Guiding Students to use Data to Support their Scientific Reasoning

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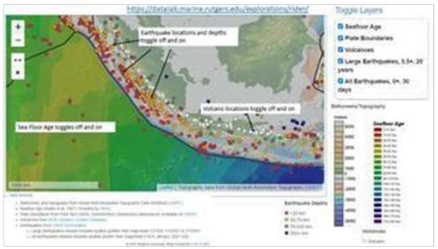
Please complete the poll so we know how to group you for later work.



Goals & Plan for Session

- provide salient background on a scaffolded approach to data literacy skills development
- engage participants in some of the steps we've used with students
- provide participants with the opportunity to begin brainstorming relevant (interactive) data sets to put these strategies to use in their own setting

Resources you can "take home": lesson plans, access to data widgets, rubric

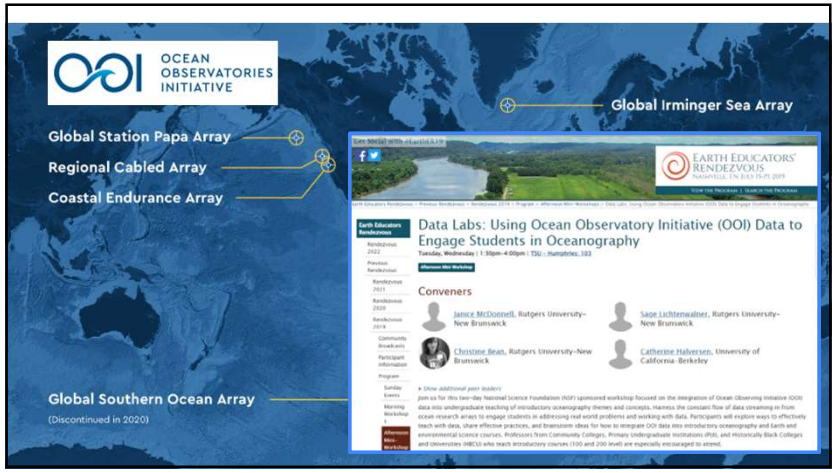
Improving Undergraduate Scientific Explanations: Exploring the Role of Data Literacy Skills in Scientific Reasoning

NSF IUSE Grant
[ID 2021347] 2020-2023
Level 1, Engaged Student Learning Track

Study Timeline

Year 1 (2020-2021; fall, spring and summer): lesson plans, interactive data visualizations, interview protocols, and assessments piloted and revised

Year 2 & 3 (2021-2023): Data collection (fall & spring semesters) & Analyses (summers)



Science & Engineering Practices

- what students *DO* to make sense of phenomena
- set of skills AND a set of knowledge to be internalized
- reflect the major practices that scientists and engineers use to investigate the world and design and build systems; adapted for K-12 learners.

- Asking questions (science) and defining problems (engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (science) and designing solutions (engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

NRC, 2012, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*

Expectations for Constructing Explanations (9-12)

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

NGSS Appendix F - www.nextgenscience.org/

Original Framework Modified for our Work

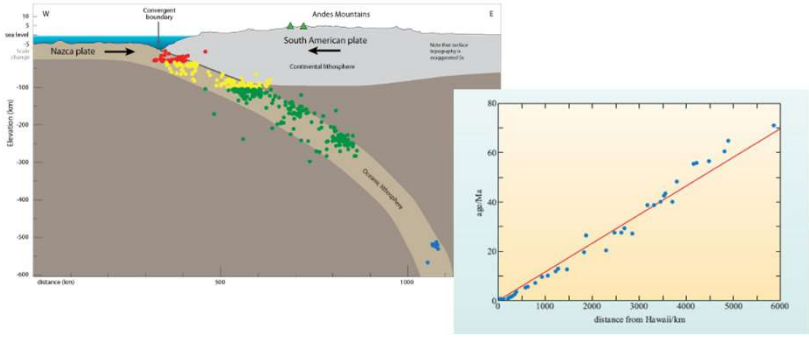
Claim-Evidence-Reasoning

TABLE 5.5 Base Rubric for Scientific Explanation

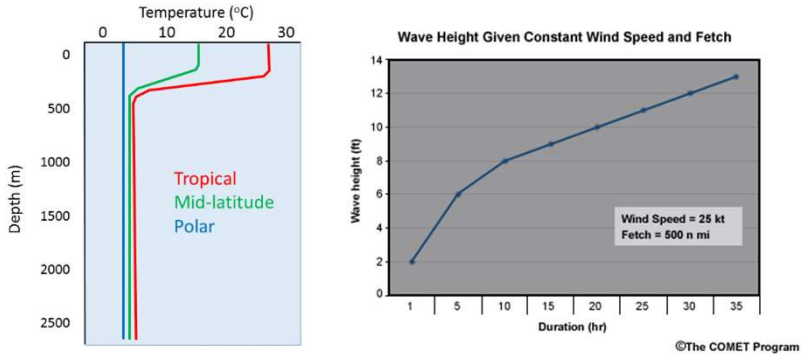
LEVEL	Claim	Evidence	Reasoning
	A statement or conclusion that answers the original question/ problem.	*Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.*	*A justification that connects the evidence to the claim. It shows why the data counts as evidence by using appropriate and sufficient scientific principles.*
0	Does not make a claim, or makes an inaccurate claim.	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support claim).	Does not provide reasoning, or only provides inappropriate reasoning.
Varies from 1 to 5	Makes an accurate but incomplete claim.	Provides appropriate, but insufficient, evidence to support claim. May include some inappropriate evidence.	Provides reasoning that connects the evidence to the claim. May include some scientific principles or justification for why the evidence supports the claim, but not sufficiently.
	Makes an accurate and complete claim.	Provides appropriate and sufficient evidence to support claim.	Provides reasoning that connects the evidence to the claim. Includes appropriate and sufficient scientific principles to explain why the evidence supports the claim.

McNeill & Krajcik, 2012

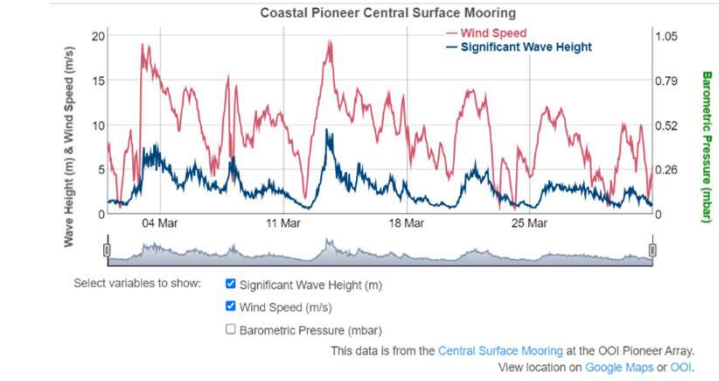
Provide Experiences with Data



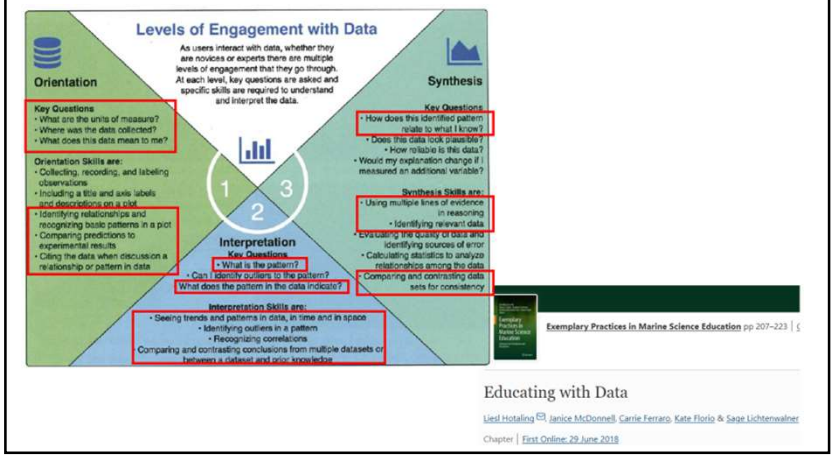
Provide More Experiences with Data



"Real World" Data

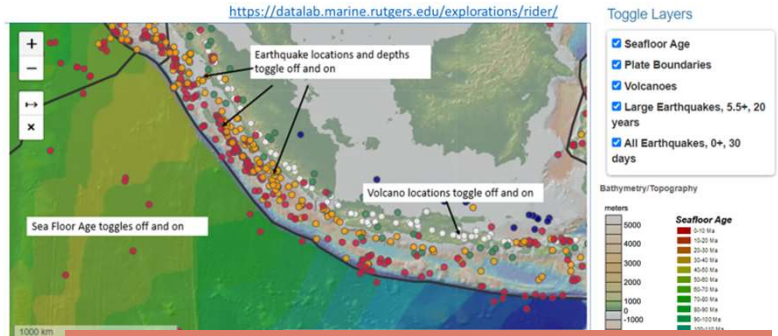


https://datalab.marine.rutgers.edu/explorations/rider/waves.htm



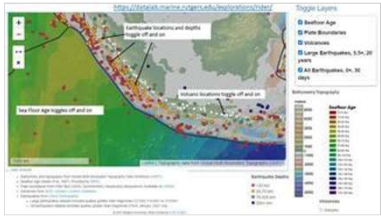
D-C-E-R Framework

- describe data (trends, patterns, ranges, outliers, similarities, differences, etc.) **[Data Descriptions-D]**
- draw conclusions about the data and relevant phenomena, **[Claim-C]**
- and support those conclusions with scientific reasoning that includes proper evidence tied to the students' understanding of relevant science concepts [**Evidence-E** and **Reasoning-R**]



After providing background on Plate Tectonics topic, assigned groups different locations with combination addressing all plate boundary types
Goals for students: Describe patterns in all data sets; Make a Claim about what type of plate boundary exists at your location and explain; Explain individually

Explore a Data Set

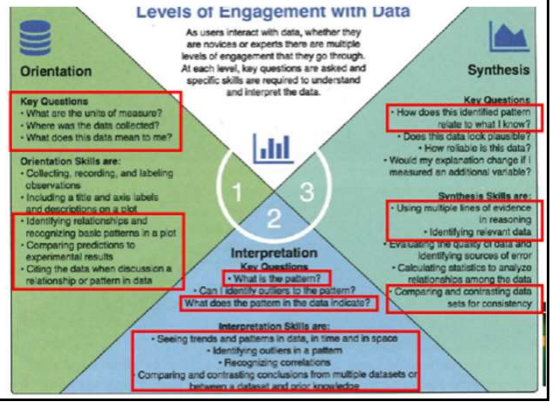


- Go to https://datalab.marine.rutgers.edu/explorations/rider/geology.htm
- Select "Indonesia" (at least to start)
- Experiment by turning on different data sets
  - Think about your students' abilities to orient themselves with the data sets, and articulate patterns in the data
  - Comments, questions?
- FYI, will next review a scaffolded set of steps to guide students to:
  - articulate patterns in the data
  - make a claim
  - support it with reasoning that includes evidence and understandings about relevant science concepts.

Summary of Instructional Plan

Hotaling et al Framework

Additional instruction details



Expanded/Modified Rubric For Analyzing Explanations

Proficiency level	***D***escriptions	***C***onclusion	***E***vidence	***R***easoning
	First, thoroughly describes all trends, patterns, similarities, and/or differences etc. ("T/P/D/S etc.") in the data.	*A statement that answers the original question/problem. If no question is provided, students make their own conclusion from the data studied.*	*Scientific data that support the conclusion. The data need to be appropriate and sufficient to support the conclusion.*	*A justification that connects the evidence to the conclusion. It shows why the data count as evidence by using appropriate and sufficient scientific principles (addressed in this class); also includes reasoning for any data that are not relevant to the conclusion.*
0	None provided; completely irrelevant	None provided; completely irrelevant	None provided; completely irrelevant	None provided; completely irrelevant
1 (weak)	Provides few "T/P/D/S etc." descriptions or mostly inappropriate descriptions and/or level of detail of descriptions.	Provides an inappropriate conclusion given the data used; or restates a data description.	Provides very little (when more is present) and/or inappropriate evidence (evidence that does not support the conclusion). 1a very little evid; 1b inaccurate evid	Provides very little or inappropriate reasoning. 1a - only incl. evidence; 1b - only incl. sci principles; 1c - both evid and principles but are connected inaccurately
2 (passing)	Provides some appropriate "T/P/D/S etc." descriptions; but not all; or level of detail is inappropriate for some described.	Provides an appropriate, but insufficient conclusion. If only one conclusion is needed, this score could be used where students reference the proper feature etc. but does not name it specifically (etc.).	Provides appropriate, but insufficient evidence (given all data present). Or provides sufficient, but some inappropriate evidence. 2a appro but insuff; 2b suff but inappro	Provides reasoning that connects the evidence to the conclusion. Some, but insufficient scientific principles or justification for why the evidence supports the conclusion.
3 (strong)	Completely describes all "T/P/D/S etc." at an appropriate level of detail. With quantitative details included when available. If interps or explanations included, they are ignored.	Provides an appropriate and sufficient conclusion.	Provides appropriate and sufficient evidence that includes some relevant specific quantitative information and pattern descriptions.	Provides reasoning that connects the multiple pieces (when available) of evidence to the conclusion. Includes appropriate and sufficient scientific principles to explain why the evidence supports the conclusion.

When you complete your answer, highlight text with the following color coding:
Conclusion/Claim
Yellow- data summaries relevant for your claim ("evidence")
Blue - science background concepts relevant to explain your claim
Green- - text that connects evidence to science concepts

IUSE NSF Project Data Collected

- Analyses of Class Data Studies (4)
  - Group data descriptions
  - Individual explanations
- Analysis of Exam Essay Questions (3, one per exam)
- Pre/Post survey data regarding data literacy skills, scientific reasoning, and ocean concepts learning
- Student Interviews

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Your turn!

- Think about data and concepts you address in your instruction
  - consider the last data set you used in your instruction that you expected students to make sense of
- In Breakout groups, consider how you might enhance your instruction (please keep groups to ~8 or smaller)
  - what additional steps you could add to your instruction that builds in more scaffolding for data literacy skills development (D) and/or scientific reasoning skills (CER)

Advice for Data Selections & Use in Instruction

- Real world data is great but still needs to get the point across, even with some "messiness"
- Visualizations you already use can still be used here!
- Be strategic in the data/concepts that you address with a full-blown lesson sequence; you can't do it with ALL data you use in your instruction; add individual elements with other data sets when possible
- Don't expect complete success immediately; look for and develop improvements over time and give feedback to help

Thank you!

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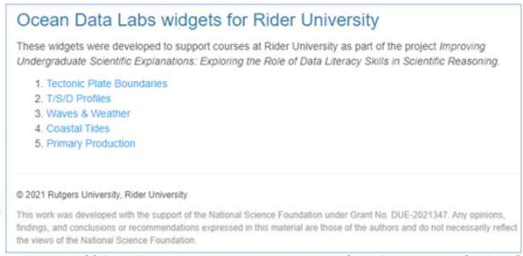

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