Appendix 1. Coding scheme pre/post assessment items

Item 1: Fossil fuels (3 points)

(Anderson et al. Carbon project: https://carbontime.create4stem.msu.edu/)

Claim: Fossil fuels are harmful for the environment. Below please (i) describe some evidence that supports this claim, and (ii) provide reasons for why you think the evidence supports the claim.

Item 2: Karen's investigation (2 points)

(Mutch-Jones et al., 2012)

Karen claimed that grasshoppers only eat grass. She wanted to find out if that was true or not. Which of the following investigations would help her support her claim? Check one.

a. Observing the grasshoppers in the field near her house for several hours and recording which of the different plants in the field the grasshoppers ate.

b. Putting a pile of grass in a cage with grasshoppers, observing them and keeping a careful record of how much they ate.

c. Carefully looking at all the different kinds of plants in the field near her house and recording which ones had holes in them.

d. Cutting different kinds of grasses from the field near her house and putting them in a cage with grasshoppers to see which ones they ate.

Please explain your choice.

Item 3: Jonas' data (2 points)

(Mutch-Jones et al., 2012)

Jonas observed shrimp over a few days and collected the following data:

Location	Number of observations
Under rocks	28
Under leaves	28
In open water	4
On the bottom	9

After completing his observations Jonas made the following claim:

- Shrimps hide under rocks.

Check the statement you think is true about Jonas's claim.

a. Jonas's claim **is** supported by the data.

b. Jonas's claim is supported by the data, but it is incomplete.

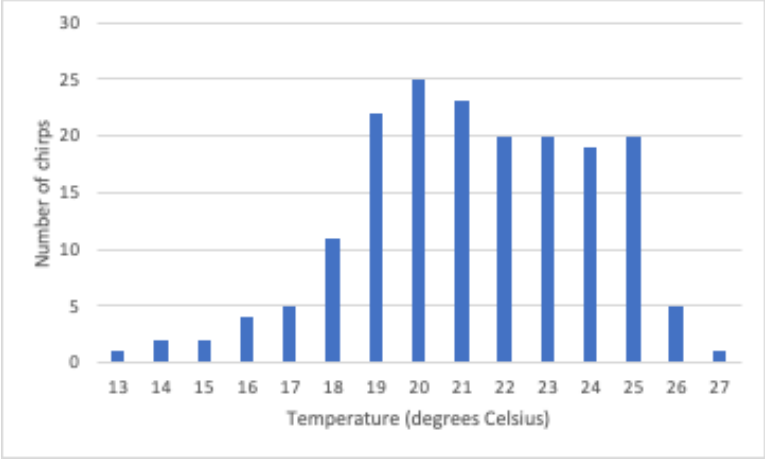
c. Jonas's claim **is not** supported by the data.

Please explain your choice.

Item 4: Cricket data (2 points)

(Developed by project)

A cricket is an insect. Male crickets make a chirping sound. Jesse thinks they chirp more when it is hot. Jaz and Sami did not agree. They predicted that temperature would not affect how much crickets chirp. The three students designed an investigation to count number of chirps at different temperatures. They collected the following data over several days.



Check the statement that you think is true about Jaz and Sami's claim.

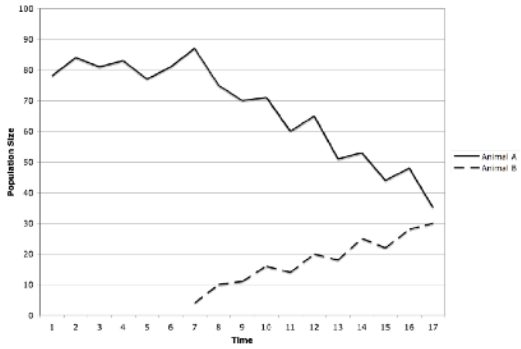
- Jaz and Sami's claim is supported by the data
- Jaz and Sami's claim is **not** supported by the data.

Please explain your choice.

Item 5. Grassland data (3 points)

(Adapted from McNeill & Krajcik, 2008)

Animal A lives in small underground tunnels in a grassland area. It eats grasses, roots and weeds. At time point 7, Animal B moves into that environment. Animal B is a much larger animal and eats small animals, insects, and reptiles. A scientist measured the size of the populations over time and made this graph.



What type of relationship do these two animals A and B have?

Use the data in the graph to explain your answer.

Item 6. Fishing (3 points)
(adapted from Zhou et al., 2016)

Tom, Dan and Jerry often go fishing together. They have the same skill and usually catch similar numbers of fish each time. Yesterday they picked 2 different locations on the same river, and each fished for 2 hours. The table describes what equipment they used and the number of fish they caught.

	Variable	Tom	Dan	Jerry
	Pole	Long	Long	Short
	Fishhook	Thick	Thin	Thin
	Location	Point A	Point A	Point B
Number of fish caught		15	15	8

a. Can the information in the table be used *to test whether* the thickness of fishhooks affects the number of fish caught? Yes No Other.
Please explain your reasoning.

Item 7. Evaluating possible mitigation projects (4 points)
(Developed by project)

Scientists have proposed some project to mitigate global warming. Choose ONE of the projects and answer the questions that follow.

Project 1: Ocean scientists propose to add iron to the ocean to boost the growth of algae and capture much more CO2.
Project 2: A group of city planners in the US proposes to plant 1 billion trees by 2028.
Proposal 3: A group of urban high school students proposes to adapt the idea of growing "green roofs" on buildings to grow green roofs on all the city buses.

1. Briefly describe how you think you would prototype this idea.
2. Do you think the scale (size) of this project could be achieved? Describe why or why not.
3. What might the project benefits be?
4. What might the project downsides be?

Appendix 2. Coding scheme for practices in student submissions. Scores were aggregated as follows to match NGSS practices (see Table 7): Evaluating a claim using evidence and reasoning: Questions 6, 7, 8; Designing an investigation: 5, 10; Evaluating design of a proposed mitigation effort: 3, 4, 9.

Code		
1.	Category of mitigation:	
2.	Strategy/method of mitigation (i.e., what is the strategy):	
3.	Is the science that supports the strategy sound and plausible overall, i.e., based on current scientific understanding? (2 points)	
a.	Yes (2 points)	
b.	For the most part (1 point)	
c.	No (0 points)	
4.	Does the strategy address biodiversity? (2 points)	
a.	Yes (2 point)	
b.	Indirectly (1 points)	
c.	No (0 points)	
5.	Is there a problem statement describing the mitigation challenge or problem? (2 points)	
a.	Yes (2 point)	
b.	No (0 points)	
c.	Not clear, or diffuse (may be distributed across the submission) (1 point)	
6.	Is the mitigation strategy supported by an argument? (6 points)	
a.	Yes, the mitigation strategy is supported by an argument that is backed up with a rationale (2 points)	
b.	The rationale relies on (check all that apply): a. Authority: Explicitly cites an authority, whether teacher, text, article, Web, etc. (2 points) b. Causal: Argument used a theory or concept to explain how the strategy will address the problem, generally predicts a specific outcome (1 point) c. Empirical: Argument is based on empirical data, either from an authority or students' own data (1 point) d. Factual: Asserts the claim as fact without citation, reasoning, or data (0 points)	
c.	Yes, the mitigation strategy is supported by an argument, but the argument is vague, implicit, or scientifically implausible, i.e., no rationale is presented (1 point)	
d.	Unclear what the mitigation strategy is, and there is no rationale (0 point)	
7.	What is the quality of evidence underpinning the mitigation strategy? (2 points)	
a.	The evidence in support of the strategy is qualitative (1)	
b.	The evidence in support of the strategy is quantitative (1)	

c.	The evidence in support of the strategy is both qual. and quant. (2)	
8. Was a prediction made about impact, or outcomes with respect to mitigation? (2 points)		
a.	The prediction was clearly stated (2 points)	
b.	The prediction was a vague or general statement, possibly scattered throughout the submission (1 point)	
c.	No prediction about impact (0 points)	
9. Limitations of design (2 points)		
a.	Directly referred to and discussed (2 points)	
b.	Referred to but not discussed (1 point)	
c.	No mention (0 points)	
10. Is literature referred to and cited? (2 points)		
a.	Yes, directly referred to and a citation is included (1)	
b.	Yes, directly referred to and more than one citation is included (2)	
c.	Directly referred to but citation not included (0)	
d.	Cited as a reference but not referred to in the body of the submission (0)	
e.	No	

Code		**Score**
1. Category of mitigation:		
2. Strategy/method of mitigation (i.e., what is the strategy):		
3. Is the science that supports the strategy sound and plausible overall, i.e., based on current scientific understanding? (2 points)		
a.	Yes (2 points)	
b.	For the most part (1 point)	
c.	No (0 points)	
4. Is there a problem statement describing the mitigation challenge or problem?		
a.	Yes (2 point)	
b.	No (0 points)	
c.	Not clear, or diffuse (may be distributed across the submission) (1 point)	
5. Is the mitigation strategy supported by an argument?		
a.	Yes, the mitigation strategy is supported by an argument that is backed up with a rationale (2 points)	

b.	The rationale relies on (check all that apply): a. Authority: Explicitly cites an authority, whether teacher, text, article, Web, etc. (2 points) b. Causal: Argument used a theory or concept to explain how the strategy will address the problem, generally predicts a specific outcome (1 point) c. Empirical: Argument is based on empirical data, either from an authority or students' own data (1 point) d. Factual: Asserts the claim as fact without citation, reasoning, or data (0 points)	
c.	Yes, the mitigation strategy is supported by an argument, but the argument is vague, implicit, or scientifically implausible, i.e., no rationale is presented (1 point)	
d.	Unclear what the mitigation strategy is, and there is no rationale (0 point)	
6. What is the quality of evidence underpinning the mitigation strategy? (2 points)		
a.	The evidence in support of the strategy is qualitative (1)	
b.	The evidence in support of the strategy is quantitative (1)	
c.	The evidence in support of the strategy is both qual. and quant. (2)	
7. Was a prediction made about impact, or outcomes with respect to mitigation? (2)		
a.	The prediction was clearly stated (2 points)	
b.	The prediction was a vague or general statement, possibly scattered throughout the submission (1 point)	
c.	No prediction about impact (0 points)	
8. Limitations of design (2 pt)		
a.	Directly referred to and discussed (2 points)	
b.	Referred to but not discussed (1 point)	
c.	No mention (0 points)	
9. Is literature referred to and cited?		
a.	Yes, directly referred to and a citation is included (1)	
b.	Yes, directly referred to and more than one citation is included (2)	
c.	Directly referred to but citation not included (0)	

d.	Cited as a reference but not referred to in the body of the submission (0)	
e.	No	