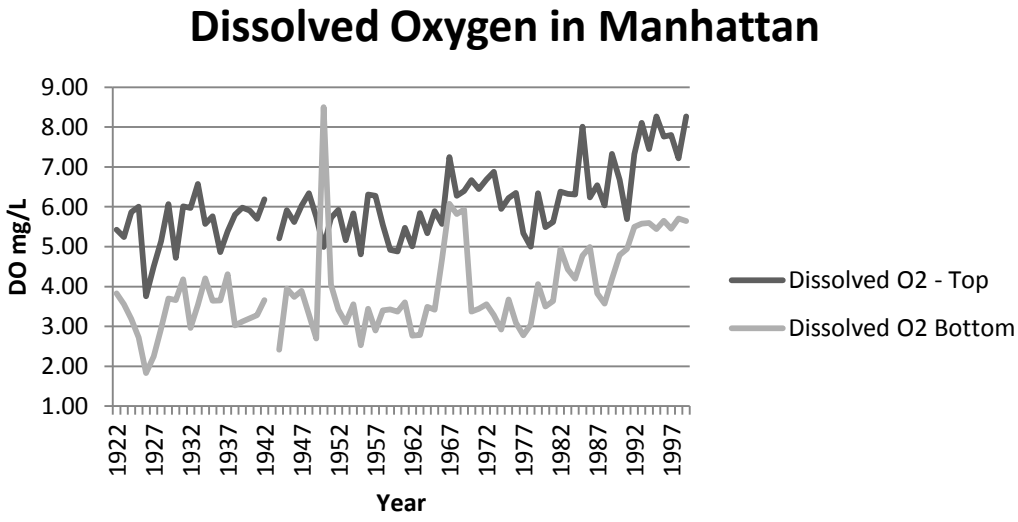


Dissolved oxygen data collected during the summers in the Hudson River off of 42nd Street, Manhattan, NY. Concentrations are averages of 8-14 samples per summer.

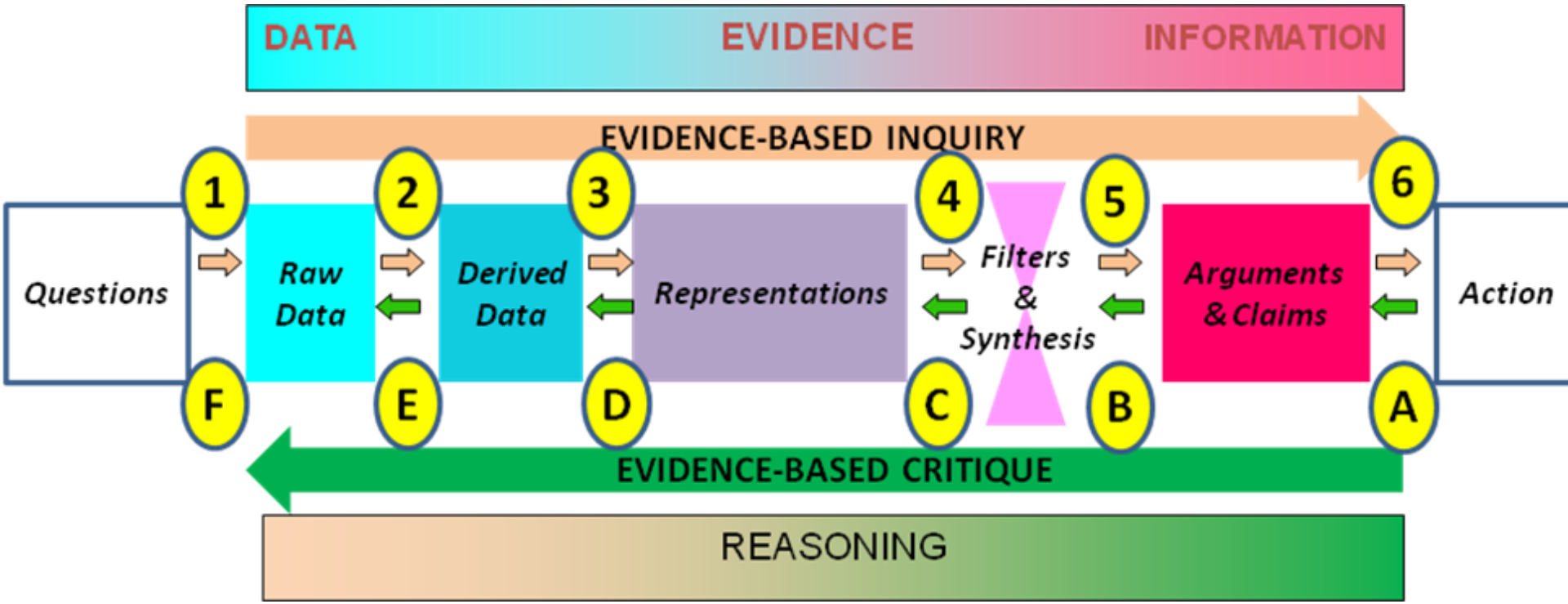
Fecal coliform bacteria also collected in the Hudson River off of 42nd Street, Manhattan, NY. Numbers represent averages of 8-14 samples per summer.

YEAR	Dissolved O2 - Top	Dissolved O2 Bottom
1922	5.43	3.825453735
1923	5.24	3.55
1924	5.87	3.19
1925	6.00	2.72
1926	3.76	1.83
1927	4.50	2.25
1928	5.14	2.95
1929	6.07	3.70
1930	4.72	3.66
1931	6.01	4.18
1932	5.97	2.96
1933	6.57	3.54
1934	5.57	4.21
1935	5.76	3.64
1936	4.86	3.65
1937	5.38	4.31
1938	5.80	3.03
1939	5.98	3.12
1940	5.91	3.20
1941	5.70	3.28
1942	6.19	3.66
1943		
1944	5.21	2.42
1945	5.91	3.95
1946	5.62	3.74





An Evidence- and Reasoning-Based Critique and Inquiry Framework



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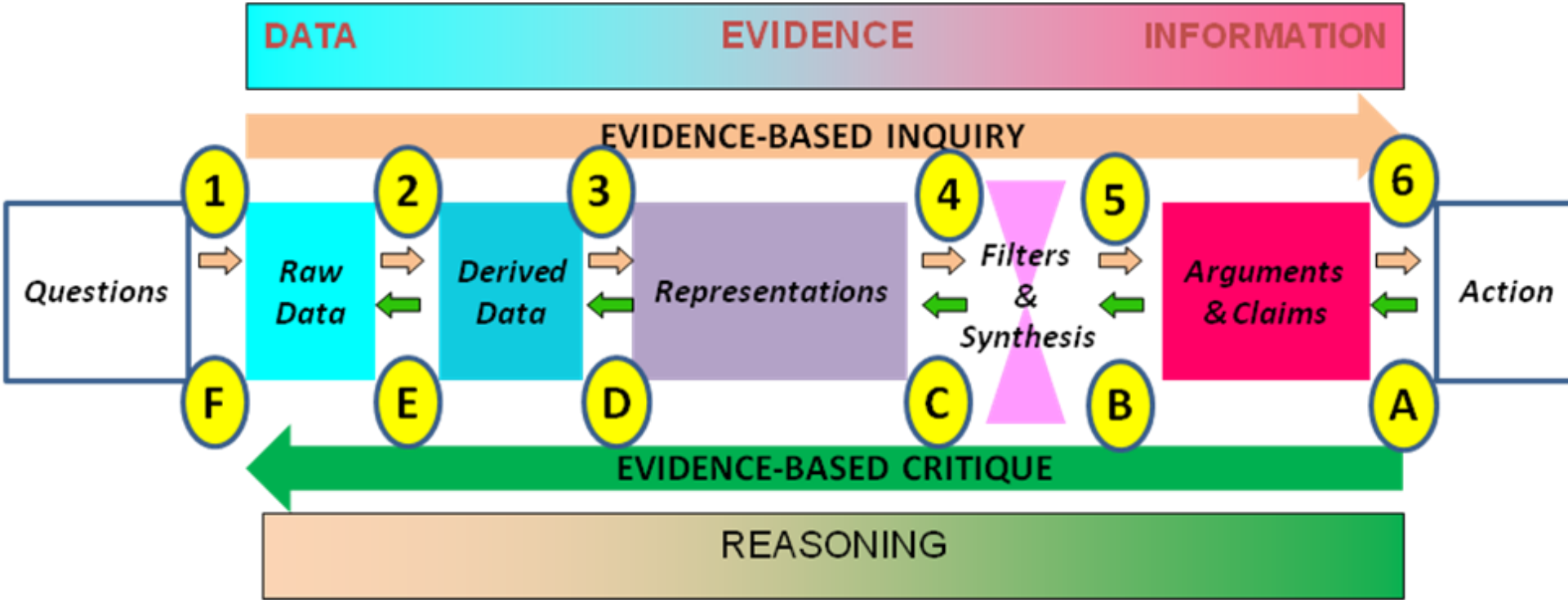


Inquiry Practices:

1. Primary research – question/hypotheses, study design, data collection
2. Data manipulation – descriptive statistics, sub-setting data, indices
3. Summarizing results – graphing, diagrams, tables, bottom line
4. Filtering results – selecting salient, relevant, and reliable results
5. Synthesizing – combining, integrating, meta-analysis
6. Communicating and recommending

Research Questions

1) What skills do students have for data exploration and how do they learn these skills?

Specifically, what do students understand about the concept of *variability* in data exploration?

2) What skills do students have for critiquing arguments in a citizenship context?

Specifically, do students use their data exploration and inquiry skills and knowledge when criticizing or evaluating claims?

Methods

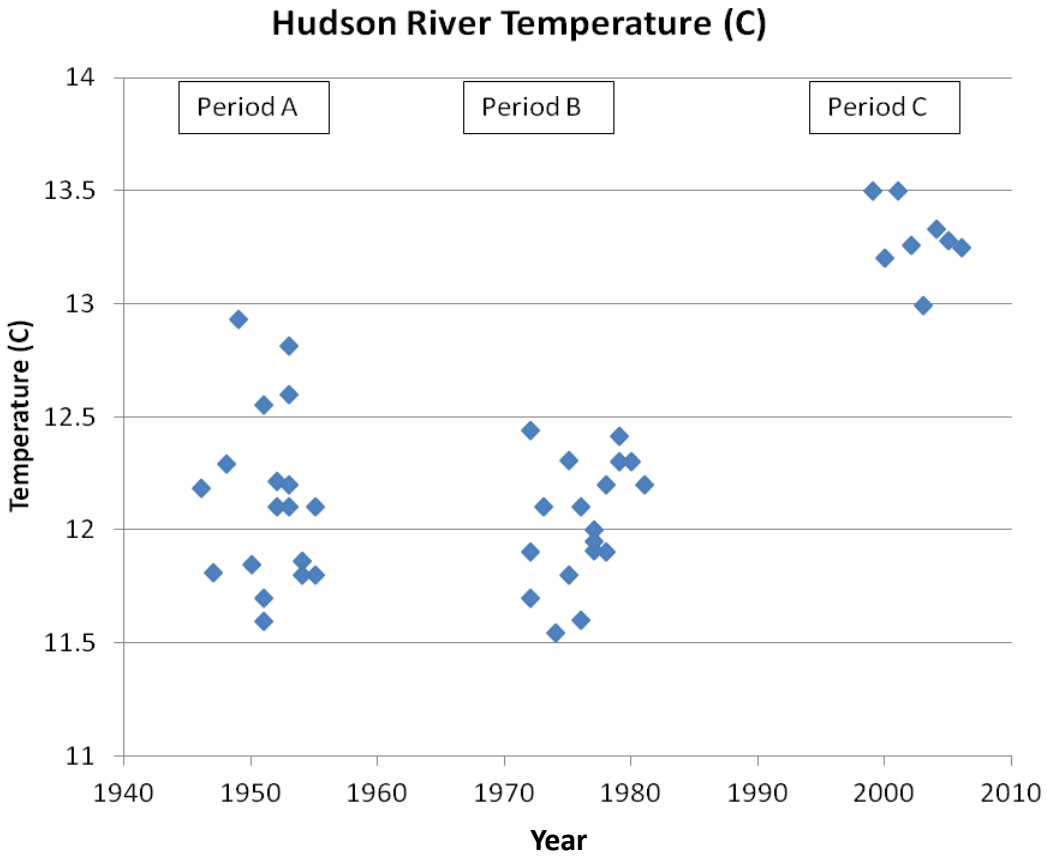
- Form a Professional Learning Community (PLC) of 14 DEEP teachers from NY and CT
- Engage over 600 student participants in 5-8 lesson modules exploring issues – hydrofracking, salt, etc.
- Administer assessments
  - pre- and post-tests of student's data exploration and critiquing proficiency, attitudes and perceptions of the learning experience
  - end-of-module "Critique and Inquiry Assignments" in response to arguments from the scientific or popular press about issues
- Code responses for key progress variables of interest

What do students understand about the concept of ***variability*** in data exploration?

- Recognition
  - can judge relative amounts of variability
- Reasoning
  - can explain their judgments about variability
  - can discuss sources of variability
- Importance
  - appreciates the importance of variability

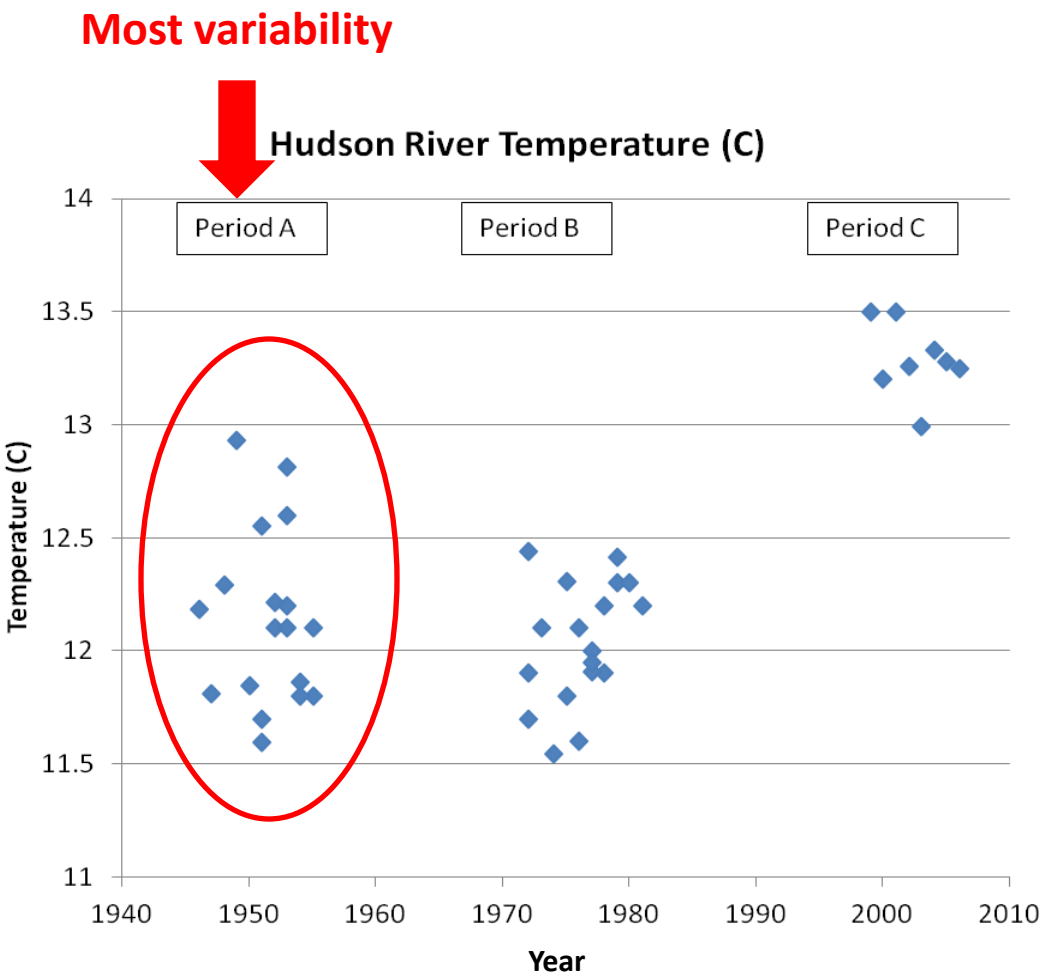
Recognizing variability

1. Look at the temperature data at different times within EACH of the three periods. Compare them and then decide which period shows the most variability. *Explain why you picked that period.*

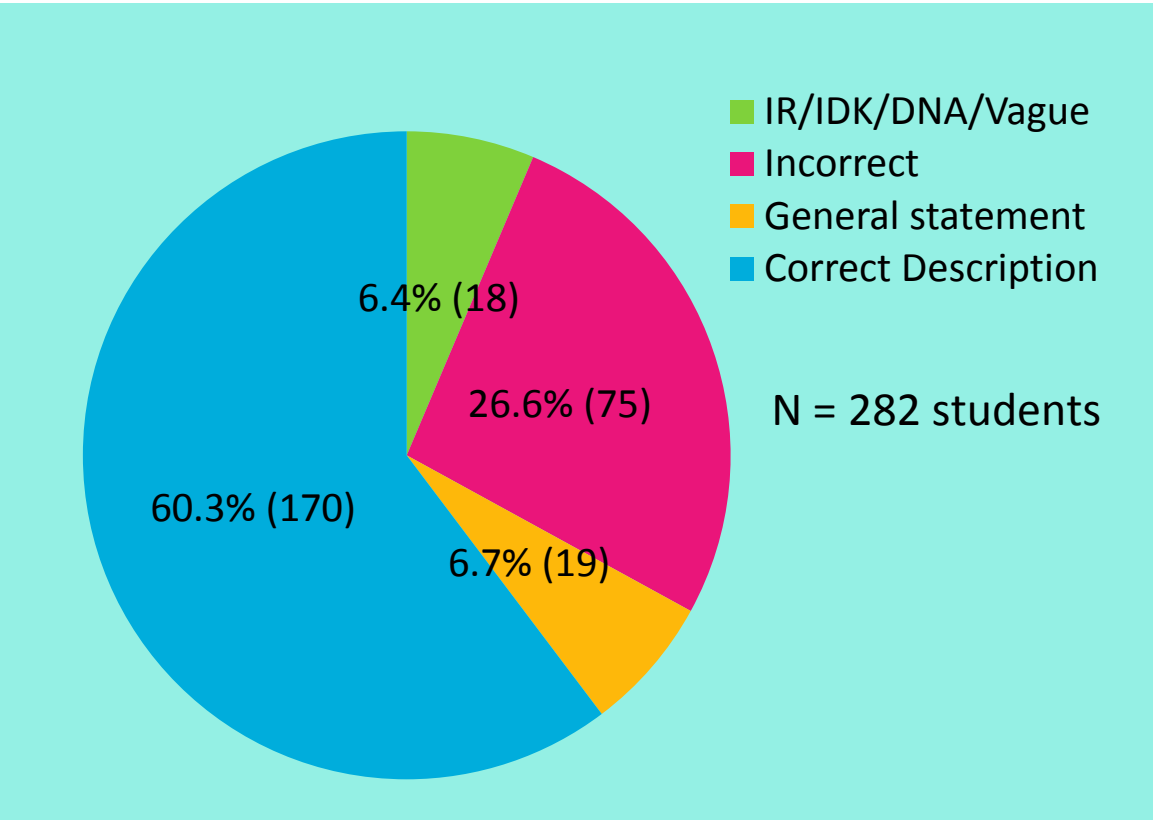


70-80% of students recognize variability

1. Look at the temperature data at different times within EACH of the three periods. Compare them and then decide which period shows the most variability. *Explain why you picked that period.*



Reasoning about variability



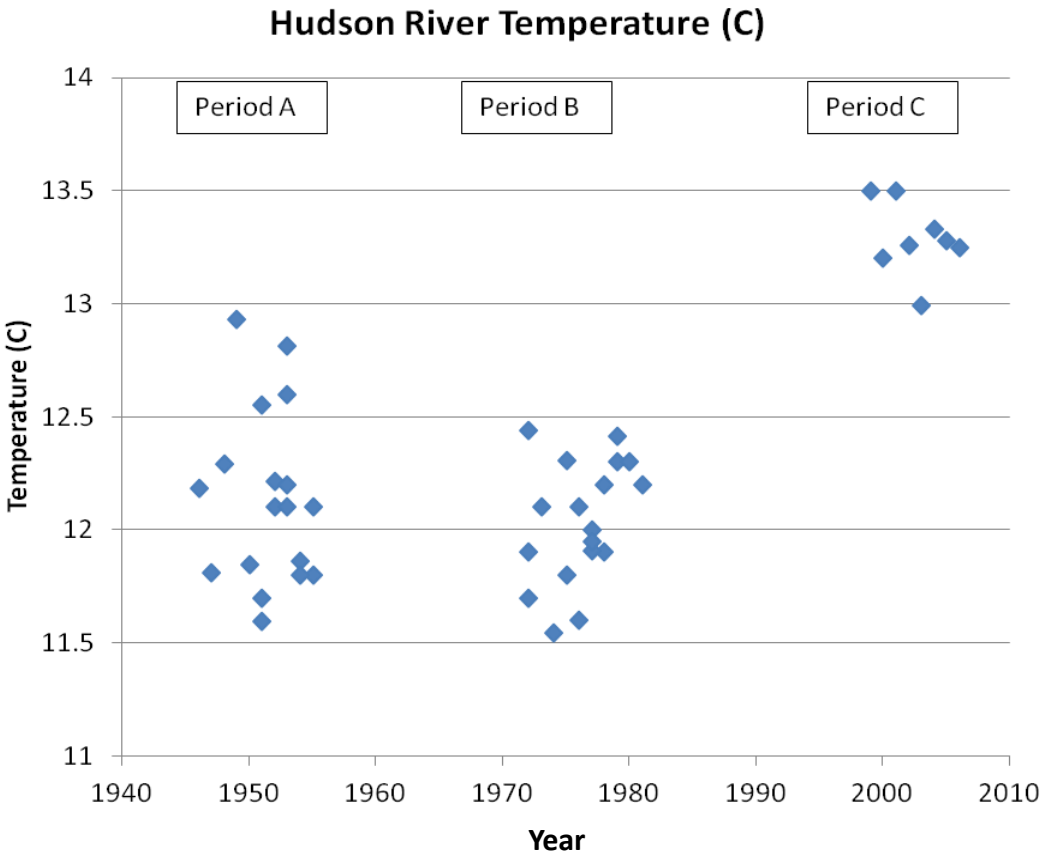
Examplars:

IR/IDK/DNA/Vague:
c is my favorite letter
Incorrect:
Period A has the most points
General statement w/o reasoning:
the temp is more varied

Correct statement with reasoning:
The diamonds are more spread out; The points are the most diverse and spread as compared to Period C, where the points are clustered closely together; … period A had the most variability because it goes from 11.5 all the way to 13 and the rest are a lot shorter

Understanding sources of variability

2. List at least two possible causes of the variability in temperature measurements within any given time period.



Sources of Variability - Exemplars

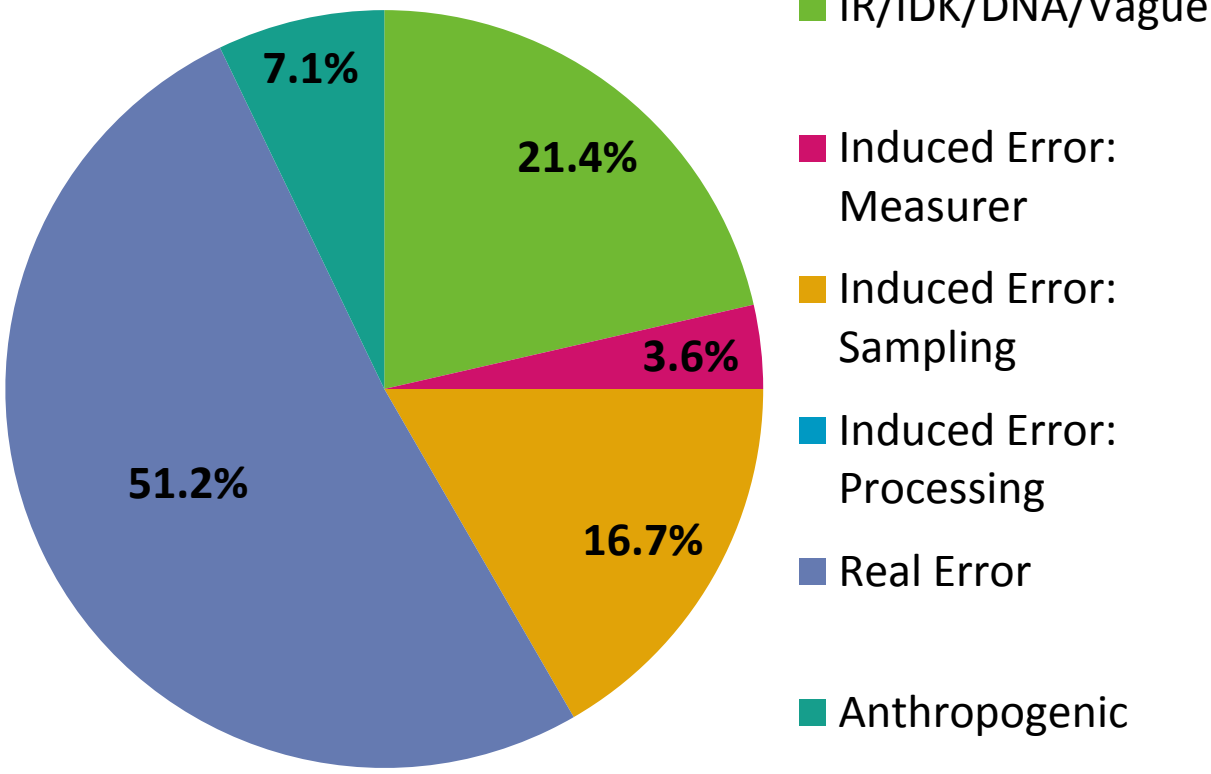
- **Induced**-errors introduced in data collection, processing

  Measurement
  - *quality of equipment was different back then;*
  - *Mistakes made by the data takers*

  Sampling
  - *The time of day the sample was taken,*
  - *the part of the river the sample was taken from*
- **Real-**variability in the phenomenon being measured
  - *Started raising because global warming;*
  - *Natural changes in seasons.*
- **Anthropogenic-**variability caused by human impacts
  - *Increase in polution;*
  - *trash*

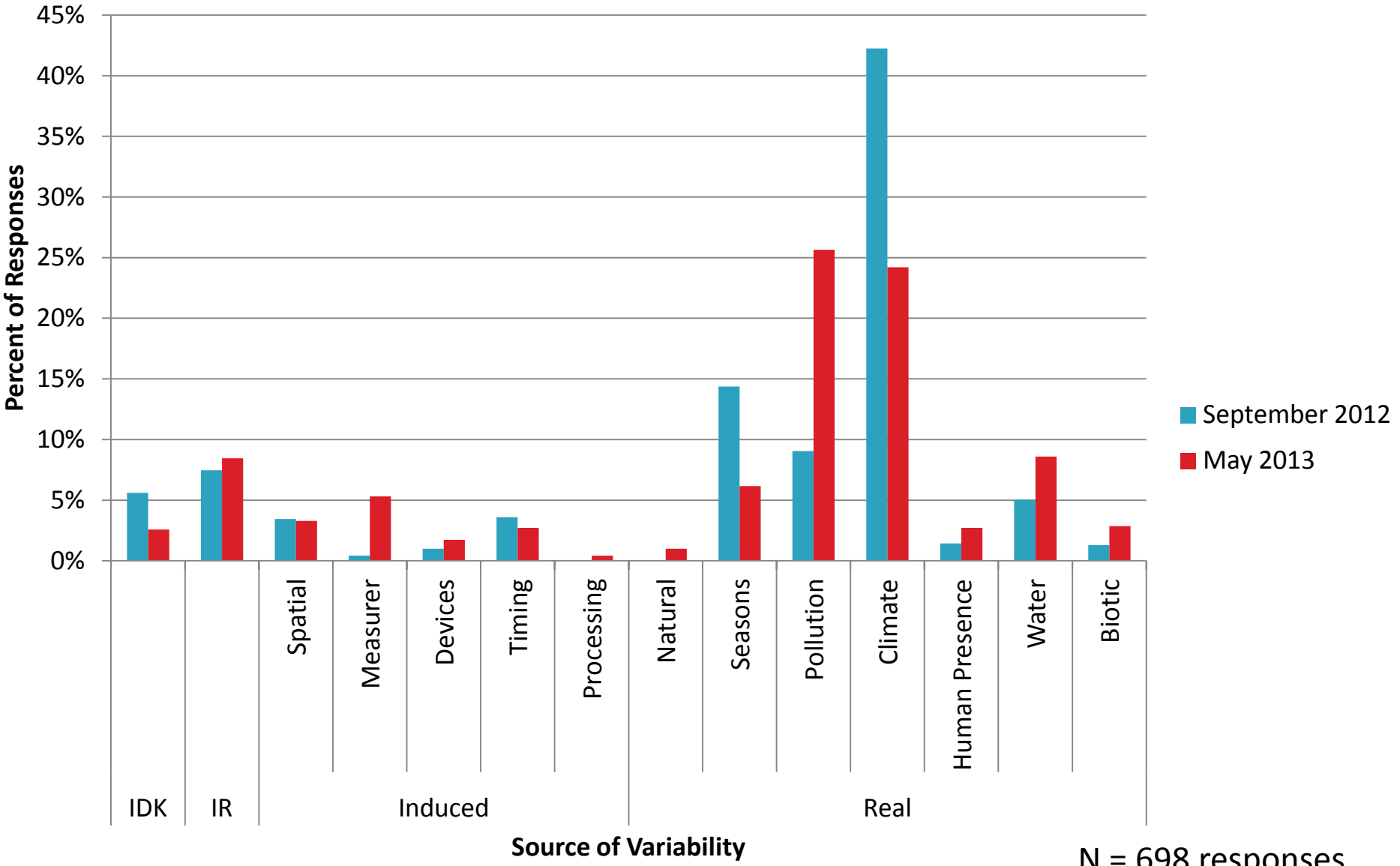
Student-Listed Sources of Variability

- **Induced** = errors or variability introduced in data collection, processing
- **Real** = variability in the phenomena or parameter being measured
- **Anthropogenic** = variability caused by human impacts on the environment



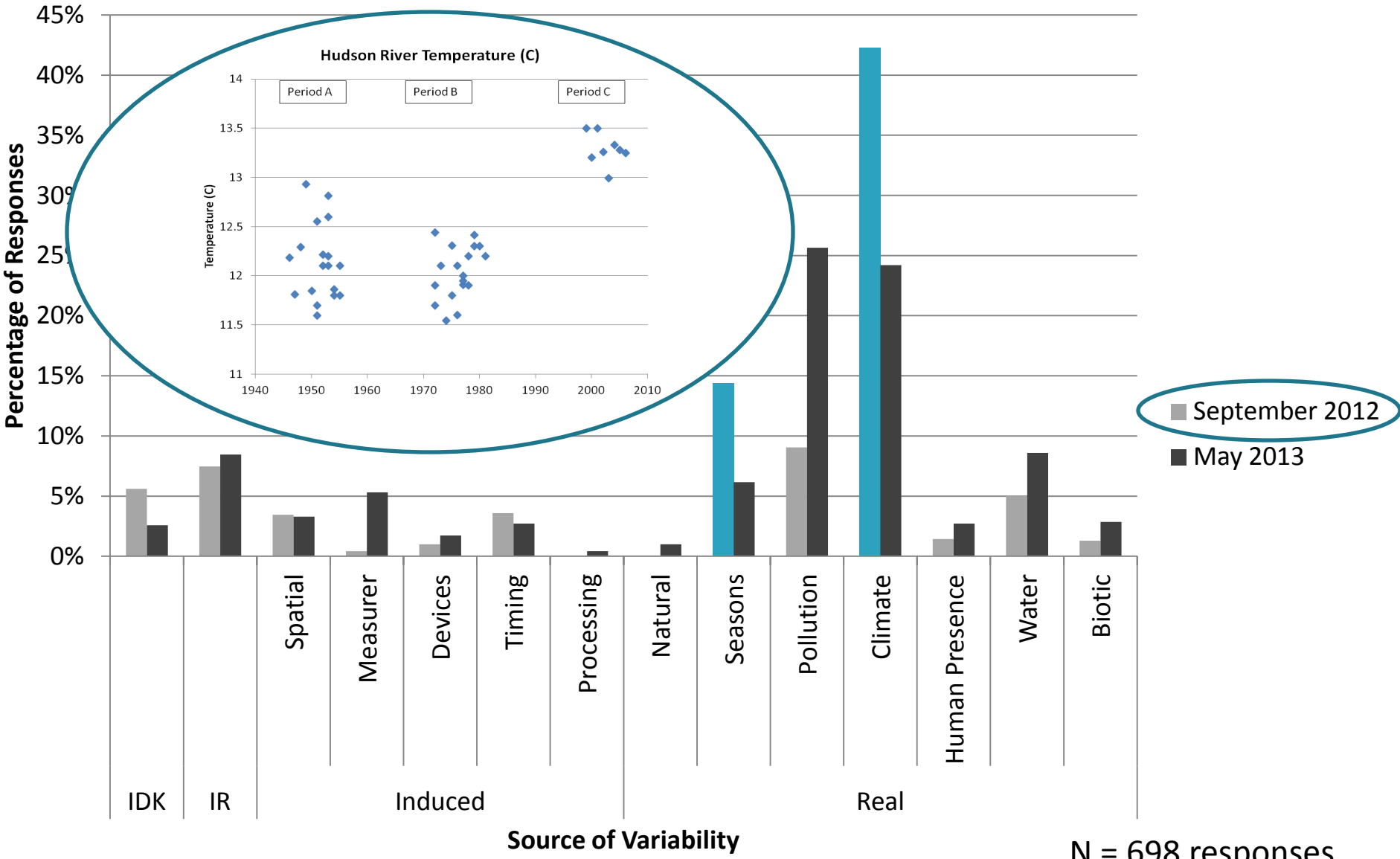
N = 252 students

Sources of Variability



N = 698 responses

Sources of Variability



N = 698 responses

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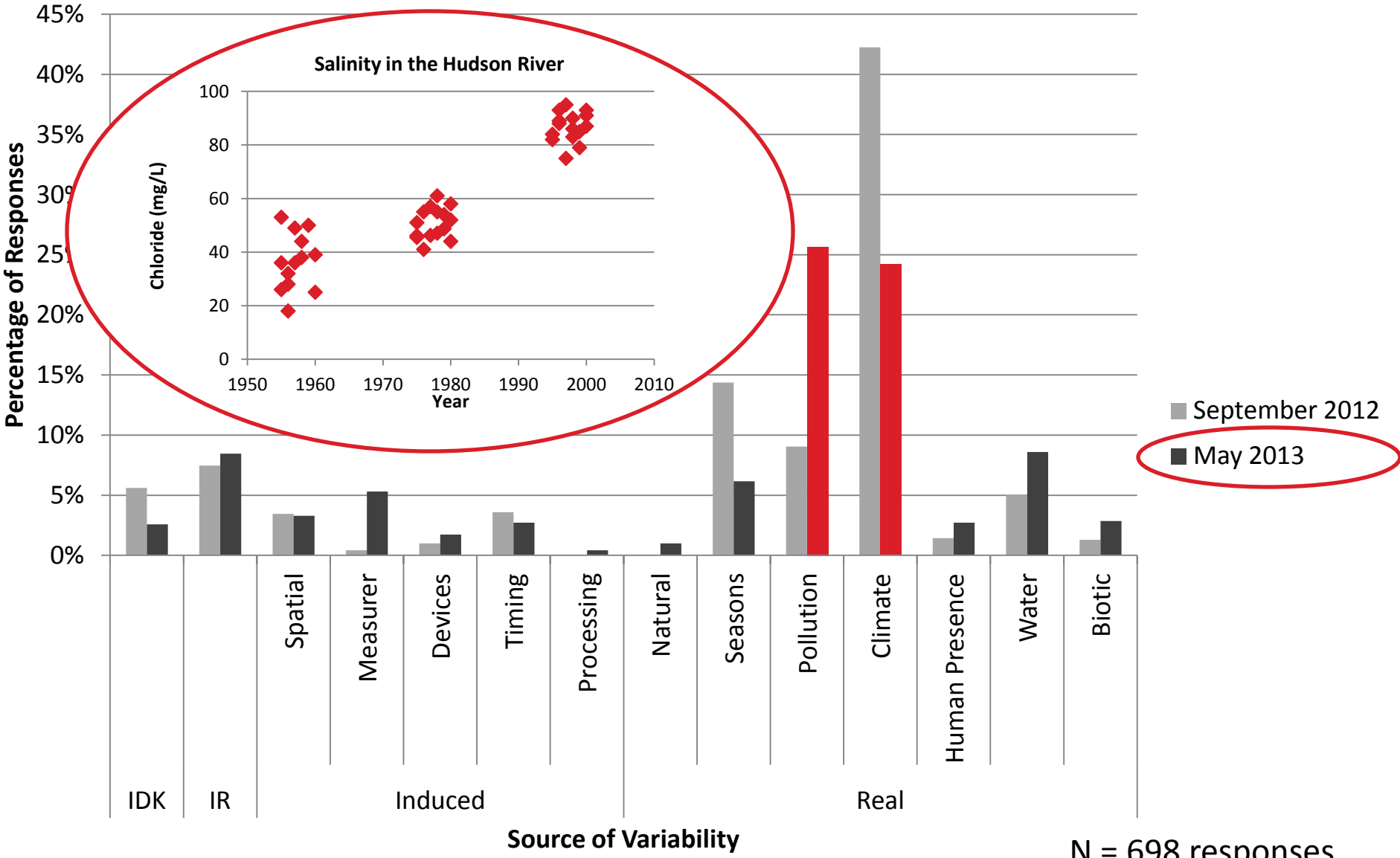


N = 698 responses

Why is it important to think about variability in a set of data?

Limited Reasoning

- **Answers a question**
  - *Maybe so that you can answer the questions asked*

Ecological Reasoning:

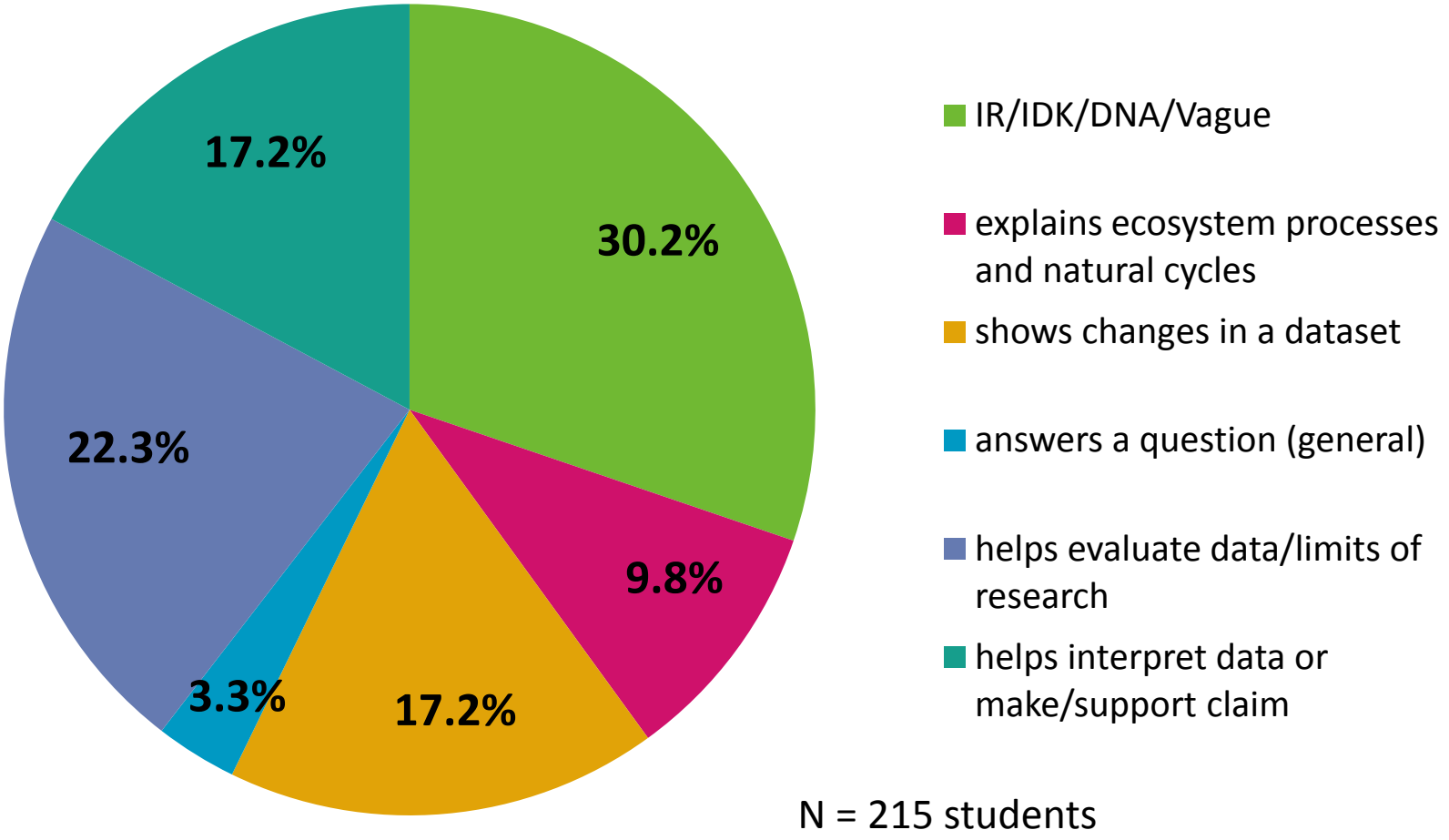
- **Explain ecosystem processes:**
  - "The variability of data could help to explain a natural cycle and to understand how the ecosystem works.."

Why is it important to think about variability in a set of data?

Quantitative reasoning:

- **Shows changes in dataset:**
  - *Variability is important because it shows that the data wasn't the same over a period of time*
- **Helps evaluate data:**
  - *The variability is important because their are many factors to change your results that cause variability*
  - *To know how accurate the data is.*
- **Helps interpret data/support/make a claim:**
  - *The less variability in a set of data, the more accurate the information will be.*

Importance of Variability



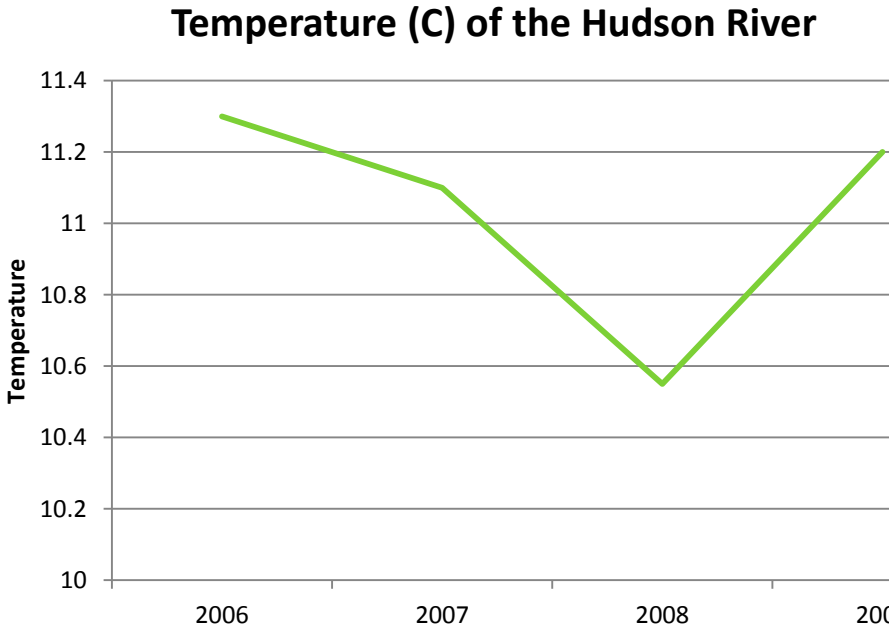
N = 215 students

How does data exploration relate to **environmental citizenship**?

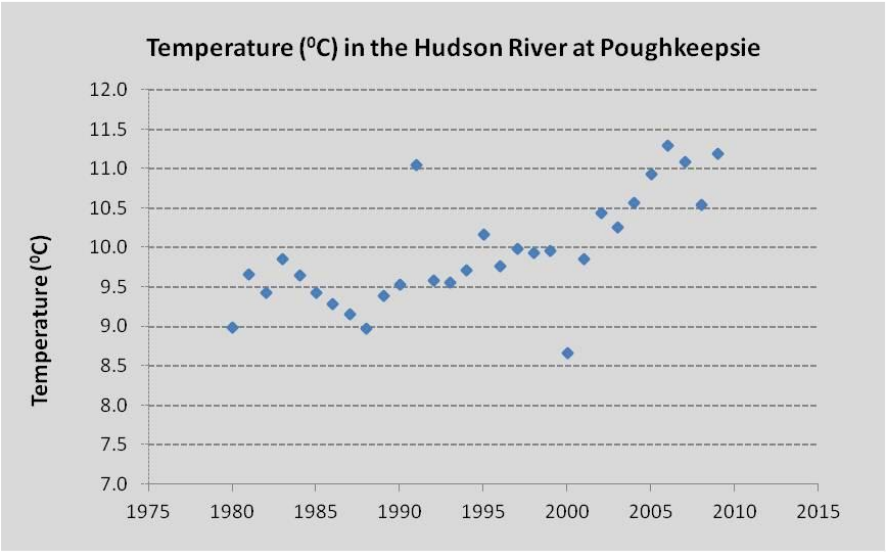
Critiquing a Claim

A local factory owner is trying to get a permit to discharge warm water into the Hudson River. He uses Graph 4 to support his claim that the water temperature of the river is variable, and thus it doesn't matter if he adds a bit more warm water to the river. Do you agree or disagree with his claim? Explain your answer, referring back to the graphs.

Graph 4

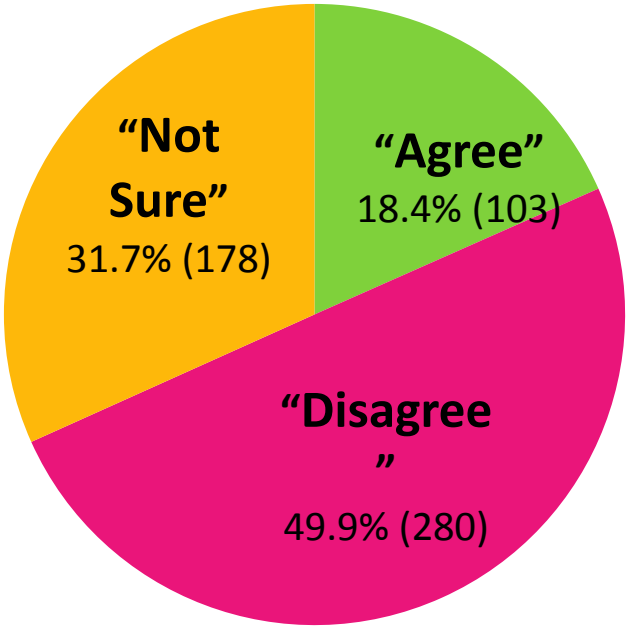


Graph 3



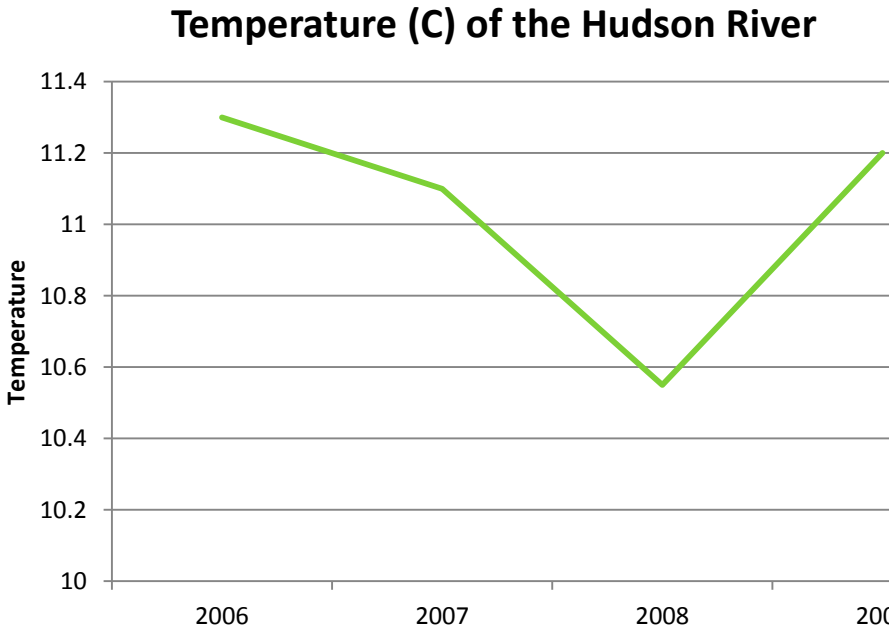
Ability to critique claims is mixed

A local factory owner is trying to get a permit to discharge warm water into the Hudson River. He uses Graph 4 to support his claim that the water temperature of the river is variable, and thus it doesn't matter if he adds a bit more warm water to the river. Do you agree or disagree with his claim? Explain your answer, referring back to the graphs.

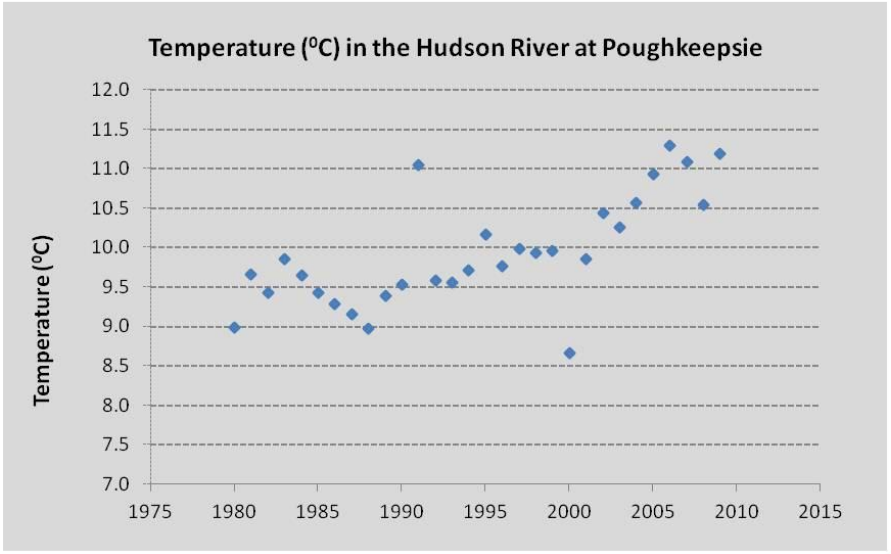


N = 561 students

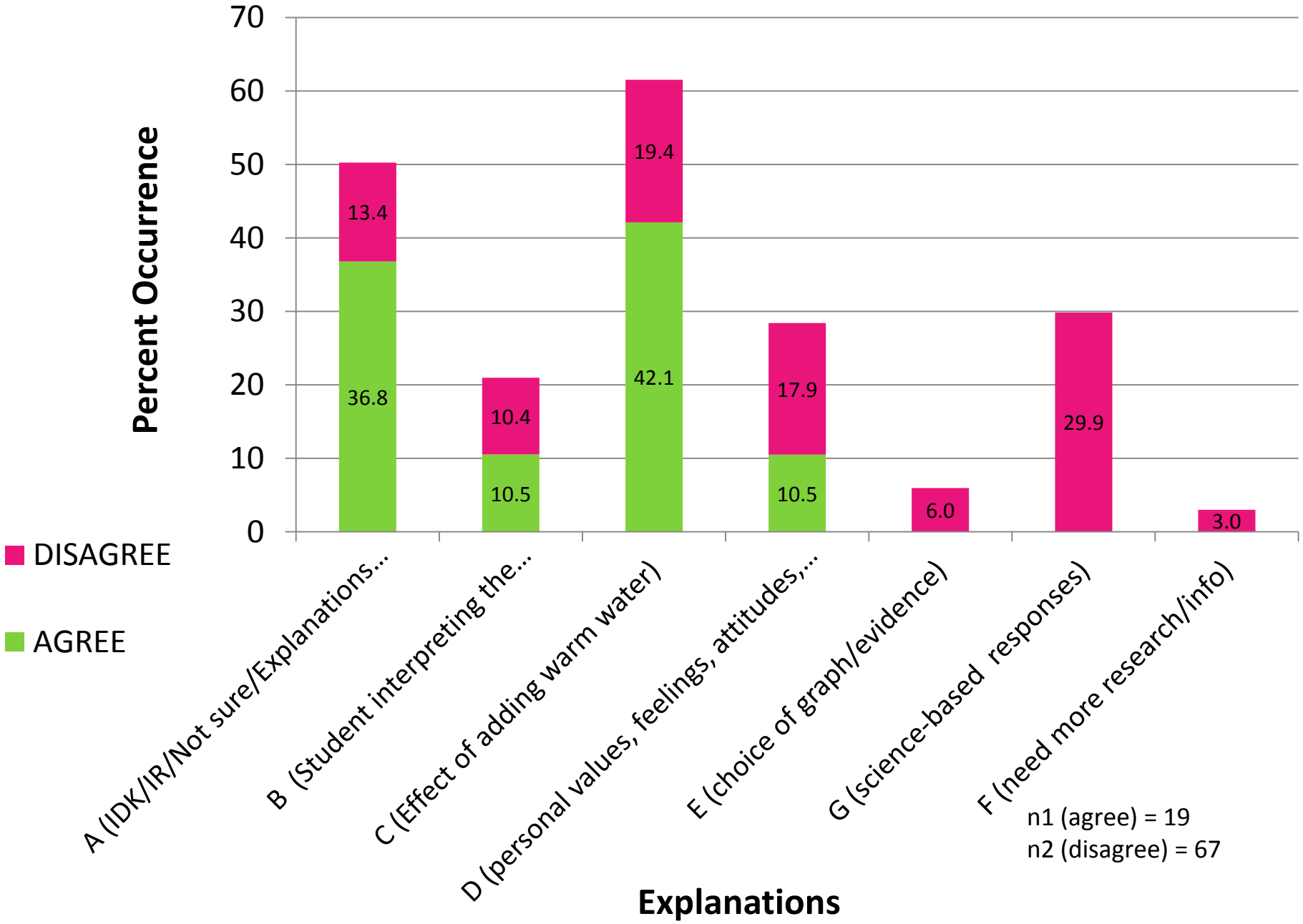
Graph 4



Graph 3



Explanations for critiques differ with nature of stance



Diverse Responses

- *Graph A only shows a small period of time where the water temperature was recorded within the river. If he observed the trends that were shown in Graph 3, he could see that there has been a clear rise in water temperature over a much larger period of time.*
- *its adding water not from the same source therefore altering the hudson's water's chemistry*
- *I agree because the graph shows that the hudson river does have a variety of temperatures*
- *I agree because there is alot of water and if he puts a little bit of warm water into the river it isn't going to make a difference.*
- *He's trying to make the water warm for certain people*
- *because that is immoral and frankly ignorant*

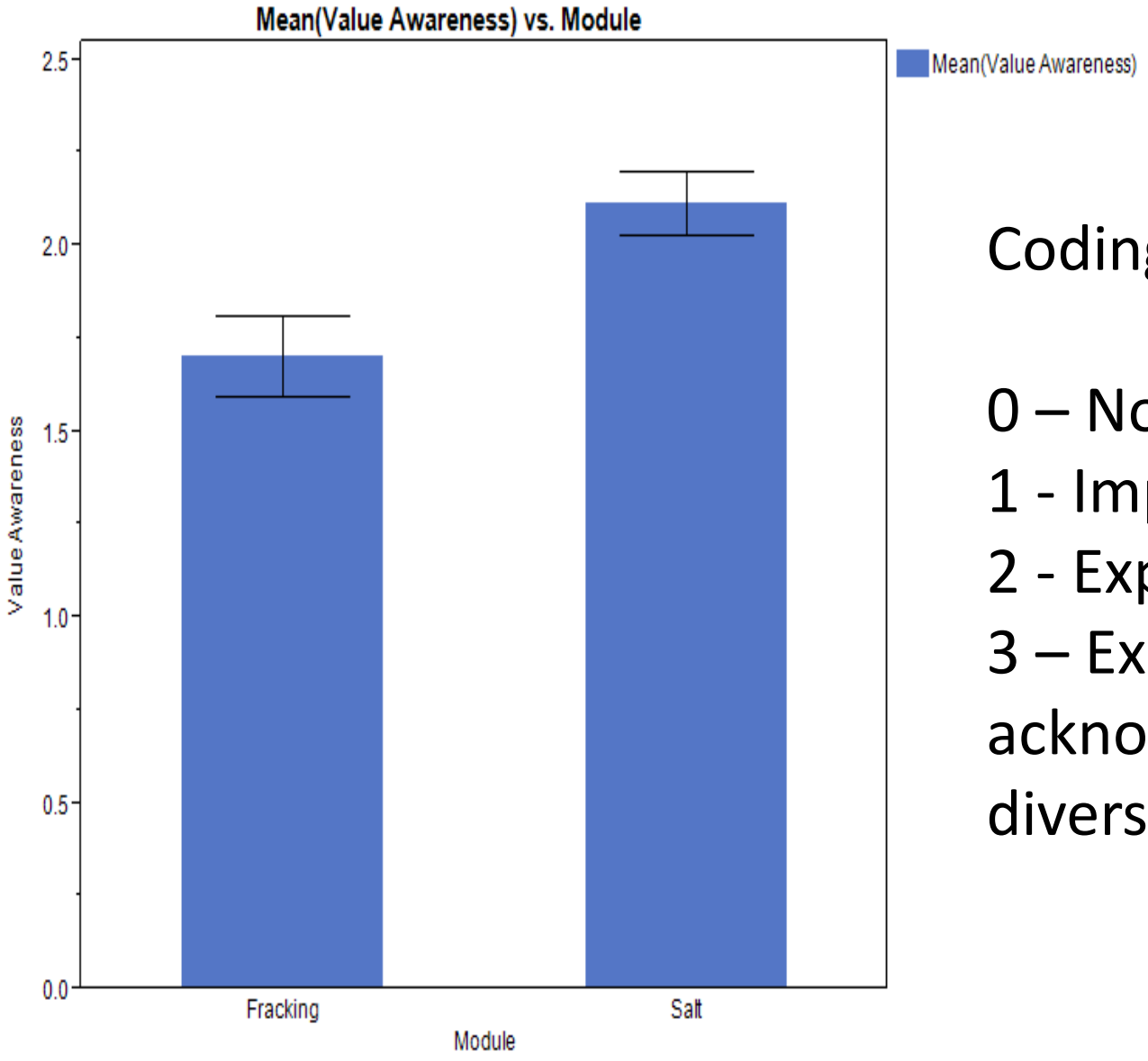
Student Final Assignment
Hydrofracking

- Consider the 5 different arguments and pick one
- Read the Argument and the article associated with it. Identify:
  - the claim
  - the evidence presented (or not) in support of the claim
  - the reasoning included that uses scientific concepts to justify or explain how the evidence supports the claim.
- Prepare a short written report with these parts:
  - Your summary (in 1 paragraph) of the claim, evidence and reasoning.
  - Your criticism of the argument based on the evidence provided and other evidence that you think is relevant. (1-2 paragraphs)
  - Your proposal for new research, using new or existing data, that would better address the question. (1-2 paragraphs)

Student Final Assignment
Hydrofracking - Arguments

- Hydrofracking is safe and proven technology and will provide lots of jobs and needed energy. (Doyle, 2010)
- Increasing the amount of natural gas that is used will benefit the environment by reducing greenhouse gases. (The Economist, 2012)
- Fracking fluids may be getting into the drinking water in Pennsylvania. (Lustgarten, 2012).
- Hydrofracking fluids likely contaminated drinking water in Wyoming, causing concern about potential health risks for the people living in the area. (Worthington, 2011).
- Regulations are not set up to manage the wastewater coming from hydrofracking operations. (Urbina, 2011)

Values Awareness in Final Assignments Differs by Topic



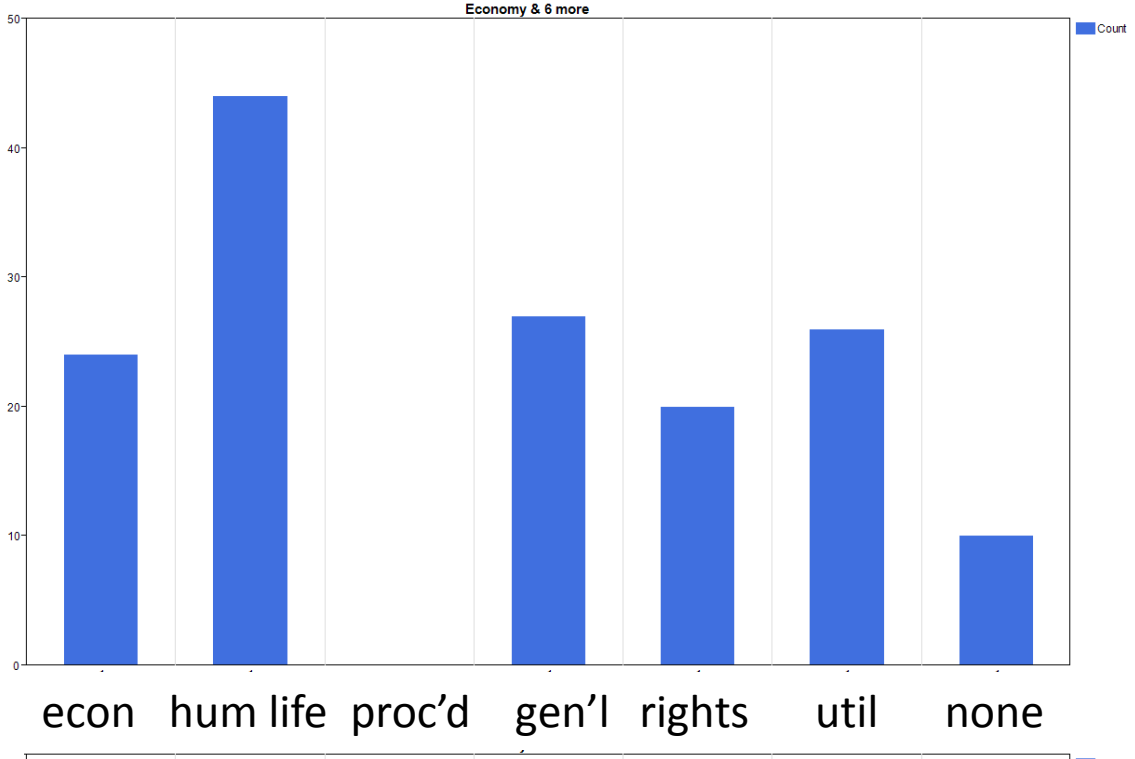
Coding Scheme:

0 – No values
1 - Implicit
2 - Explicit, self aware
3 – Explicit, acknowledging diversity

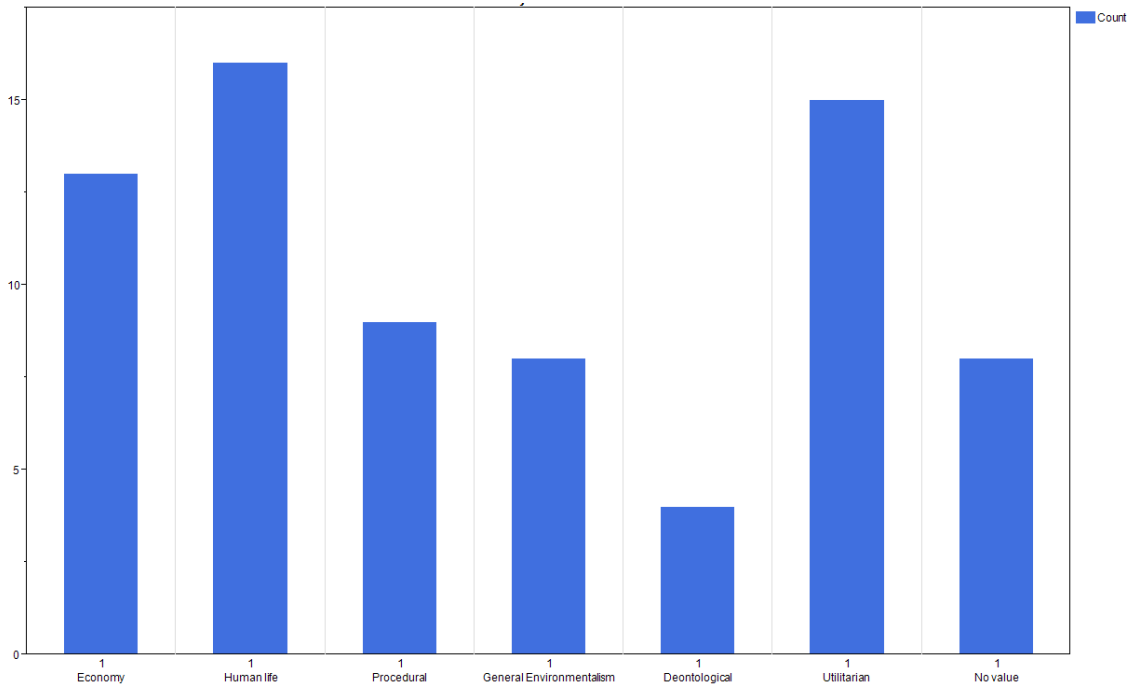
A preliminary coding scheme for values students include in final assignment papers

None mentioned	
Direct Human Benefits	Economy/Society
	Human Life
Ethics	Procedural ethics
	General Environmental
	Deontological (rights)
	Utilitarian (services)

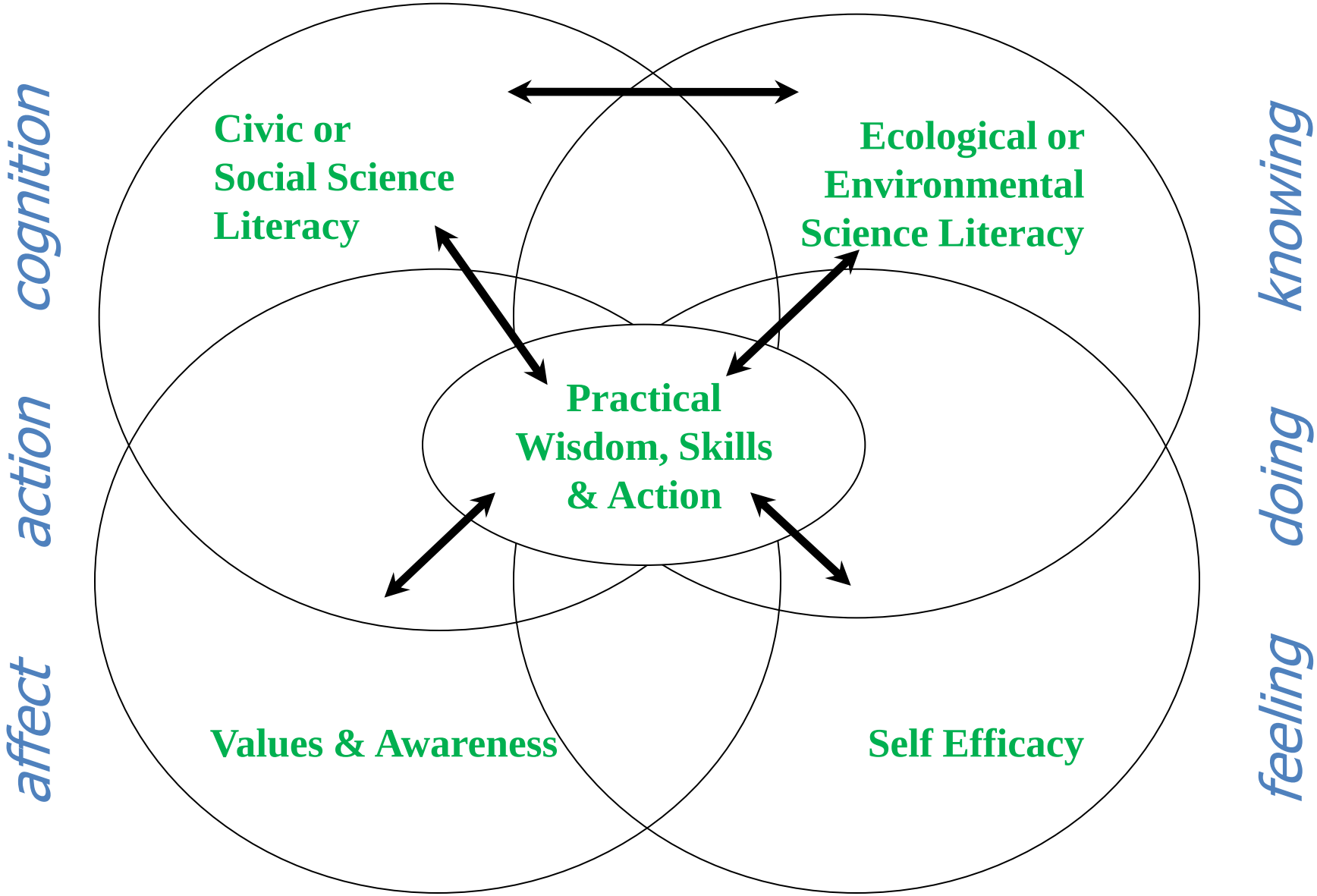
Salt



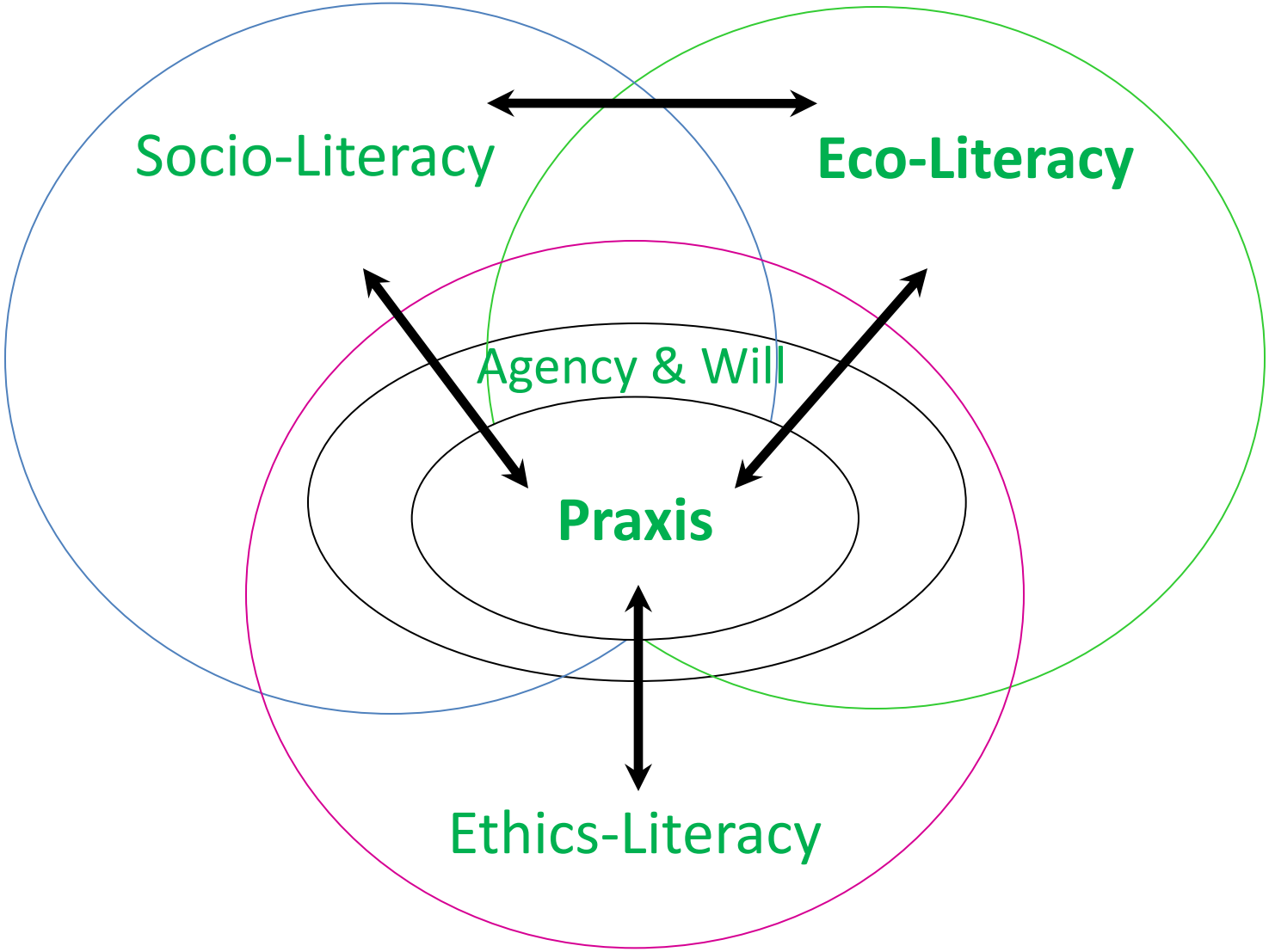
Hydrofracking



Environmental Citizenship



Environmental Citizenship - revised



Conclusions

- Students are able to identify variability, but are limited in their ability reason about or to explain it.
- Students think of real sources of variability more often than induced sources of variability.
  - But responses depend on the context of the question.
- Students are able to use graphs as evidence to critique claims related to environmental issues.
- Students bring values into their critiques of claims.
  - But they are more likely to be aware of the normative dimension in less “hot button” issues.
  - The diversity of kinds of values they cite supports the opportunity and/or need to explore values intellectually.

Questions?

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