Developing Science Practices: Constructing Explanations and Engaging in Argumentation

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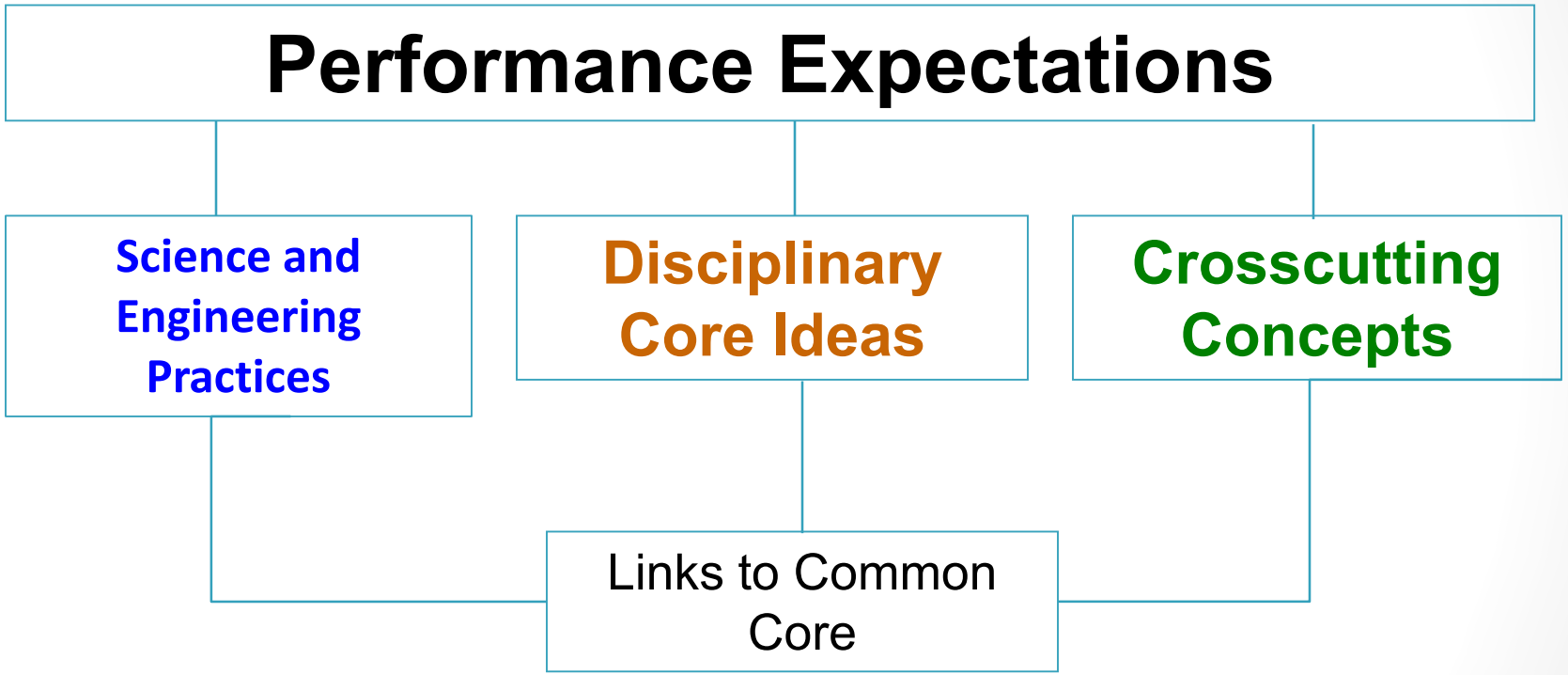
Where do Practices Fit in NGSS?



Science and Engineering Practices (SEPs)

- Analyzing and Interpreting Data
- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Investigations
- Using Mathematics and Computational Thinking

What does it mean to construct an explanation?

Scientific questions are distinguished from other types of questions because the answers lie in explanations supported by empirical evidence, including evidence gathered through explanation.

The goal of science is to construct explanations for the causes of phenomena.

- NGSS Appendices, 2013

What is engaging in argumentation?

- Argumentation is the process by which evidence-based conclusions and solutions are reached.
- Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits.

- NGSS Appendices, 2013

Types of Argumentation

- Scientific: Does our data support Explanation A or Explanation B?
- Social: Have humans had a positive or negative influence on our town's harbor?
- Other Types?

Example Activity

- From a model middle school NGSS-aligned unit on ecosystems
- Overarching issue in chapter: invasive species (Zebra mussel in the Hudson River)
- Activity four out of five in the chapter
- Elaborate activity in the 5E cycle

Choose one parameter

- Chlorphyll (phytoplankton)
- Cladocera (zooplankton)
- Alosa (fish)
- Sphaeriidae (mollusk)
- Copepod nauplii (zooplankton)
- Rotifers (zooplankton)

RIVER ECOLOGY

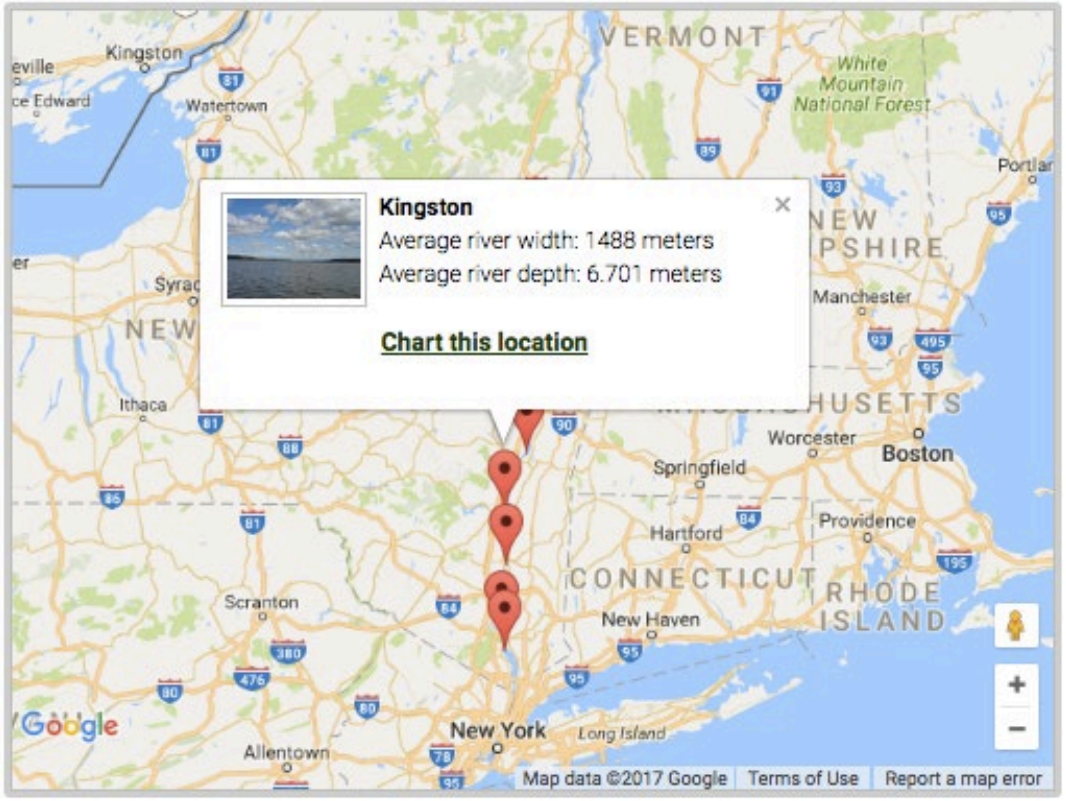
Investigating the effect of zebra mussels on the Hudson River

- Home
- Explore the River
- Meet the Scientists
- Graph the Data
  - Overview
  - Over Time
  - Along the River
- Analyze the Data

Graph the Data:

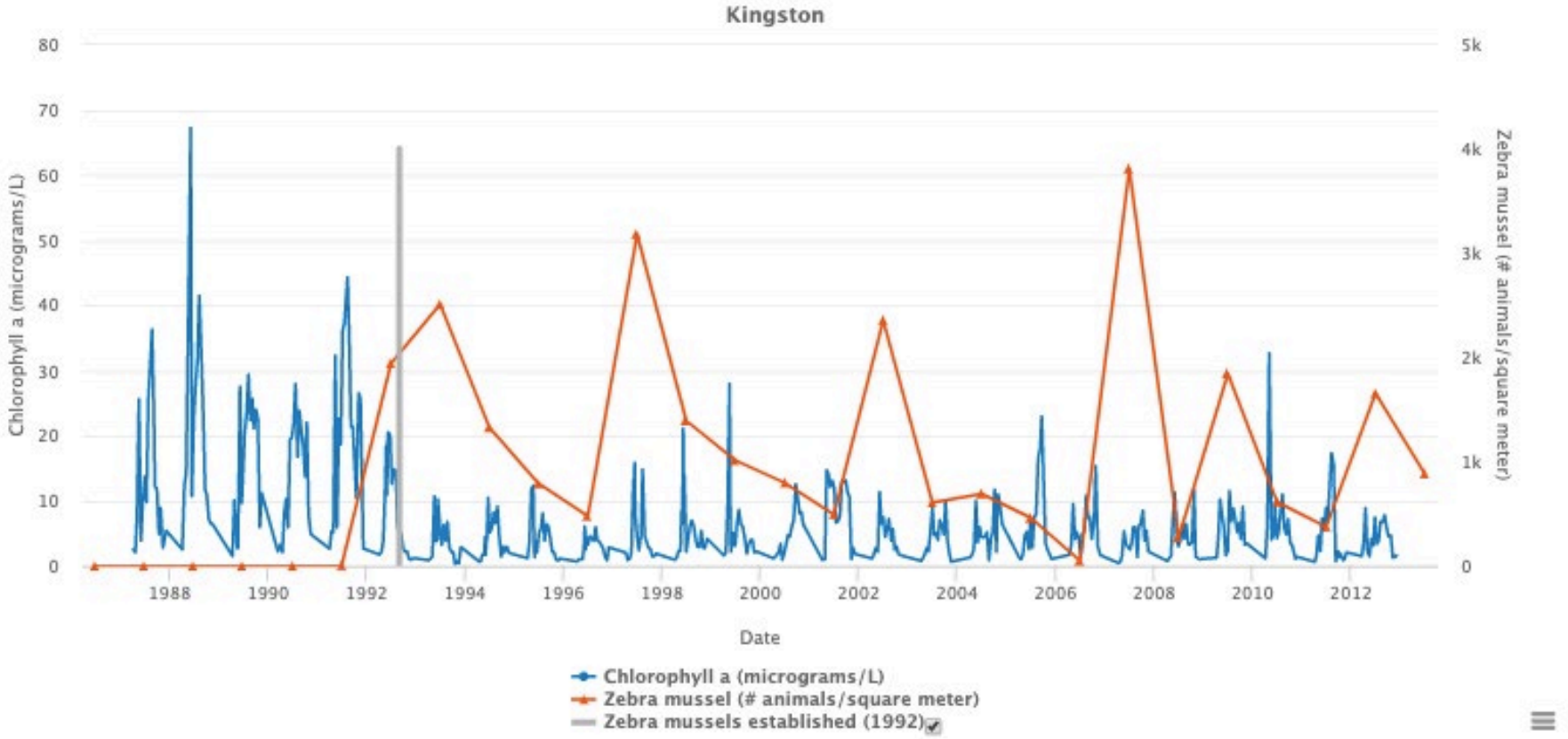
Over Time

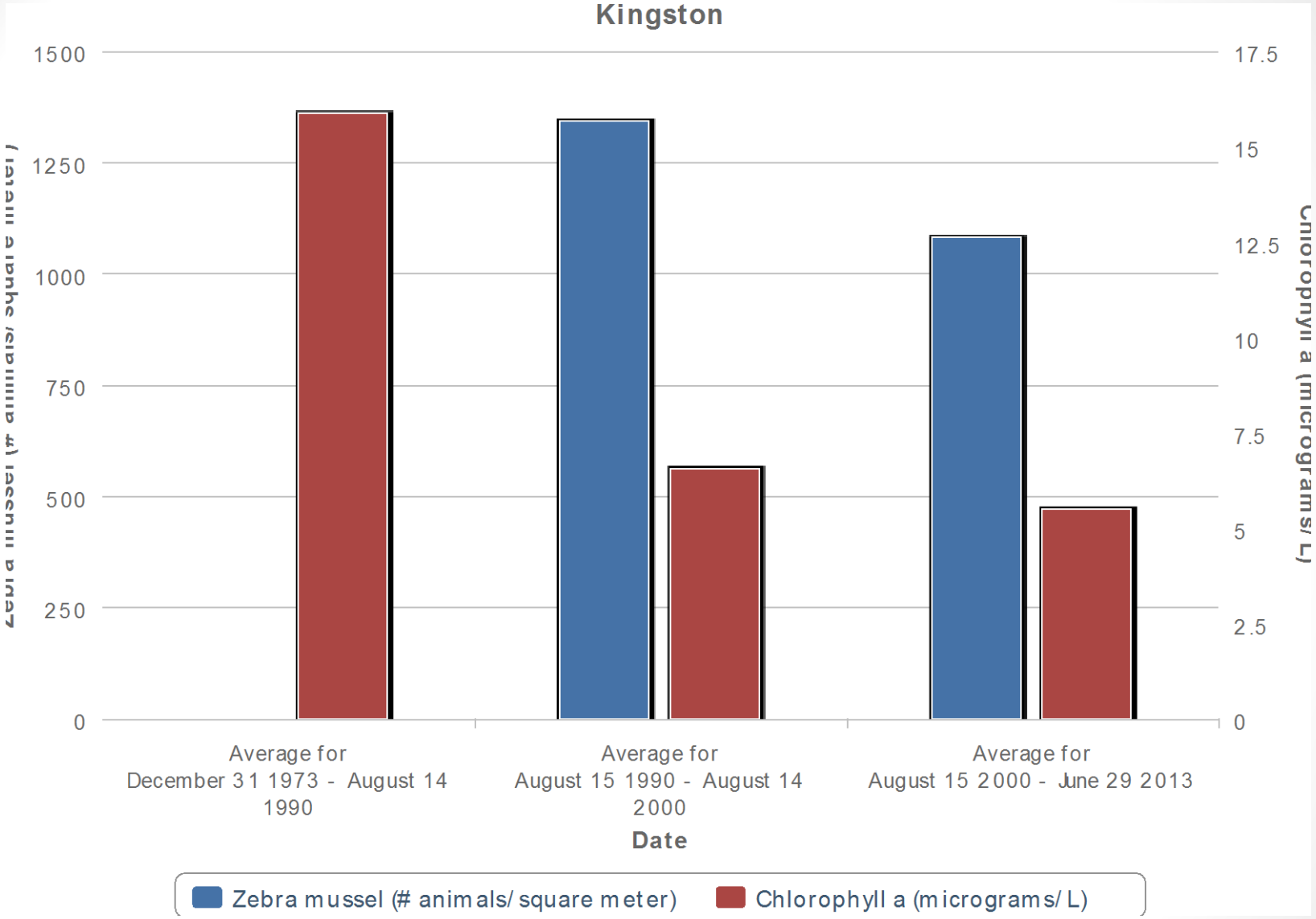
1. Select a sampling station from the map below.
2. Click "Chart this location" to view data for that location.



First parameter: Temperature (degrees Celsius)

Short Term: 1988-1996





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What is the scientific question you are investigating?

What is the long-term effect of zebra mussels on the factor you chose? (rotifers)

Evidence What are the science observations or data that address your question?	Science Concepts What science concepts are connected to the evidence and might help answer the question?
Between 1990 and 2000 the zebra mussel population increased from zero to about 1300/m2. The average rotifer population went from 409/L to 161/L. Between 2000 and 2013, the zebra mussel population decreased slightly to an average of 1085/ m2. The average rotifer population increased slightly to an average of 186/L.	*This is a predator/prey relationship. Zebra mussels are the predators and rotifers are the prey.*

Scientific Reasoning

How do the science concepts connect to the evidence and to the question you are trying to answer?

Normally as the population of predators increases the population of prey will decrease, and as the predator population decreases the prey population increases. The evidence shows this happening with zebra mussels and rotifers.

Scientific Explanation

What is the long-term effect of zebra mussels on the factor you chose? (rotifers)

My claim is that if the zebra mussel increases, the rotifer population decreases, but if the zebra mussel decreases the rotifer population will increase. The evidence that supports my claim is that the patterns in the graph show that as the population average of zebra mussels increased (1990-2000), the population average of rotifers decreased. However, when the population of zebra mussels decreased (2000-2013), the rotifer population increased. Because zebra mussels are predators that prey on rotifers, a larger zebra mussel population will eat more rotifers, causing a decrease in the rotifer population. The reverse will happen if the predator population (zebra mussels) decreases: the prey population (rotifers) will increase. This is what normally happens in predator-prey relationships: when a predator population increases, it causes the prey population to decrease, and vice versa. This is an example of a cause and effect relationship.

What is the question that you are investigating?

Has the zebra mussel had a positive or negative effect on the Hudson River ecosystem?

Claim A	Claim B
What is a claim you could argue? *The zebra mussel had a positive effect on the Hudson River ecosystem.*	What is a claim you could argue? *The zebra mussel had a negative effect on the Hudson River ecosystem.*
The evidence that supports this claim is . . . *. . .even though the rotifer (zooplankton) population decreased when the zebra mussels first arrived, it is starting to go back up now that the zebra mussel population has started decreasing. Between 2000-2013 the population average for rotifers went from 161/L to 186/L, while the zebra mussel population went from 1300/m2 to 1085/ m2.*	**The evidence that supports this claim is . . .** *. . .the rotifer (zooplankton) population is much smaller than it was before the zebra mussels arrived. There used to be 1,000-2,000/L and after the zebra mussel arrived it dropped to less than 200/L. The number of open water fish was10.35 million before the zebra mussels arrived. It fell to 5.24 million after the zebra mussels arrived. Between 2000 and 2013 the number of open water fish has continued to fall and is now at 3.34 million.*

Scientific Reasoning: Evaluating the Evidence and Claim

Critique the quality and strength of the evidence that supports this claim. *Even though the rotifer population is a little higher, it has not gone up enough to show that the ecosystem has recovered or that the zebra mussel has had a positive effect. The number of open water fish has not recovered.*	Critique the quality and strength of the evidence that supports this claim. *The rotifer population had decreased significantly, and this means that other plankton-eaters like fish and native mussels do not have as much food. The number of open water fish has continued to go down even when the zebra mussel population has been reduced.*

Scientific Argument

Has the zebra mussel had a positive or negative effect on the Hudson River ecosystem?

My claim is that the zebra mussel has had a negative effect on the Hudson River ecosystem. The evidence that supports this claim is that the rotifer (zooplankton) population is much smaller than it was before the zebra mussels arrived. There used to be 1,000-2,000/L and after the zebra mussel arrived it dropped to less than 200/L. Even though the rotifer population has increased a little since 2000 (from 161/L to 186/L) the population is still much smaller than it used to be. The number of open water fish was 10.35 million before the zebra mussels arrived. It fell to 5.24 million after the zebra mussels arrived. Between 2000 and 2013 the number of open water fish has continued to fall and is now at 3.34 million even though the zebra mussel population has decreased during this time. My scientific reasoning is that the decrease in the rotifer population means that all predators that eat zooplankton, such as native fish and mussels, will therefore have less to eat and their populations will decline. Therefore, this is the claim that fits best with all of the data on zebra mussels and rotifer populations.

Critique of the Rebuttal

Other people might claim _____ . I think the problem with this argument is _____.

Other people might claim that the zebra mussel has had a positive effect on the Hudson River ecosystem. I think the problem with this argument is that there is more evidence of negative effects, like the rotifer population decreasing, than there is evidence of positive effects, like the fact that the rotifer population is starting to increase a little bit.

NGSS 3-D Alignment

DCIs	SEPs	CCCs
MS LS2.C.1	Analyzing and Interpreting Data	Stability and Change
MS LS2.A.1	Engaging in Argument from Evidence	Cause and Effect
MS LS2.A.2		

PEs: MS-LS2-4 and MS-LS2-1

Taking it Back

- What are other contexts explanations would be good for?
- What's another context/type of argument this would be good for?

Teaching Channel Videos

teachingchannel.org/videos/argument-tool-ngss

Contact Info

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- Thank you to NSF for funding this project!
- Presentation will be available on sepuplhs.org
- Curriculum (2nd Field Test Ed) available on nextgenscience.org (search for Disruptions in Ecosystems)
- Zebra mussel materials (graphing tool, readings) are on https://www.amnh.org/learn-teach/curriculum-collections/river-ecology
- If you are interested in 3-D assessments feel free to stay for one more slide.

Research Study

- **Purpose of our study**

We are developing high-quality assessments to monitor students' progress towards understanding the Next Generation Science Standards (NGSS).

Who can participate?

To participate, you must be currently teaching the NGSS in your middle school science classroom at a public or private school. Additionally, your principal or district must agree that we can conduct research in your classroom.

Interested in participating?

Please contact us!

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